

Tomorrow's Kwinana



Effective planning today, helps to
shape the Kwinana of tomorrow.

An aerial photograph of a residential area in Kwinana is shown, overlaid with a semi-transparent green filter. A thick green line with arrowheads at its ends runs horizontally across the middle of the map. A dark green horizontal bar is positioned over the bottom portion of the map, containing the title text.

Local Biodiversity Study

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LOCAL BIODIVERSITY STUDY

1. Introduction

The Local Planning Strategy (LPS) aims to provide a land use planning vision extending to 2050 for the City of Kwinana (City), thus setting out a long-term strategic direction for land use, and in the process, consider a wide range of local economic, social and environmental issues that are affecting the City. The Local Biodiversity Study (LBS), one of the studies that informs the preparation of the LPS, aims to identify the issues associated with the City's biodiversity values and areas and provide guidance to future protection, retention and management.

2. Importance of Biodiversity

2.1 Biodiversity - why is it important?

Biodiversity underpins the ecological processes necessary for maintaining marine and estuarine quality, soil fertility, and clean, fresh water and air. Biodiversity is also fundamental to the quality and character of the landscape and provides recreational opportunities, aesthetic value and cultural identity.

A land use framework/mechanism should recognise the importance of biodiversity while considering changes to land use, which could include consideration of any future potential value, such as a source of genetic material.

2.2 Values and Benefits of Protecting Biodiversity

Biodiversity plays a vital role in sustaining the living networks and systems that provide humans with health, food, wealth, fuel and the vital services our lives depend on. These organisms, ecosystems and ecological processes supply humans with oxygen and clean water, help keep our lives in balance and regulate the climate. The benefits derived from protecting biodiversity are both tangible, for example economic returns and tourism, and intangible, for example heritage values and the mere existence of humanity. The 'ecosystem services' provided by the natural environment in Australia are worth an estimated \$1327 billion in economic terms (see Table 1). Biodiversity and the ecosystem services it provides has been compared to a bank account of capital assets capable of paying life-sustaining dividends in perpetuity, but only if the capital is maintained.

Naturally vegetated areas in Western Australia's cities and towns support significant biodiversity and provide important amenity to urban residents (*Environmental Protection Authority 2013*).

The rich diversity of Western Australia is in decline due to human activities. Local government can slow, stop and reverse this trend by showing leadership within the community and also encouraging local land and property owners to conserve native flora and habitats of fauna. Local governments can and should use their position to:

- Regulate land use;
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- Utilise available powers to influence community behaviour through implementing biodiversity friendly regulations and planning provisions;
- Promote and demonstrate environmentally, ecologically and socially responsible behaviour;
- Offer community education programs and staff training; and
- Provide incentives for sustainable natural resource management on private land.

Table 1 Four main types of ecosystem services (Adapted from Lismore City Council Biodiversity Management Strategy 2015)

PROVISIONING SERVICES
<ul style="list-style-type: none"> o Food, including bush tucker, fibre, fuel and many medicines o Genetic resources o Biochemicals o Fresh water
REGULATING SERVICES
<ul style="list-style-type: none"> o Resistance to invasion by weeds o Herbivory – food for animals o Pollination of crops and natural vegetation o Seed dispersal of crops and natural vegetation o Climate regulation o Pest regulation o Disease regulation o Natural hazard protection o Moderation of extreme weather and its impacts o Regulation and protection from erosion and flood damage o Mitigation of the impacts of drought and flood o Water purification
SUPPORTING SERVICES
<ul style="list-style-type: none"> o Primary production e.g. agriculture, forestry and fisheries o Provision of habitat o Nutrient cycling o Soil formation and retention o Decomposition of wastes and cycling of nutrients o Production of oxygen and maintain air quality o Water cycling
CULTURAL SERVICES
<ul style="list-style-type: none"> o Tourism and recreation resources o Enhancement of landscape and aesthetic amenity o Spiritual and religious values o Knowledge system o Education and inspiration o Sense of place o Improvement of the overall health of the community

People and community place six different values on biodiversity according to Williams et. al. (2001) (Table 2).

Areas with high levels of biodiversity are more easily able to withstand significant environmental changes and disturbances than areas of lower diversity. Conserving biodiversity is an essential part of safeguarding our biological life support systems.

Table 2 Value of biodiversity (based on Williams et al. 2001)

Values	Examples
Direct utilitarian	<ul style="list-style-type: none"> • Food • Feed stock • Building materials (timber, fibres) • Medicines • Genetic material
Indirect utilitarian	<ul style="list-style-type: none"> • Maintaining water quality • Sequestering carbon • Hydrological functions • Soil stability • Decomposition and assimilation of wastes
Aesthetic and recreational	<ul style="list-style-type: none"> • Enjoying landscapes (e.g. Coral Reefs, National Parks) • Enjoying specific taxa (e.g. birds, trees, whales) • Hiking • Bird watching • Fishing
Scientific and educational	<ul style="list-style-type: none"> • Scientific discovery can lead to utilitarian values • Education in wide range of areas (botany, zoology, ecology)
Intrinsic, spiritual and ethical	<ul style="list-style-type: none"> • Cultural and religious systems • Ethical: non-human forms have intrinsic value
Future or 'option'	<ul style="list-style-type: none"> • Further research in the future may reveal significance (e.g. medicinal) • Existence value: satisfaction in knowing it exists • Bequest value: knowing it will exist for future generations

3.0 Planning and Legislative Framework

The protection of biodiversity and conservation areas in Western Australia is achieved through a hierarchy of planning and legislative framework. A combination of statutory and non-statutory planning processes and instruments address matters related to the retention and protection of flora and fauna, and management of habitats.

3.1 Federal Government

3.1.1 Environment Protection and Biodiversity Conservation Act 1999

The *Environment Protection and Biodiversity Conservation Act 1999* (the EPBC Act) is the Australian Government's central piece of environmental legislation. It provides a legal framework to protect and manage nationally and internationally important flora, fauna, ecological communities and heritage places as defined in the EPBC Act as matters of national environmental significance. Specifically, the EPBC Act aims to:

- provide for the protection of the environment, especially matters of national; environmental significance;
- conserve Australia's biodiversity;
- protect biodiversity internationally by controlling the international movement of wildlife;
- provide a streamlined environmental assessment and approvals process where matters of national environmental significance are involved;
- protect Australia's world and national heritage; and
- promote ecologically sustainable development.

The EPBC Act tries to promote and protect threatened species through two principal mechanisms:

- A permit system, by which the taking, trading or damaging of listed and protected species and ecological communities can be authorised, and acting without a permit is an offence; and
- An environmental impact assessment process for actions that have a significant impact on a matter of national environmental significance.

3.1.2 *Draft Australia's Strategy for Nature 2018-2030: Australia's biodiversity conservation strategy and action inventory 2016*

This strategy is a shared roadmap to care for and sustainably manage nature over the years to 2030. It provides a long-term vision for nature in Australia and identifies goals and objectives to guide the collective efforts of governments and other sectors.

Once it is finalised, the strategy will be supported by an action inventory identifying what local, state/territory and federal governments are doing to achieve the goals and objectives of the strategy. The inventory will also help non-government stakeholders to identify where their effort can support national areas of focus.

The objectives outlined in the draft Strategy are:

- Encourage Australians to get out into nature
 - Empower Australians to be active stewards of nature
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- Increase Australians' understanding of the value of nature
- Respect and maintain traditional ecological knowledge and stewardship of nature
- Improve conservation management of Australia's landscapes, seascapes and aquatic environments
- Maximise the number of species secured in nature
- Reduce threats to nature and build resilience
- Use and develop natural resources in an ecologically sustainable way
- Enrich cities and towns with nature
- Increase knowledge about nature to make better decisions
- Share and use information effectively
- Effective measurement to demonstrate our collective efforts

3.2 *State Government*

3.2.1 *Wildlife Conservation Act 1950*

The *Wildlife Conservation Act 1950* (Wildlife Conservation Act 1950) provides for the conservation and legal protection of flora and fauna. Specifically, the Act provides that:

- All species of native fauna are protected unless declared otherwise by the Minister for the Environment.
- The Minister may request that certain species, listed as 'threatened', be given special protection.
- It is an offence to 'take' protected or threatened fauna without authorisation from the Department of Biodiversity Conservation and Attractions (DBCA). 'Taking' includes killing, hunting and disturbing.
- The Minister may declare an 'open season' on certain protected native species at certain times and in certain locations.

3.2.2 *Conservation and Land Management Act 1984*

The *Conservation and Land Management Act 1984* (CALM Act), administered by DBCA, applies to all land under the control of the Conservation Commission including State forest, timber reserves, national parks, conservation parks, and nature reserves. The DBCA is responsible for the conservation and protection of flora and fauna throughout the State and is required to promote and encourage rehabilitation of land and conservation of biodiversity throughout the State.

3.2.3 *Environmental Protection Act 1986*

The *Environmental Protection Act 1986* provides for the prevention, control and abatement of pollution and environmental harm; for the conservation, preservation, protection, enhancement and management of the environment; and for matters incidental to or connected with the abovementioned, specifically:

- where a development proposal is likely to have a significant effect on the environment, a proponent may refer the proposal to the Environmental Protection Authority for a decision on whether or not it requires assessment under this Act
 - A clearing permit is required to clear native vegetation unless the clearing is exempted in specific cases.
 - A works approval is required for works undertaken on a prescribed premise.
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3.2.4 *Soil and Land Conservation Act 1945*

The *Soil and Land Conservation Act 1945* is the main act directed towards controlling land and soil degradation. The Act defines land degradation as soil degradation and the removal or deterioration of natural or introduced vegetation where it diminishes the future use of the land.

Landowners who wish to protect and manage native vegetation on their property may enter into a conservation covenant with the Commissioner under section 30 of the *Soil and Land Conservation Act 1945*. Non-compliance with the Act may result in Soil Conservation Notice being issued. Soil Conservation Notices are a legally binding directive for landowners to take certain management steps aimed at mitigating the identified problems.

This legislation allows local governments to require the use of covenants in development to protect or offset environmental values. Where local government intends to undertake works which involve clearing or drainage from under the land, the Commissioner for Soil and Land Conservation must be notified accordingly.

3.2.5 *Planning and Development Act 2005*

The integration of local biodiversity conservation into statutory land use planning is provided for in the *Planning and Development Act 2005* (PDA). The PDA requires Local Planning Schemes (LPS) to be referred to the EPA in order for the EPA to decide whether or not the scheme requires environmental assessment. This provides the opportunity for a strategic assessment of significant environmental impacts identified on land affected by the LPS.

The PDA has established biodiversity as a valid planning consideration in “Schedule 7 - Matters which may be dealt with by planning scheme”. This incorporates provision for preservation and conservation matters, including *‘the conservation of the natural environment of the scheme area, including the protection of natural resources, the preservation of trees, vegetation and other flora and fauna, and the maintenance of ecological processes and genetic diversity’*.

According to the PDA, the above matters apply to State Planning Policies (section 26(3)), Region Planning Schemes (section 34(2)), Local Planning Schemes (section 69(1)(b)), and conditions of subdivision (section 138(2)).

3.2.6 State Planning Policy No. 2.0 - Environment and Natural Resources Policy 2003 (SPP 2.0)

The policy measures in SPP 2.0 in regards to biodiversity are aimed at adopting a holistic approach for its retention, protection and management. Specifically, SPP 2.0 recognises that *the planning strategies, schemes and decision-making should support conservation, protection and management of native remnant vegetation where possible, to enhance soil and land quality, water quality, biodiversity, fauna habitat, landscape, amenity values and ecosystem function.*

With respect to protecting valued landscapes, SPP 2.0 recognises that planning strategies, schemes and decision-making should:

- a) Identify and safeguard landscapes with high geological, geomorphological or ecological values, as well as those of aesthetic, cultural or historical value to the community, and encourage the restoration of those that are degraded.
- b) In areas identified above, consider the level or capacity of the landscape to absorb new activities and incorporate appropriate planning and building design and siting criteria to ensure that new development is consistent and sensitive to the character and quality of the landscape.
- c) Consider the need for a landscape, cultural or visual impact assessment for land use or development proposals that may have a significant impact on sensitive landscapes.

3.2.7 State Planning Policy No. 2.6 – State Coastal Planning Policy 2013 (SPP 2.6)

SPP 2.6 is a higher order policy for all coastal matters. One of the main objectives of this policy is to protect, conserve and enhance coastal zone values, particularly in areas of landscape, biodiversity and ecosystem integrity, indigenous and cultural significance.

SPP 2.6 prescribes that any rezoning, structure planning, subdivision, strata subdivision or development should ensure that a coastal planning strategy or coastal foreshore management plan is prepared and implemented by the local government and/or proponent for the coastal foreshore reserve.

3.2.8 State Planning Policy No. 2.8 - Bushland Policy for the Perth Metropolitan Region 2010 (SPP 2.8)

SPP 2.8 is a supplementary policy under the environment and natural resources policy (SPP 2.0) and seeks to address, in more detail, the protection and management of significant bushland areas, particularly those identified for protection through strategies and processes at the regional and local level in the Perth Metropolitan Region (PMR). Regionally significant bushland areas are known as 'Bush Forever sites' and are identified in this Policy.

SPP 2.8 contains policy measures for 'local bushland' and also provide for the preparation by local government of a local bushland protection strategy or local biodiversity strategy, in accordance with the *Local Government Biodiversity Planning Guidelines for the Perth Metropolitan Region* (WALGA 2004). The local biodiversity strategy should be prepared in consultation with affected landowners, broader community, and relevant government agencies.

3.2.9 Bush Forever Policy 2000 – Keeping the Bush in the City

The Bush Forever policy provides a policy and implementation framework that is aimed to ensure bushland protection and management issues in the PMR are appropriately addressed and integrated with broader land use planning and decision-making. Besides, the policy recognises the protection and management of significant bushland areas as a fundamental consideration in the planning process, while also seeking to integrate and balance wider environmental, social and economic considerations. Bush Forever Sites, which are representative of regional ecosystems and habitats, play a central role in the conservation of Perth's biodiversity.

Bush Forever identifies 51,200 hectares of regionally significant bushland recommended for protection and management in 287 Bush Forever sites, and includes lands with either some level of protection or unprotected land in both public and private ownership. The City has 953 ha of Bush Forever Sites.

3.2.10 State Planning Strategy 2050

The State Planning Strategy presents a vision for Western Australia to 2050 and beyond based on a framework of planning principles, strategic goals and strategic directions. Specific to biodiversity and natural areas, *Section 4 Environment* of the Strategy aims to effectively manage the biodiversity values within the formal conservation and off-reserve system and associated threats by developing ecological linkages and protecting landscapes.

3.2.11 South Metropolitan Peel Sub-regional Planning Framework 2018

This is a subset of the over-arching Perth and Peel @3.5million strategy and has considered where future homes and jobs will be located; what community and social infrastructure will be required; better integrated use of existing infrastructure; protection of important environmental assets and critical services; and staging and sequencing of future development. Specific to protecting biodiversity, it sets out proposals to set aside 'planning investigation areas' at the eastern part of Kwinana. Key environmental considerations for these areas include to investigate the implications of/for significant on-ground environmental attributes and Peel-Harvey catchment considerations.

3.2.12 Draft Perth and Peel Green Growth Plan for 3.5 million 2015

The draft *Green Growth Plan* is a set of documents, which provide a comprehensive approach to the avoidance and mitigation of environmental impacts and a committed Conservation Program. It is intended that this plan will deliver significant improvements to the protection and management of the environment as the Perth and Peel regions grow to a population of 3.5 million people.

The draft plan indicated that there were going to be a variety of impacts in the City of Kwinana ranging from loss of vegetation in some areas, additions to conservation estate and areas where rehabilitation may have been considered.

As of June 2018, the WA Government has suspended work on this Plan and appointed an independent four-member panel to undertake the review over the next six months, which include consulting across governments, industry, local governments and non-government organisations.

3.3 Regional Planning

3.3.1 Regional Natural Resource Management Strategies

Regional natural resource management planning encompasses a multi-stakeholder approach to consultation and to the provision of a coordinated delivery of natural resource management outcomes in a range of areas including biodiversity, water quality and land use planning.

In the Perth Metropolitan Region, the Swan Region Strategy for Natural Resource Management has been developed through a consultative process with stakeholder groups including State and Local Government, community, industry and research institutions.

The City works in accordance with the Swan Region Strategy to deliver outcomes that lead to the protection of its assets including air, land, coastal, water, biodiversity and cultural heritage.

3.4 Local Government

The City does not have an adopted 'biodiversity strategy', and if so would have provided a framework and/or lead to prepare either a revised strategy, or a new strategy by considering the State initiated strategic directions. It is expected that the outcomes of this Study could provide the guidelines necessary to prepare a biodiversity strategy for the City.

The role of the Local Government is to refer to State and Federal policies and guidance on matters to do with Flora and Fauna conservation. The City's role is to ensure that due consideration of the values present, their location and extent has been considered in regards to ensure that the best outcome is pursued.

The biodiversity strategy is to amass the guidance from a variety of agencies, apply to the remaining natural areas within the City, determine if there are areas where the guidance applies and develop strategies to ensure that the impact on these values is minimised.

3.4.1 City of Kwinana Local Planning Scheme No 2 (LPS2)

The City's LPS2 through Section 6.16.2 "Areas of landscape protection" provides for measures to be adopted for conserving the natural ecological values and amenity values existing in those areas, while allowing development.

6.16.2 Areas of Landscape Protection

- 6.16.2.1 *Council's objective in setting aside Areas of Landscape Protection is to conserve areas of natural ecological value or landscape amenity whilst at the same time allowing development as provided in the Zoning Table No. 1 of the Scheme.*
- 6.16.2.2 *No person shall, in any Area of Landscape Protection, without Council's Planning Approval in writing;*
- (a) Carry out clearing of trees or other vegetation;*
 - (b) Carry out any filling, dredging or changes to the contour of the land;*
 - (c) Erect any advertising sign,*
 - (d) Erect or construct any building or outbuilding,*
 - (e) Degrade any natural wetland system,*
 - (f) Detract from the amenity of the locality.*
- 6.16.2.3 *In considering an application for Planning Approval in respect of any land within an Area of Landscape Protection, Council shall have regard to the following:*
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- (a) *The overall impact of the proposed development on the landscape amenity of the area and the desirability of limiting or modifying the siting, construction, design or materials of any building or associated services;*
- (b) *The need for an overall management plan prepared by Council in consultation with the affected owners as a prerequisite to any Planning Approval being issued;*
- (c) *The extent to which any subdivision proposal should guarantee the protection of natural ecological features or areas of landscape amenity;*
- (d) *The desirability of minimising the effect of new road construction including earthworks and clearing of vegetation within road reserves.*

3.4.2 City of Kwinana Natural Areas Management Plan 2014-2024

The Natural Areas Management Plan aims to prioritise management issues and threats facing reserves identified in the Management Plan (21 natural area reserves comprising coastal, woodland and wetland communities), including investigating and implementing suitable methods to control these issues and threats. The following implementation programs have been established to achieve the objectives of the Management Plan:

- Weed control program;
 - Access control program;
 - Retention, regeneration and revegetation program;
 - Fire management and fuel reduction program;
 - Pest and bio-security program; and
 - Community education and volunteer program.
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4.0 Biodiversity and Conservation Areas Profile

The biodiversity profile in Kwinana was developed by analysing and collating relevant information from a range of sources at a local, regional, state and national scale. The following section provides a summary of biodiversity values existing in Kwinana and includes flora, fauna and its habitat, threatened species, populations and ecological communities.

4.1 Distribution of Areas having Biodiversity Values

The category of biodiversity and conservation areas that are the responsibility of State or local government within City is outlined in Table 3. This data has been obtained through desktop study, including the approved Structure Plans, Perth Biodiversity Project, and the Metropolitan Region Scheme. The data excludes the area of LNAs in POS resulted from subdivision process.

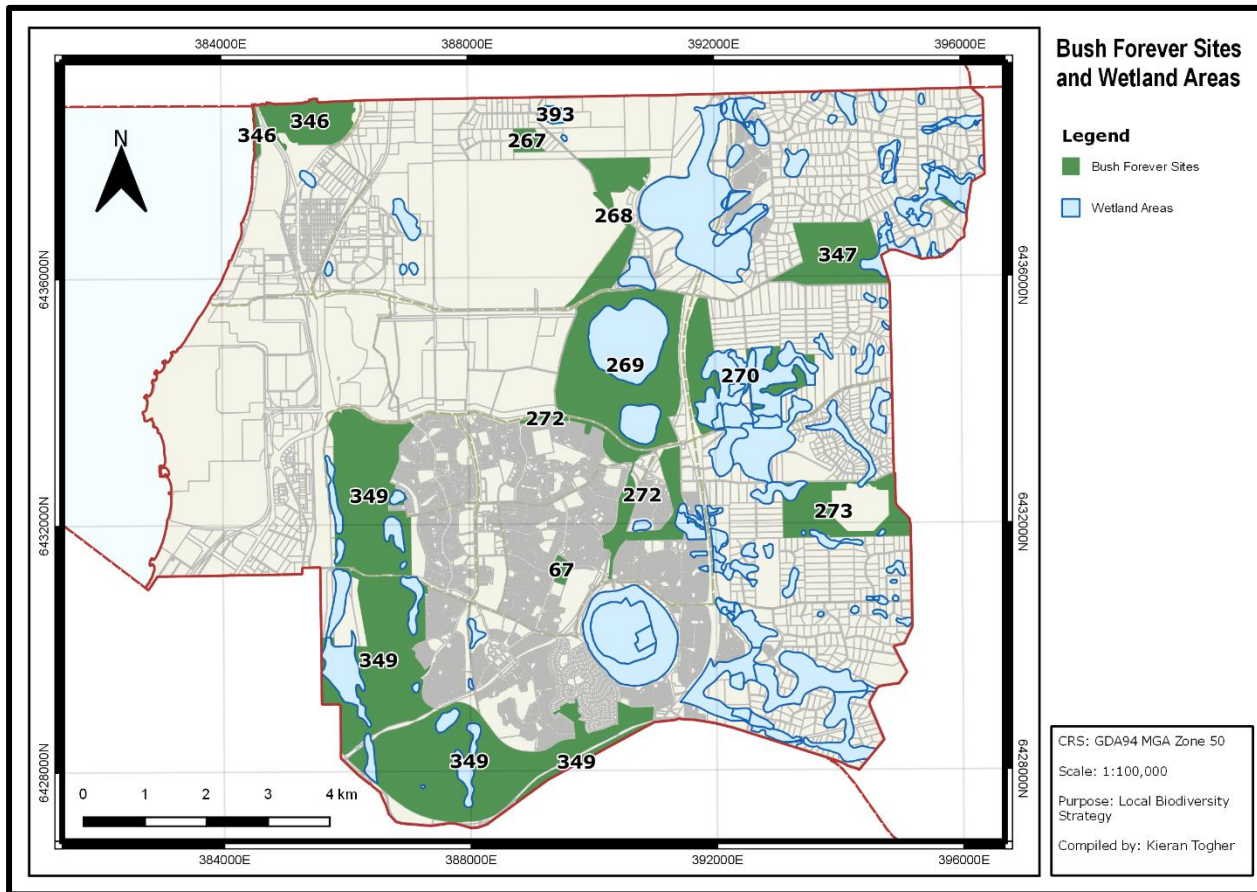
Table 3 Government Agencies and Biodiversity Conservation

Agencies	Main Categories of Natural Areas	Protection Status Categories	Area in the City (ha)
State Government	<ul style="list-style-type: none"> ▪ Bush Forever Sites ▪ DBCA managed Estates: <ul style="list-style-type: none"> ○ National Parks, ○ State Forest, ○ Nature Reserves, ○ Conservation Parks ▪ Parks and Recreation Reserves through the Metropolitan Region Scheme (MRS) 	<ul style="list-style-type: none"> ▪ Native Vegetation ▪ Exists in CALM Estate and Regional Parks ▪ Vegetated and non-vegetated Conservation Category Wetlands and Resource Enhancement Wetlands ▪ Environment Protection Policy Lakes ▪ Parks and Recreation Reserves 	2,342
City of Kwinana	Local Natural Areas, but exclude: <ul style="list-style-type: none"> ▪ DBCA managed estates; ▪ Regional Parks; and ▪ Bush Forever sites not managed by Local Government or in private ownership. 	<ul style="list-style-type: none"> ▪ Public Open Space (POS) 	2,148

Originally, the City had 11,980 ha of natural areas (i.e. pre-European). Table 4 shows that 4,490 ha remains, 2,342 ha is under State Government management and 2,148 ha are Local Natural Areas (LNA) which are the responsibility of the City (this excludes Bush Forever Sites in private ownership).

4.1.1 Bush Forever Sites

Section 6.2.9 provide details about Bush Forever sites. Map 1 and Table 4 depict the type and extent of Bush Forever sites remaining in the City.



Map 1 Bush Forever Sites

Table 4 A Snapshot of Bush Forever Sites (2013¹)

Bush Forever Sites	Location	Ownership	Management	BF Area (ha)	Vegetated Area (ha)	Water Area (ha)	Cleared (ha)
67	Parmelia Avenue Bushland	WAPC	Crown Reserve vested with the City	8.56	6.96	0.00	1.60
267	Mandogalup Road Bushland, Hope Valley	WAPC	WAPC	16.33	16.05	0.00	0.28
268	Mandogalup Road bushland, Mandogalup	Commercial, Private, State Government	Part no management authority, and part Crown reserve vested with the City	99.97	88.19	0.00	11.78
269	The Spectacles Bushland	Commercial, Private, State Government	Part WAPC, part Department of Water and Environmental Regulation (DWER), part no management agency	422.46	386.92	2.96	32.88
270	Sandy Lake and adjacent Bush land, Anketell	WAPC, Commercial	Part WAPC, part DWER, part no management agency	202.55	188.35	11.34	2.87
272	Sicklemore Road Bushland, Parmelia / Casuarina	Commercial, Private, State Government	Part unallocated crown land, part drain reserve, part Crown reserve vested with the City, part no management agency	107.60	87.01	0.00	20.60
273	Casuarina Prison Bush land	State Government	Crown reserve vested in Department of Corrective Services	113.43	112.35	0.00	1.08
346 (partial)	Brownman Swamp, Mt Brown Lake and adjacent Bushland, Henderson / Naval Base	State Government, Water Corporation, WAPC	Part DBAC conservation Park, part Crown Reserve vested in Local Government, part unallocated Crown land, part no management agency (Beeliar Regional Park)	558.3	-	-	-

¹ Source: 1. WA Parliament (2012) *Tabled Paper for Legislative Council Question on Notice 5878 – List of current Bush Forever sites and managers for each site, August 2012*, Perth, Western Australia.
2. Western Australian Local Government Association (2014) *Towards Establishing a Green Network*, Perth, Western Australia.

347 (partial)	Wandi Nature Reserve and adjacent Bush Land, Wandii / Oakford	WAPC, State Government	Part DBAC Nature Reserve, part WAPC (Jandakot Regional Park)	170.231 (412.3 total)	-	-	-
349	Leda and adjacent Bushland	Commonwealth, WAPC, State Government	Part DWER nature reserve, part Vacant Crown Land, part WAPC part Crown Reserve vested with the City, part no management agency	1,107.51	917.95	4.86	184.70
393	Wattleup Lake and adjacent Bushland, Wattleup / Mandogalup	Commercial, Private, State Government	No Management Agency	18.9	-	-	-

4.1.2 DBCA and DPLH Reserves

DBCA and DPLH manages conservation wetland reserves and Beeliar Regional Park (partial in the City).

4.1.3 City managed Local Natural Areas (LNA)

Many LNAs in the City have been cleared or modified for farming, industrial and residential development purposes. Currently, these LNAs are under threat from various sources, including urbanisation (for more details, refer to **Section 5.0** Threats to City's Biodiversity and Conservation Areas).

The LNAs are a significant part of the biodiversity assets of a local government and this study focusses on LNAs. They are broadly categorised into 'vegetation complexes' and contain Threatened Ecological Communities (TECs), Priority Ecological Communities (PECs), Declared Rare Flora, priority fauna and its habitat, and other vegetation having biodiversity values.

4.2 *Vegetation component*

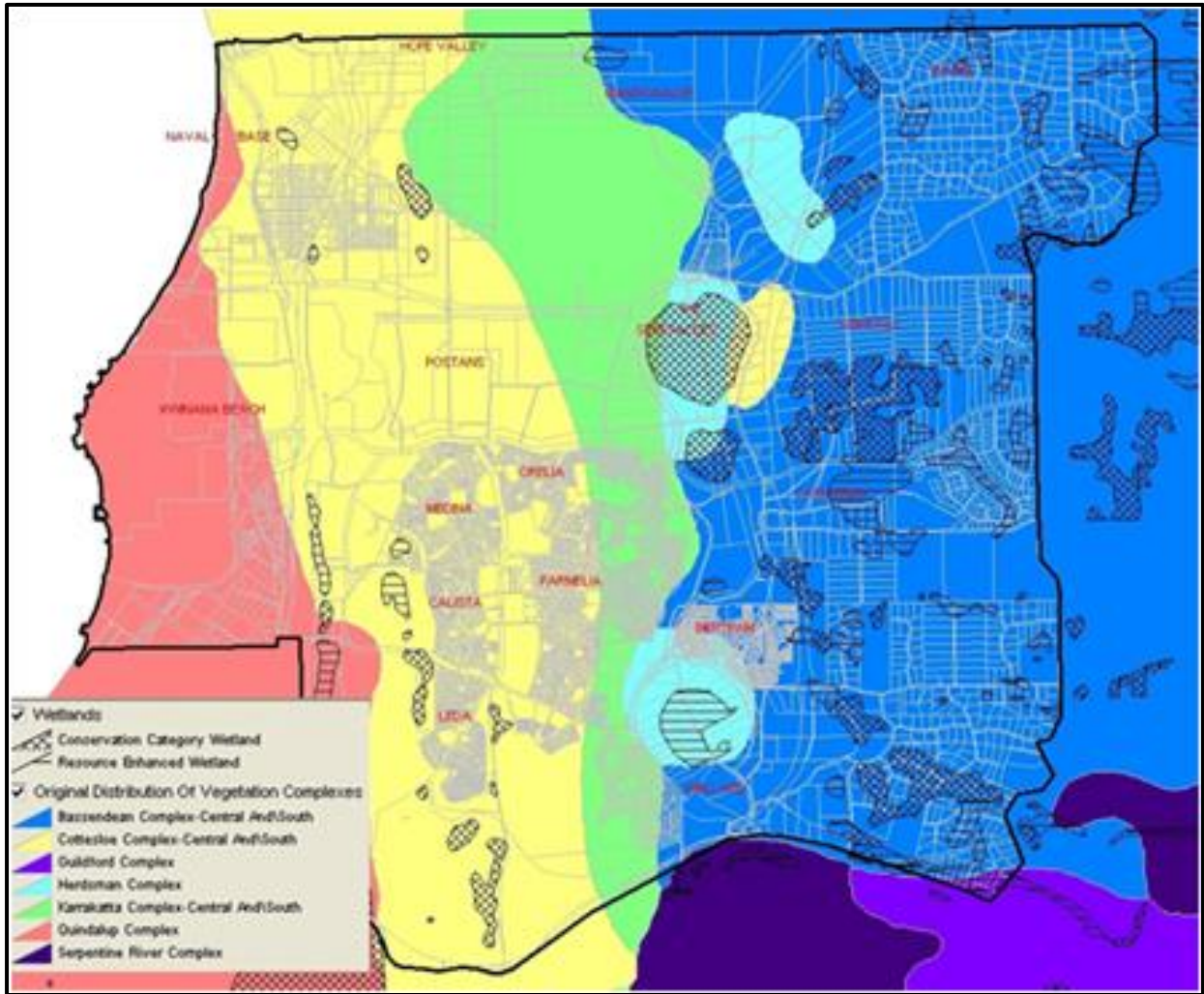
4.2.1 Vegetation Complexes

In the Perth Metropolitan Region, the most common way to interpret and quantify ecological communities based on area are the vegetation complexes defined by Heddle, Longeran and Havel (1980) and Matiske and Havel (1998). These complexes have been mapped across the region in a way that allows them to be used for quantitative targets, based on original and current area (WALGA & PBP 2004).

These vegetation complexes are based on the patterning of vegetation at a regional scale and reflect the underlying key determining factors of landform, soil and climate. These complexes contain communities of both plant and animals that change with variations in soils, slope, and vegetation condition.

There are seven vegetation complexes found within the City (Table 5). These include Quindalup, Cottesloe (Central and South), Karrakatta (Central and South), Herdsman, Serpentine River, Bassendean (Central and South), and Guilford. Five of these vegetation complexes, Bassendean (Central and South), Herdsman, Guilford, Karrakatta (Central and South) and Cottesloe (Central and South) are considered regionally significant, as less than 10% of the original extent of the complexes are found within formally protected reserves.

Map 2 depicts the original extent (pre-European) of the vegetation complexes that existed in the City.



Map 2 Original extent of vegetation complexes in the City (adapted from the Local Biodiversity Strategy Draft for Public Discussion 2007)

Where do Vegetation Complexes Occur in the City?

1. Most occurrences of the remaining Bassendean Central and South Vegetation Complex are located within the Rural A, Rural B, Special Rural, and Development zoned areas of the Wandí, Anketell, Casuarina and Wellard suburbs.

The Bassendean Central and South Complex is made up a number of different vegetation communities including Banksia-dominated woodlands (e.g. *Banksia menziesii*), wetlands with flooded gums (*Eucalyptus rudis*) and paperbarks (*Melaleuca preissiana*), or heathlands of *Pericalymma ellipticum* and *Hypocalymma angustifolium*.

2. The Herdsman Vegetation Complex is typically seasonal wetland type vegetation ranging from woodlands of flooded gums (*Eucalyptus rudis*) through to dense heaths and sedgeland.

3. Vegetation types of the Karrakatta Central and South Vegetation Complex include woodlands dominated by Tuart, Jarrah, Banksia or she oak (*Allocasuarina fraseriana*) and seasonal wetlands with *Melaleuca raphiophylla*.
4. Cottesloe Central and South Vegetation Complexes include highly saline seasonal wetlands, woodlands of Tuart, Jarrah and Marri and low Banksia dominated woodlands. The vegetation types in this complex are influenced by Tamala Limestone.

More than 40% of the LNA of this vegetation complex is zoned Residential, General Industry, or Town Centre and provide few opportunities for natural area protection.

5. The Quindalup Vegetation Complex is typically coastal vegetation and includes vegetation types on dune ridges and the seasonal wetlands that sometimes form in between the dunes. A wide variety of vegetation types occur in this complex supporting a range of distinctive floristic communities.

Table 5 Status of Vegetation Complexes

Vegetation Complex	Pre-European extent	2018 Local Natural Area	% of original
	Ha	Ha	%
Bassendean Complex -Central and South	4,679	1366.322	29.2
Cottesloe Complex-Central and South	3,790	227.7197	6.01
Guildford Complex	19	0	0
Herdsmen Complex	579	107.5711	18.58
Karrakatta Complex-Central and South	1,634	333.7041	20.42
Quindalup Complex	1,274	113.0365	8.87
Serpentine River Complex	4	0	0
Total	11,978	2148.3534	17.93

The above table shows that just under 18% of the pre-European vegetated area remain in LNAs, These areas do not have the same level of formal protection that exists in Bush Forever sites, and DBCA and DPLH managed reserves.

4.2.2 Wetland and Riparian Corridor Vegetation

Wetland vegetation is essential for the maintenance of clean water supply and provides habitat and refuge for many fauna. Riparian refers to the zone along or surrounding a water body where the vegetation and natural ecosystems benefit from and are influenced by the passage and storage of water. Riparian land provides a number of important environmental services and other values that are given below:

- a diversity of habitat for terrestrial, riparian and aquatic species
- food for aquatic and terrestrial fauna

- movement and recolonisation of plant and animal species and populations
- shading and temperature regulation
- conveyance of flood flows
- settlement of high debris loads
- maintaining water quality through trapping of sediment, nutrients and other contaminants
- an interface between development and waterways
- passive recreation
- visual amenity
- a sense of place with green belts naturally dividing localities and suburbs

Wetlands, such as the Spectacles and Bollard Bullrush Swamp have been important for food, recreation, and cultural reasons for tens of thousands of years, and continue to serve these purposes today. These and other wetlands provide a home for endangered birdlife and orchids, filter our water, and provide a water storage function which protects against floods (Department of Environment and Conservation, 2012).

4.2.3 Coastal Vegetation

Coastal vegetation includes all vegetation that grows on beaches and sand dunes or may have an affinity with coastal locations. This vegetation provides considerable protection to the adjacent coastline through reducing wind erosion of beaches.

Additional to the physical buffering of weather provided by coastal vegetation, one particular vegetation type with an affinity to coastal locations is present regionally being the Sedgeland in Holocene Dune Swales of the southern Swan Coastal Plain Floristic Community.

4.3 Other Biodiversity Feature components

4.3.1 Threatened Ecological Communities (TECs) and Priority Ecological Communities (PECs)

An ecological community is a naturally occurring group of plants, animals and other organisms that interact in a unique habitat. Its structure, composition and distribution are determined by environmental factors such as soil type, position in the landscape, altitude, climate, and water availability.

An ecological community becomes threatened when it is at risk of extinction. That is, the natural composition and function of the ecological community has been significantly depleted across its full range. This can occur for a number of reasons including clearing of native vegetation, altered fire regimes, non-native or invasive species, climate change, water diversion, pollution and urban development. Because of these threats, many ecological communities in Australia have undergone, and continue to be affected by a rapid and significant reduction in geographic distribution and/or ecological function.

In Australia, three categories exist for TECs under the EPBC Act: critically endangered, endangered, and vulnerable. Only two known State TECs are recorded to occur in the City, the Honey myrtle (*Melaleuca huegelii* - *M. systema*) on limestone community (This TEC occurs within the Cottesloe Central and South vegetation complex) and Communities of

Tumulus Springs (Organic Mound Springs, Swan Coastal Plain). It is highly likely that there are TECs present that have not been recorded.

In 2016 the Federal Government Listed Banksia Woodlands of the Swan Coastal Plains a TEC. This has significant implications for the City of Kwinana as much of the remnant vegetation would now qualify as a TEC and have another significant layer of protection. Planning mechanisms are yet to adequately address the implications this listing will have on the development process in the medium and long term frameworks.

PECs are ecological communities that are likely to be under threat and are either awaiting further information to establish their status of threat. Four PECs occur in the City:

- Coastal shrublands on shallow sands, southern Swan Coastal Plain.
- *Banksia ilicifolia* woodlands, southern Swan Coastal Plain.
- *Eucalyptus gomphocephala* - *Agonis flexuosa* woodlands, southern Swan Coastal Plain
- Low-lying *Banksia attenuata* woodlands or shrublands.

4.3.2 Declared Rare Flora (DRF) and Specially Protected Fauna (SPF)

At present, the City requires that flora and fauna surveys be carried out to determine the presence of any DRF or SPF. This normally occurs during the structure planning process or as a part of a local planning scheme amendment. Table 7 lists Declared Rare Flora and Specially Protected Fauna known to occur in the City.

Table 7 Declared Rare Flora and Specially Protected Fauna

Declared Rare Flora	Specially Protected Fauna
<i>Diuris micrantha</i> (Swamp Donkey Orchid) – Bertram	<i>Calyptorhynchus latirostris</i> (Carnaby’s Black Cockatoo) – Oakford and surrounds
<i>Caladenia huegelii</i> (King Spider Orchid) – Wandii, Bertram	
<i>Drakaea elastica</i> (Glossy-leaved Hammer Orchid) - Anketell	

It is not possible to estimate how many additional DRF or SPF will be identified in the City in the future as these species are generally only located with on-ground biological surveys.

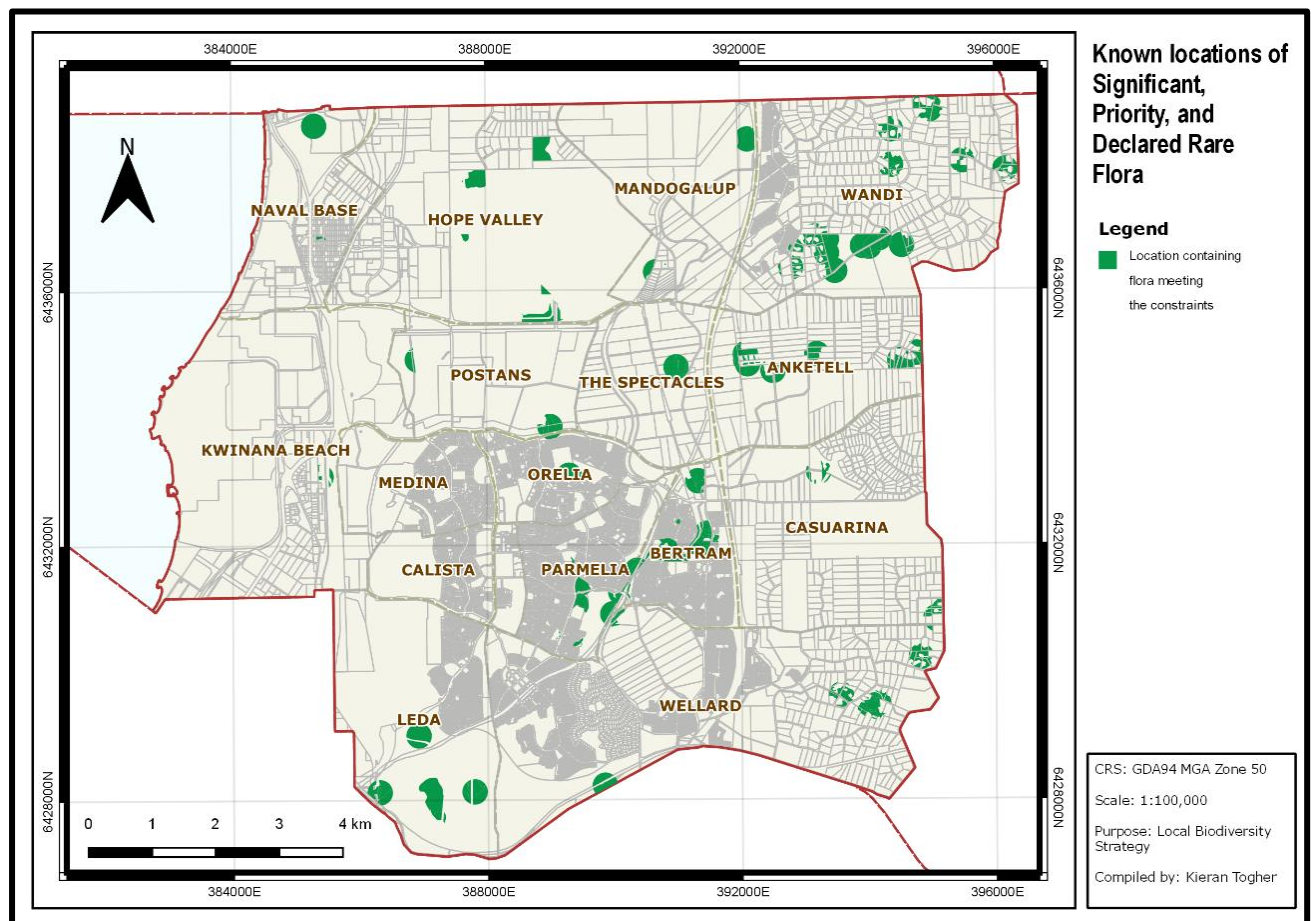
4.3.3 Priority Flora and Fauna

Priority Flora and Fauna are native species that are either under consideration as threatened species and need further survey to adequately determine their status, or are adequately known and require monitoring to ensure their security does not decline. Table 8 lists Priority Flora and Fauna species (refer to Map 3 and Map 4 respectively) known to be present in the City.

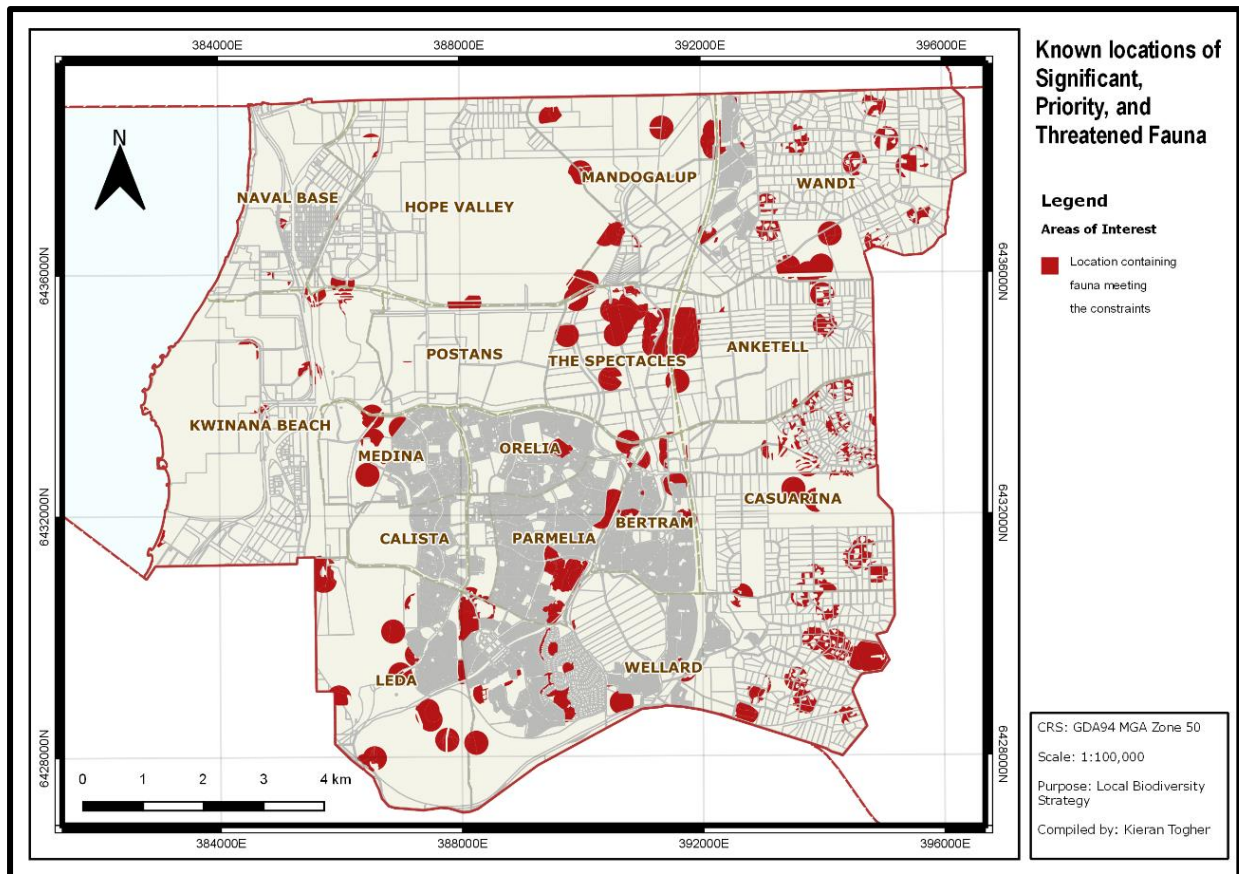
Table 8 Priority Flora and Fauna

Priority Flora	Location	Priority
<i>Aponogeton hexatepalus</i> (Stalked Water Ribbons)	Bertram	4
<i>Dodonaea hackettiana</i> (Hackett's Hobbush)	The Spectacles	4
Priority Fauna	Location	Priority
<i>Isodon obesulus fusciventer</i> (Quenda)	Hope Valley / Oakford / Bertram / Wellard East / Wellard / Leda	5
<i>Macropus irma</i> (Western Brush Wallaby)	Wellard / Leda / Casuarina	4

The conservation status of flora and fauna and the management of priority flora and fauna is managed by the State Government. It is not possible to estimate where occurrences of these species will be found until further ecological surveys are conducted.



Map 3 Known locations of Declared and Priority Flora



Map 4 Known locations of Declared and Priority Fauna

4.3.4 Ecological Linkages

Ecological Linkages link locally and regionally significant natural areas and provide stepping stones for flora and fauna. The consideration of linkage between protected natural areas is important to meet the needs of avifauna and maintain long-term movement of genes between the former ranges of species.

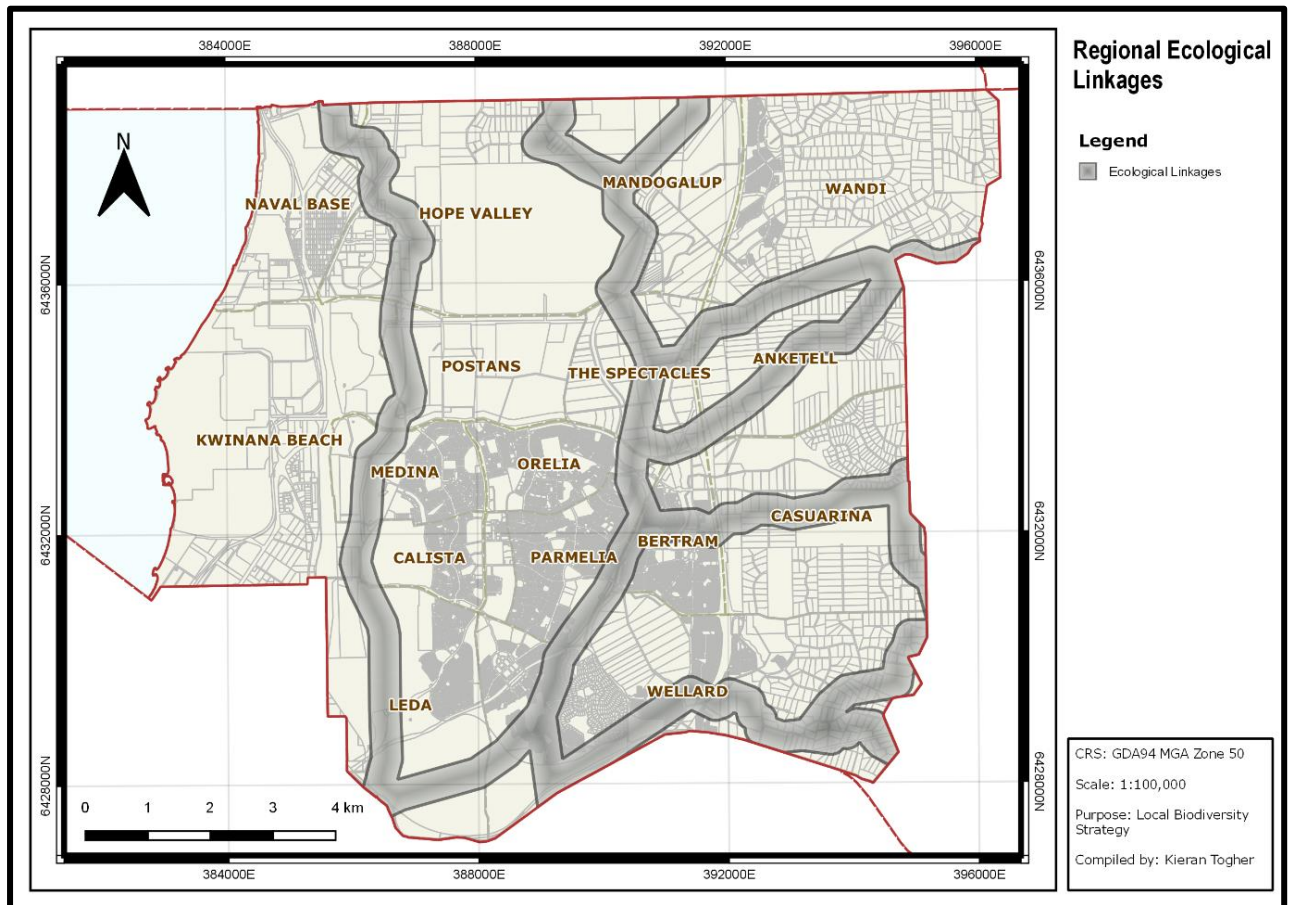
Avifauna, such as birds, bats, many insects, frogs and reptiles, need to move across the landscape to meet feeding and breeding needs and deal with threats such as fires and feral animals. Many of these species are important in moving pollen and seeds between natural areas that might otherwise be isolated within developments.

To be effective, Regional Ecological Linkages (REL) should incorporate the major variation in plant communities and fauna habitat typical of the region so that the widest range of flora and fauna possible can use the links. For example, only using waterways as RELs will limit the movement of flora and fauna to only those species that utilise riparian habitat (WALGA & PBP 2004).

Similarly, Local Ecological Linkages (LEL) play an important role in improving the viability of localised natural areas that are too small or too degraded to survive on their own. Local linkages consist of stepping stones formed by POS or other public lands such as schools within the shortest distance between Bush Forever areas and existing local conservation

reserves. It is necessary that these linkages should include as many ecological communities to maximise usage by diverse fauna and flora.

The 'Towards establishing a Green Network' Study (2014) identified RELs for the City (Map 5). The Study indicated that there is scope for developing and maintaining local linkages using existing 'stepping stones' having biodiversity values (Table 9)



Map 5 Regional Ecological Linkages

Table 9 New Local Ecological Linkages identified in the 'Towards establishing a Green Network' Study (2014)

Conservation Values	Recommended Actions
Local linkage between K7 through K37, K34 to C32	Due to the alignment of Kwinana Freeway, east-west movement of terrestrial fauna is limited in this part of the landscape, however, there are several patches retained with new subdivisions within 500m from each other and the linkages follows a drain reserved in the LPS as Parks, Recreation and Drainage. Manage the Parks and recreation reserve and all future POS areas to maximise fauna habitat provision.
Local linkage between K23 (BF 270) and K25 (BF 273)	Two opportunities can be explored, one utilising vegetation retained within the Special Rural properties (as mapped in the Environmental Planning Tool). Another opportunity exists within Rural Water Resource lands east of Bombay Boulevard and adjoining a golf course. Improvement of vegetation condition within the golf course and the Rural Water Resource properties will improve connectivity between the two regionally significant bushland areas.
East-west linkage between two major north-south regional linkages	There are no opportunities to establish a good linkage between the coastal foreshore reserves and bushland reserves in the eastern parts of the City. K38 and K12 (part of Latitude 32 Structure Plan) are closest to the coast but separated by from it by the industrial development. There are three parallel linkages: <ol style="list-style-type: none"> 1. one along Thomas Road consisting of BF272, local recreation reserves 2. vegetation along Anketell Road connecting wetlands to be retained as part of Latitude 32 structure plan to BF269 3. East-west linkage formed by vegetation within K9, K8 and K7.

The Local Government Biodiversity Planning Guidelines suggest a maximum distance of between 500 metres (m) and 1000m (but state a preference of 500m) to maintain a linkage function between natural areas (WALGA & PBP, 2004).

4.3.5 Wetlands

Wetlands are areas that are wet by surface water or groundwater, or both. They remain wet for long enough periods of time that the plants and animals in them are adapted to and depend on moist conditions for at least certain part of their lifecycle. Some wetlands are ephemeral, and their extent will vary depending on climatic conditions.

The City provides for 50m buffers around Conservation Category Wetlands (CCW). In addition, the City requires developers to produce and implement a management plan for any CCW retained as part of any subdivision. The Spectacles, Bollard Bullrush, Long Swamp and Sloans Reserve are examples of CCW Wetlands in the City. The City also requires developers to produce a Local Water Management Strategy for all subdivisions. As

Resource Enhancement Wetlands (REW) represent wetlands with lower environmental significance, the City only requires that efforts should be made to retain portions with high environmental values.

4.3.6 Ecological Corridors

Ecological connectivity is vital to the long-term viability of native flora and fauna, and is recognised as one of the most effective tools available for conserving biodiversity. Ecological corridors provide connections between habitat areas across a landscape allowing the movement of fauna and the transfer of plants through seeds and pollen. The important functions of ecological corridors include:

- Corridors may act as conduits: organisms may pass through the corridor from one habitat patch to another, ensuring its continued sustenance;
- Corridors allow re-colonisation of habitat areas by fauna and flora that have become locally extinct from events such as fire, disease or poor breeding success;
- Corridors permit seasonal movements of fauna between temporarily available resources; and
- Corridors permit gene flow between reserves.

Landscape elements that contribute to ecological corridors in urban environments include parks, golf courses, street trees and gardens that provide habitat.

5.0 Results of Investigation – Baseline Data

To inform this study, the various protection mechanisms that apply, such as Hydrological Wetlands of the Swan Coastal Plain, Bush Forever, and Threatened Ecological Communities (TECs) were determined and their spatial extent mapped using mapping supplied by the custodians of those data sets.

The City undertook an exercise to provide a highly accurate figure of the total vegetated area of Kwinana that involved hand-drawing polygons for each patch of vegetation using GIS and applying recent high quality aerial imagery.

Further to this, ground truthing of some areas was undertaken to determine if vegetation on the site was native vegetation or introduced species such as Brazilian Pepper (*Schinus terebinthifolia*).

This mapping exercise included all vegetation and was tenure-blind which produced a map and area of vegetation that represents the total vegetated area in the City, the vegetation area by vegetation Complex (Heddle), and the location and size of each individual polygon. Map 6 displays this data.



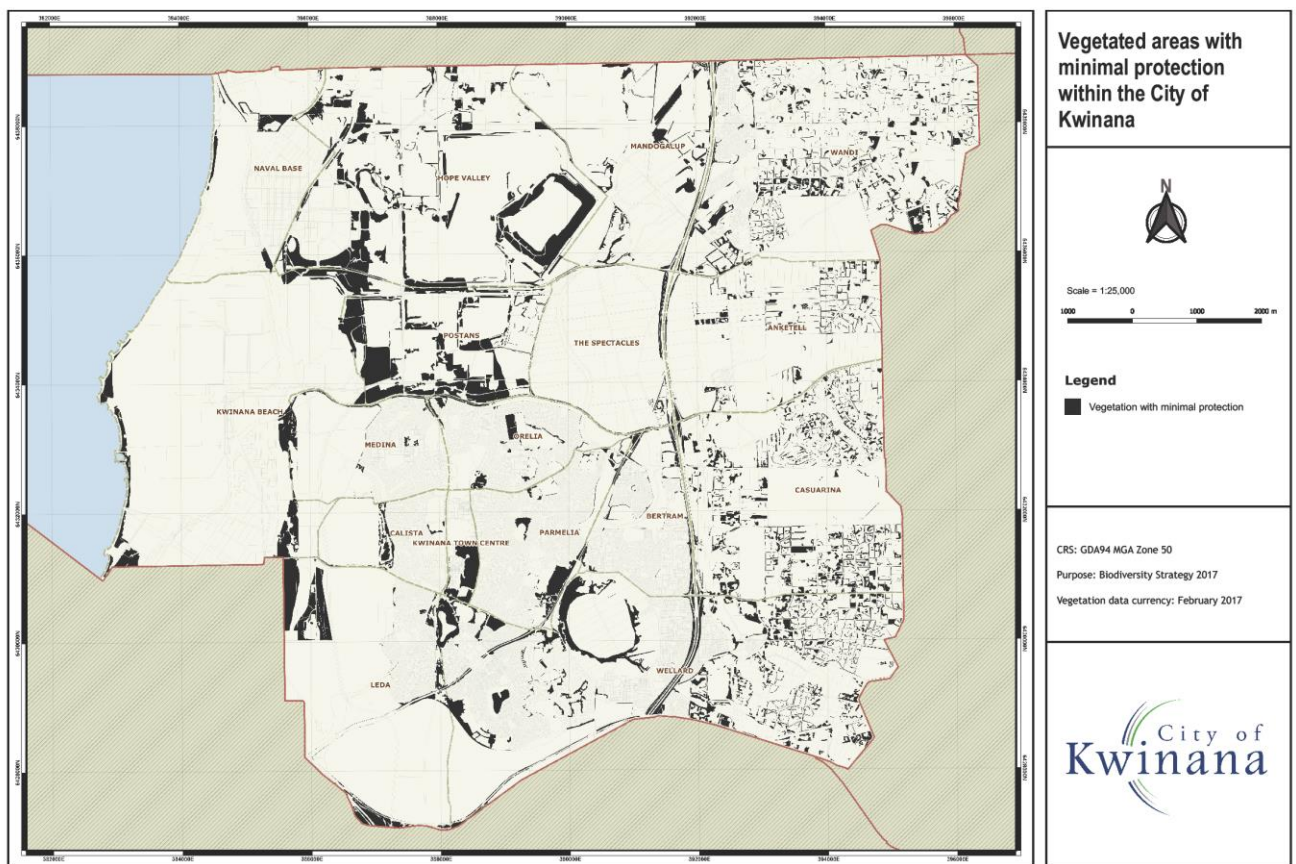
Map 6 Remnant Vegetation by complex within the City of Kwinana

Using this as a base line, several further refinement steps were undertaken using GIS to remove areas that are outside the considerations of this study, being:

- Resource and Conservation Category Wetlands and a corresponding 50m buffer

- Bush Forever Sites;
- Class A Reserves, Nature Reserves and conservation reserves;
- Known locations of DRF and their respective buffers;
- Approved Local Structure Plans;
- DBCA listed TEC's;
- EPBC TECs; and
- Heddle complexes below 30% locally.

The resulting area are those referred to as Local Natural Areas (LNA). The total area of LNAs within the City is 17.93%. These areas are shown in Map 7. This is not to be confused with the total vegetated area (39.95%) or the area that is already protected through the state mechanisms (19.5%).



Map 7 Local Natural Areas within the City of Kwinana

One constraint that has not been applied to the determination of LNAs is the federally listed Banksia Woodlands of the Swan Coastal Plain TEC. When this layer of protection/protection mechanism is applied across the City, the areas of LNA covered by legislative protection increases significantly. Almost all of the remnant vegetation in the City's east is identified as a potential listed federal TECs. Map 8 provides an indication of the data that is available.

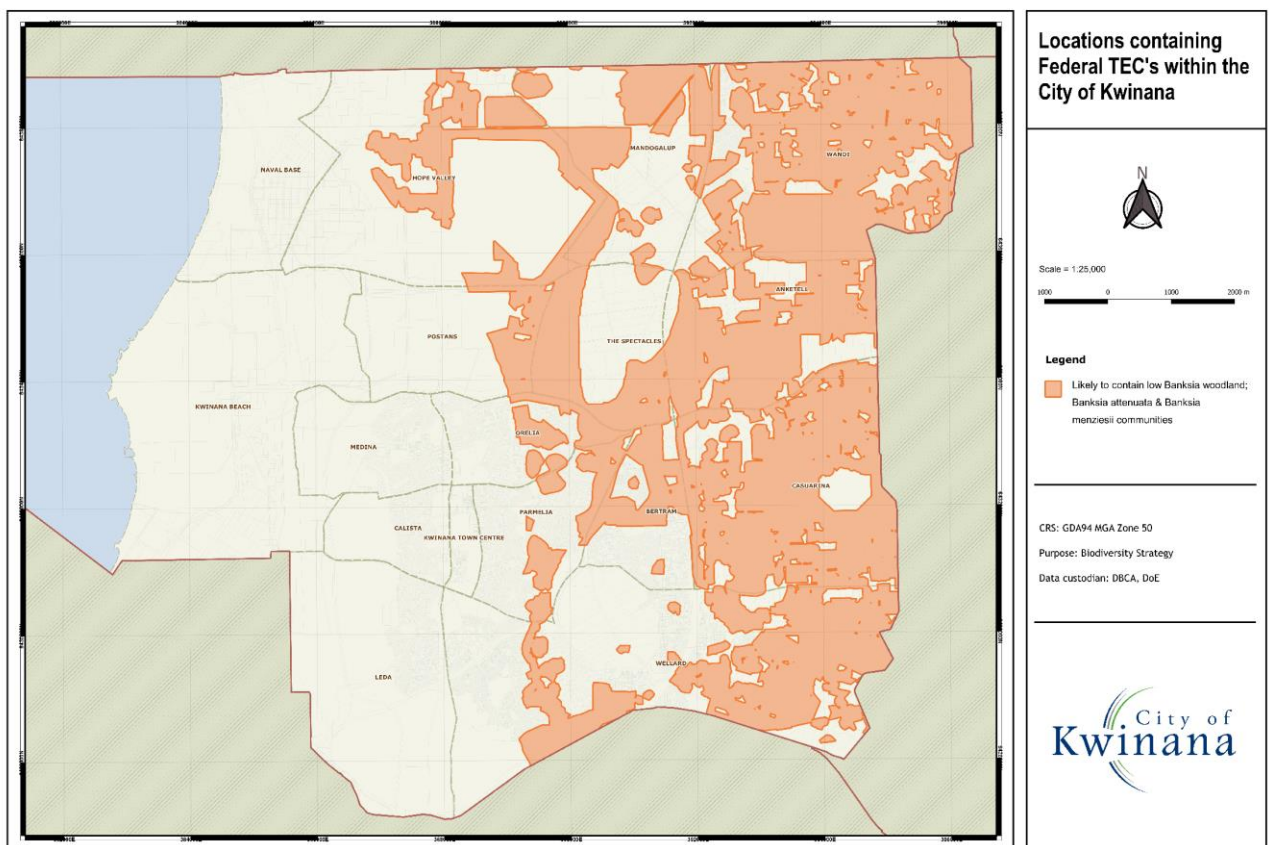
The Federal Governments listing of Banksia Woodlands of the Swan Coastal plain as TEC is relevant for the City as much of the vegetation remaining in the City is likely to comprise

vegetation that is now Banksia Woodland TEC. The condition of the vegetation, given that much of the locations where this vegetation occurs is Rural or Special Rural, is generally intact meaning that clearing may require consideration of the EPBC Act requirements.

It should be noted that this listing blankets all remnant Banksia Woodland vegetation although there may be examples where, according to the Conservation Advice, the protection measure may not be appropriate such as:

- areas that have experienced degradation reducing the condition to a point that the EPBC act is not triggered;
- areas where the size of the patches may be too small;
- areas where EPBC applications have been made before the listing of the Banksia Woodland TEC, but TEC exist; and
- Areas where TEC may exist outside of the recognized formal extent of the TEC.

The Federal Department of Energy and Environment includes an assessment matrix for Banksia Woodlands TEC based on size and condition. From this matrix, and other factors relating to the general trend relating to decreasing patch size of remnant vegetation and the correlating decrease in diversity, the City refined some of the mapping based on assumptions relating to the size of patches.



Map 8 Likely locations of the federally listed Threatened Ecological Community (Banksia Woodlands of the Swan Coastal Plain).

Smaller patches are likely to be altered or impacted and are more susceptible to further alterations and impacts, even if the surrounding area does not have any change in land use or management practices. If these patches are managed with the intention to prevent further degradation, and management actions are implemented consistently, then there is a likelihood that the diversity and function of these smaller patches would improve. This may often be time consuming and more costly than concentrating equivalent efforts on larger areas. Nonetheless, property owners with patches of native vegetation need to be encouraged to manage these areas for conservation and biodiversity value.

Review of the LNAs above and the current levels of protection indicates that there are very few areas of vegetation in the City that do not have some level of protection or significant conservation value. There are also areas which have more values than others, more areas of fragmented vegetation and areas with higher percentages of cleared land.

The above discussion and the series of maps have sought to be presented spatially:

- The extent of native vegetation in Kwinana currently;
- The areas which this study considers to be LNAs (i.e. are not Bush Forever, nature reserve, national park etc.);

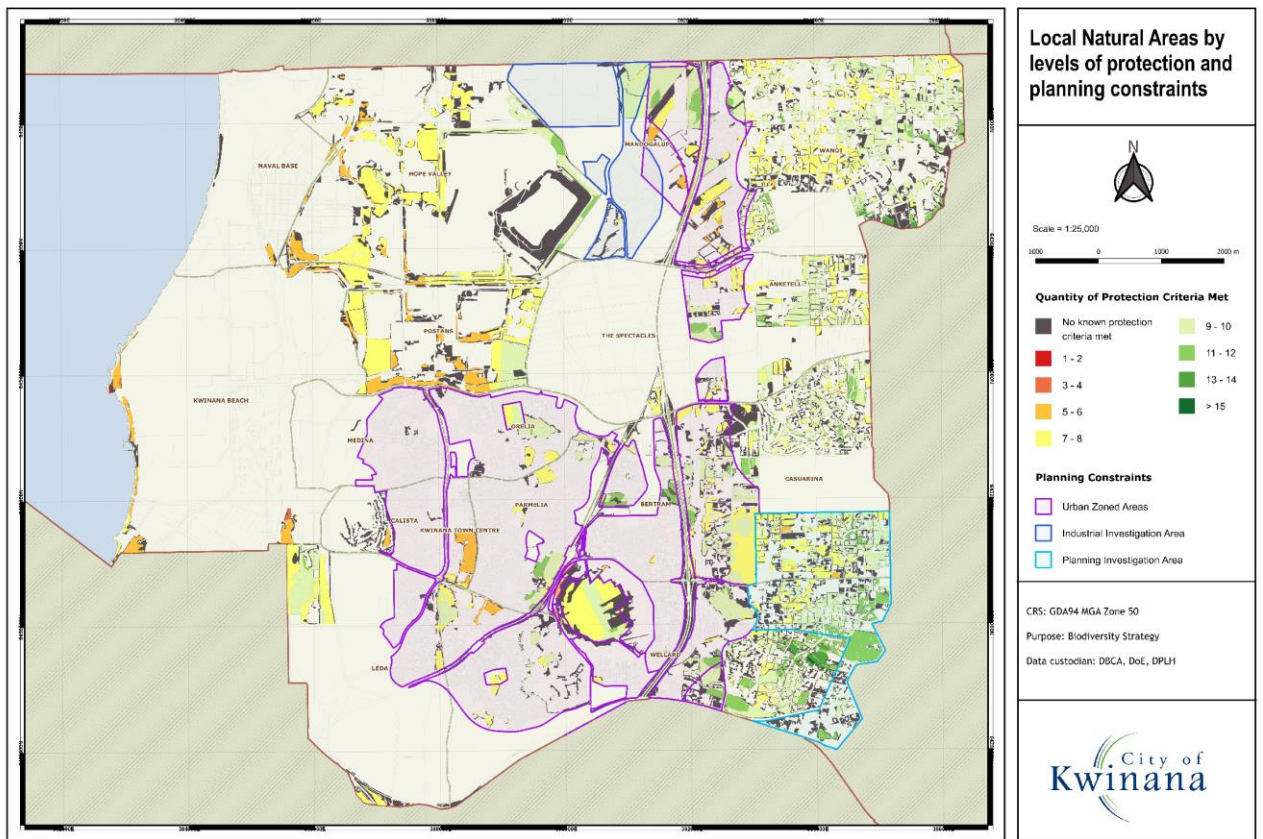
The discussion and maps have removed from consideration the following:

- The LNAs layer has had the mapped Conservation Category and Resource Enhancement Wetlands (and their buffers) removed as these are protected;
- Declared Rare Flora (and their buffers);
- State TECs (PECs have not been removed, but have been highlighted); and
- Federally Listed TECs (for Kwinana, the Banksia Woodlands TEC has the most relevancy).

Map 9 shows the above criteria mapped spatially and indicates the level of protection of the City's NLA's. Various protection measures have spatial extents that overlap indicating that several values cover the same area. These have been mapped and have a colour scale, indicating increasing protection measures, which ranges from the green spectrum (the highest level of protection) to the red spectrum (with the lowest level of protection).

The spatial extent of each layer of protection have been projected upon each other in Map 9. This map demonstrates that there are few areas of remnant vegetation in Kwinana that do not have some level of protection. These layers of protection need to be considered in the context of the Local Planning Strategy.

The results show that wetland protection mechanisms have produced a high representation of wetlands within the native vegetation that remains in the City. Conversely, the historically fewer protection measures for upland vegetation such as banksia woodlands on the Bassendean and Spearwood Dunes have reduced the representation of these areas in the stock of remaining native vegetation. This disparity in protection level was recently adjusted through the recognition of much of the City's upland vegetation as a federally-listed TEC.



Map 9 Number of protection mechanisms covering Local Natural Areas.

The study results indicate that there is increasing challenges when considering the opportunities for development in areas where there is native vegetation due to the increasing conservation value of this remnant vegetation (resulting from increasing scarcity due to ongoing clearing for urbanisation). The impact of human intervention and development is such that native vegetation will become increasingly scarce, to a point where ecosystem and biodiversity functions fail, unless protection measures are implemented that regulate urban development through planning and regulatory frameworks.

The cumulative impacts of human activity and development to date in Kwinana need to be recognised, with effective policies needed to protect LNA'S where possible.

It is evident that the most significant areas of LNA's are within the City's eastern areas which are primarily occupied by Rural and Special Rural lands uses. Section 6 'Threats to City's Biodiversity and Conservation Areas' discuss how LNA's can be best protected whilst facilitating appropriate development and land use.

In summary of the information included within previous mapping, it is possible to list significant biodiversity values in certain locations of the City as detailed below:

Wandi-

- Localised populations of *Caledonia huegelii* spread throughout the Wandii area. It is likely that further detailed surveying would identify more occurrences of the species in this locality;
- Banksia Woodland TEC;
- High occurrences of priority flora species;
- Carnaby Cockatoo/Black Cockatoo Habitat;
- Wetlands;
- Environmentally Sensitive Area; and
- Regional Ecological Linkage.

Anketell -

- Banksia Woodland TEC;
- Carnaby Cockatoo/Black Cockatoo Habitat;
- Wetlands; and
- High occurrences of priority flora species.

Casuarina -

- Banksia Woodland TEC;
- Carnaby Cockatoo/Black Cockatoo Habitat;
- Banksia Woodland TEC;
- Wetlands;
- Environmentally Sensitive Area; and
- Regional Ecological Linkages.

Wellard (East of Freeway) -

- Banksia Woodland TEC;
- Carnaby Cockatoo/Black Cockatoo Habitat
- Wetlands;
- Regional Ecological Linkages; and
- Communities of Tumulus (organic mound) Springs (and their buffer).

Mandogalup -

- Banksia Woodland TEC;
- Wetlands; and
- Carnaby Cockatoo/Black Cockatoo Habitat.

6.0 Threats to City's Biodiversity and Conservation Areas

It has been established that for the effective conservation of biodiversity, a standard level of native vegetation retention of at least 30 per cent of the pre-clearing (pre-European) extent of the ecological communities on the Swan Coastal Plain has to be promoted.

This approach was recognised in the National Objectives and Targets for Biodiversity Conservation 2001-2005 (Commonwealth of Australia 2001) which recognised that the retention of 30 per cent, or more, of the pre-clearing extent of each ecological community was necessary if Australia's biological diversity was to be protected.

The EPA in 2000 recognised a 30 per cent threshold level for native vegetation retention target, below which species loss appears to accelerate exponentially at an ecosystem level. Originally, the City had 11,980 ha of natural areas (i.e. pre-European). Table 4 showed that 4,490 ha remains (i.e. 2,342 ha under State Government and 2,148 ha LNA's which are the responsibility of the City). This equates to about 37% of pre European levels.

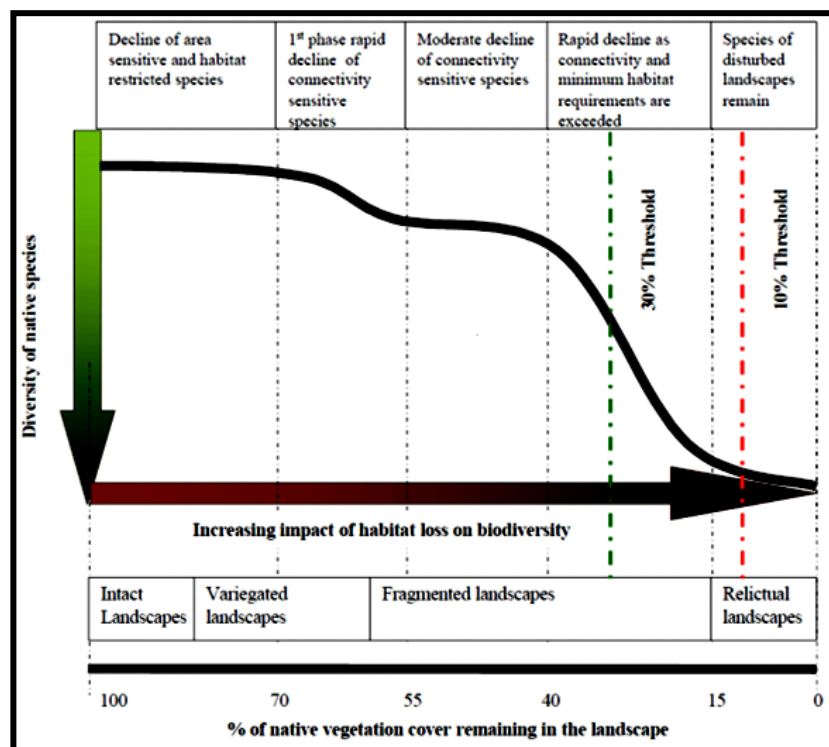


Figure 1 Diagrammatic Representation of Decline in Biodiversity in Relation to Decline in Native Vegetation Cover and Habitat (Del Marco et al. 2005).

The challenge for the City is how best to protect the remaining LNA's within the City within the planning context. Pressure must also be exerted upon State Government to ensure that the biodiversity areas under its control within the City are protected and maintained.

6.1 *Vegetation Clearing causing Habitat Loss, Degradation, and Fragmentation*

Clearing of vegetation is one of the greatest threats to biodiversity in the City. Mainly, vegetation clearing isolates, displaces and removes species. It also destroys habitat and food resources for a wide range of species not only those that would live permanently in the

vegetation but also those that rely on it for food and shelter seasonally or during crisis times. It interferes with the ability of populations to disperse and recolonise areas after disturbance or mortality.

The negative impact of surrounding land uses (edge effects) is magnified in comparison to corresponding areas of habitat that are not fragmented (WALGA & PBP 2004). Reduced habitat could lead to inbreeding causing the emergence of weak generation and a slow decline of the species. Population sizes may decrease below the threshold where they can be self-sustaining through reproduction.

In general, land clearing destroys or alters ecological process relating to or dependent on hydrology and soil composition. It can also cause salinity and increase flooding.

The City's Natural Area Management efforts are focussed on mitigating the effects of fragmentation and habitat loss. It also target all of the threatening processes that are expected to impact upon the bushland and wetland reserves managed by the City.

Since the publication of the WALGA Network Study, the WAPC has introduced State Planning Policy (SPP) 3.7, Planning for Bush Fire Guidelines, the implementation of which has seen a significant increase in the clearing required for new residential properties in Special Rural zoned areas. To comply with the SPP, a Bushfire Attack Level (BAL) is required to be achieved that can result in Area Protection Zones (APZs) of 27 metres plus (~BAL 29).

This, coupled with the sizes of buildings being constructed, results in significant clearing outside of building envelopes. Driveways are permitted in these areas and the *Bush Fires Act 1954* still requires the removal of vegetation for a firebreak.

6.2 *Erosion*

Erosion contributes to sedimentation and eutrophication of wetlands as well as leading to a physical decline in (upland) natural areas due to changed soil processes. Erosion also contributes to dune blowouts with the loss of stabilising vegetation in coastal ecosystems (WALGA & PBP 2004).

6.3 *Inappropriate Fire Regimes*

An almost clockwork style of easterly winds in the morning and sea breezes in the afternoon, meant that the season known to local traditional people as 'Birak' (roughly corresponding with December-January) was the traditional burning time of year. Traditional land managers would burn the country in mosaic patterns for several reasons including fuel reduction, increasing the grazing pastures for some animals, to promote flowering and fruiting of food plants, to aid in seed germination for some plants, and for ease of mobility across the country.

Inappropriate fire regimes can affect the structure, density and floristic composition of natural areas. A fire regime can be considered 'inappropriate' based on one or more aspects that define that particular regime, including the fire's interval, seasonality, extent, and intensity. Fire regime change (particularly toward increased fire frequency; prescribed burning during

late autumn to late spring when plants are in active growth, flowering and seed development and animals are active) can compromise the life cycles and habitats of many species.

For example, more frequent burning and fire management practices that result in burning during the growing season (late autumn to late spring) and during the seeding season (from November to December) result in the following changes to Banksia Woodlands (Fisher et al., 2009 a, b; Stevens et al., 2016):

- reduction in canopy cover;
- loss of many wildflowers;
- increased weed abundance and diversity;
- reduced habitat for wildlife; and,
- increase in overall fire danger, for example, the weed *Ehrharta calycina* is highly flammable and infestations promote further fires.

Floristic communities and even individual flora species respond very differently to fire and it is important that enough information is gathered on the vegetation present to determine what fire regimes are appropriate. Fauna is also impacted through direct mortality or through a lack of refuge areas during and in the recovery period after fire.

6.4 *Changed Water Regimes and/or Water Quality*

Activities such as agriculture, forestry, mining, and urbanisation have the potential to alter the water regime, including alteration to natural flow regimes, alteration of groundwater hydrology, sedimentation, pollution via run-off, and activation of acid sulphate soils. Such changed water regimes and hydrological imbalances can cause significant effect on vegetation as the types of plants and plant communities in a given area are strongly influenced by water availability.

Discharging stormwater into a vegetated damp land can have significant impacts on plant communities, habitat and thus fauna. Wetlands are especially vulnerable to changes in water regime. Upland vegetation can also be affected by human-induced changes in water regime, such as the death of banksias caused by the abstraction of groundwater, below-average rainfall and long hot summers.

Similarly, excessive nutrients, sediments and pollutants can have a significant effect on native vegetation, wetlands and waterways. Excessive nutrients and pollutants contribute to algal blooms, death of aquatic life in wetlands, and promote the spread of weeds in both upland and wetland areas.

6.5 *Inappropriate Human Use*

Humans can become a direct threat to species, populations and ecological communities. Similarly, their actions such as mountain bikes tracks and off-road vehicles could become secondary threats as a result of negative impacts of certain land uses or management activities. These tracks are a typically informal and unmanaged and a source of weeds and erosion.

Human use of natural areas including inappropriate access, recreational activities and firewood collection can have a detrimental effect on a natural area. Inappropriate or

uncontrolled recreational activities can directly disturb the vegetation that may result in erosion, and allows the introduction of weeds and disease (WALGA & PBP 2004).

The City limits the threats to bushland remnants through inappropriate human use by managing access to Natural Areas with border fences. The City Environment Field Crew completes weekly inspections and ongoing repairs to fences surrounding bushland reserves.

6.6 Diseases/weeds/pest animals

Diseases such as *Phytophthora* dieback and canker can alter the structure and floristic of natural areas through causing the death of native vegetation.

Weeds compete with local native plant species for space and light, and could negatively affect biodiversity by degrading or destroying habitat or by providing inappropriate foods for fauna depriving them of suitable habitat.

Pest and feral animals can alter the structure of vegetation through grazing and soil disturbance. In addition, pest animals can cause habit degradation by trampling and species loss by predation, and alter ecosystem processes. They sometimes act as carrier of weed seeds and its spread.

The City plays an important role in the management of pest species through involvement with control programs and by restricting some potential pest species in some areas. The City monitors camera traps, conduct surveys for feral animals, and completes ongoing annual weed control work timed to take advantage of the season susceptibility of the target weed. In addition, the City engages contractors for:

- the production of *Phytophthora* dieback distribution maps and *Phytophthora* Dieback treatment;
- Feral animal control; and
- Peak-season priority weed control.

6.7 Urbanisation

Rezoning of land to such zones and Urban and Industrial under the Metropolitan Region Scheme (MRS) and to corresponding zones under the Local Planning Schemes include a detailed approval process which includes environmental assessment by organisations such as the Environmental Protection Authority and the Department of Water and Environmental Regulation. At the MRS level in particular, regional biodiversity considerations are an important consideration and these are balanced against other planning and sustainability land use and infrastructure concerns which can be found within the large City such as Perth.

LNA's are not necessarily considered at the wider metropolitan level however and much of its protection needs to take place by the City within the planning framework established above.

In this context, extensive clearing of native vegetation in the City as a result of subdivision and development approval has been one of the biggest threats to LNA. Apart from direct impacts on biodiversity resulting from loss of habitat, many human activities in urban and peri-urban areas can adversely affect biodiversity, which include:

- effects of roads and traffic on fauna (i.e. road kills or injuries);
- effects of domestic animals on native animals; and
- Illegal dumping of rubbish and green waste in bushland creating habitat for pest animals and facilitating the spread of weeds.

At present, there are areas within the City zoned for urban use, which have not been fully developed. In some areas, it will be necessary to develop structure plans for future urban and industrial development. Currently there are no set criteria for choosing conservation areas during the structure planning phase. It is important that high quality bushland remnants are not lost by addressing biodiversity conservation early in the structure planning.

The development of appropriate planning mechanism will provide a strong position for the City when assessing new developments and constructing structure planned areas.

6.8 Government policy and economic disincentives

Land tax regimes can have a significant impact on conservation and may be an impediment. Most State and Local Government taxes do not differentiate between natural areas and cleared areas. The valuation of a land is more tilted towards its economic development potential than its ecological value. To substantiate, land zoned 'Conservation' under a local planning scheme still remains ineligible for exemption from land tax (a State Government tax), whereas primary producers are exempted.

6.9 Lack of knowledge, understanding and awareness

A direct result of the above is the dumping of rubbish, soils and garden wastes in areas of remnant vegetation that has the potential to increase noxious weed species and smother seeding growth of native species. In addition, illegal dumping of garden waste is a significant problem in many reserves within the urban areas.

There is substantial work to be done to increase community awareness of the values of biodiversity and natural areas in the Perth Metropolitan Area. On-ground, the City's knowledge of the biodiversity of individual LNA varies considerably. Field assessment of these areas is needed so that informed decisions can be made about their future use and management.

6.10 Climate Change

Climate change is recognised as a major threat to biodiversity and ecosystem functions. It impacts upon all levels of biodiversity, ranging from biological, ecosystem and ecological impacts through to population level impacts.

Climate change also has the potential to impact on the urban environment, particularly through the heat-island effect. In such instances, temperature increases in urban areas due to the extent of non-permeable surfaces such as roads, buildings and similar hardscapes. Removal of vegetation can have an added adverse effect on urban environment affecting the local community, wildlife and gardens.

The impact of climate change on biodiversity can be direct or indirectly through interactions with other species that are affected by climate change. This leads to changes in competition for food, habitat, and predation patterns and processes.

For some species, the indirect impacts may be stronger than direct impacts. This could also lead to interacting with other human pressures on biodiversity such as habitat degradation and loss, water extraction, pollution, and introduction and spread of pest species. Not only do climate change impacts add to these other pressures, they also interact, altering the way species and ecosystems would otherwise respond and adapt.

6.11 Threats specific to Kwinana

Key threats to the conservation of biodiversity in the natural areas managed by the City comes in many forms and periods of scale and time. Some of the key threats are listed in Table 10.

Table 10 Key threats specific to Kwinana

Natural Processes	Anthropogenic Processes
ACUTE	ACUTE
Fire	Destruction for 'development'
Flood	Mining
Storm	Arson
Pests	Illegal vehicle access (Trampling and soil disturbance)
	Illegal dumping / Littering
	Tree felling / firewood gathering
	Inappropriate management
CHRONIC	CHRONIC
Climate change	Weed invasion
Drought	Climate Change
Sea level rise	Groundwater depletion
Groundwater depletion	Introduction of pathogens
Disease	Eutrophication
Genetic and population effects of habitat fragmentation	Ineffective planning for biodiversity and conservation on a local and regional scale

7.0 Generally Adopted Biodiversity Conservation Methods at the Local Government level

Local Governments in Australia are conscious of the ongoing loss of all forms of biodiversity. They are also playing a leading role in the conservation of biodiversity by adopting various mechanisms. A local government authority (LGA) has the capacity to influence biodiversity conservation in its areas in a number of ways.

LGA's can directly influence biodiversity conservation by:

- Managing the LGA's natural areas to protect and restore biodiversity, restore ecological corridors, and minimise the impacts of pest species;
- Encouraging urban biodiversity through the use of native species in streetscapes and public open spaces;
- Promoting waterway health in urban, rural and natural areas by protecting or restoring riparian vegetation, managing stormwater and grey water, reducing sediment and chemical loads in run-off, and protecting coastal vegetation; and
- Using local planning policies to minimise ecological impacts of urban development.

LGA's can indirectly influence biodiversity conservation by:

- Influencing land management practices on private land through incentives, education and other schemes;
- Advocating to State and Federal government for improved biodiversity outcomes;
- Encouraging and supporting community actions that protect and enhance biodiversity; and
- Raising community awareness and encouraging appreciation of the LGA and wider region's biodiversity values.

The City promotes biodiversity conservation through both regulatory and non-regulatory mechanisms, for example:

- Regulation over privately owned lands.
- Land management of Crown and Council owned lands.
- Impact management of its own activities when building infrastructure.
- Environmental protection and management (e.g. waste management).
- Monitoring and reviewing outcomes of reserve management plans.

7.1 *Regulatory*

7.1.1 Local Planning Scheme (LPS)

A LPS is a statutory/legal document that regulates planning and development within a local government area. Specific to conservation of biodiversity values, the tools available primarily are through using reserves, land use categories, and special control areas.

LPS's may include general development requirements relevant to biodiversity conservation, such as subdivision plans, guidelines for development of building envelopes, setbacks, management plans, vegetation clearing controls, stock and weed management, and requirements for rehabilitation or revegetation of degraded land.

City adopted methods:

LPS2 contains no provisions to address matters that are relevant to 'biodiversity' as such, however Section 6.16.2 support the "areas of landscape protection" for its continued sustenance from inappropriate land use and development. Section 6.16.2 is supported with landscape protection areas identified in the planning scheme maps (refer to Section 4.4 for further details).

7.1.2 Local Planning Polices (LPP)

LPP's are prepared and adopted by Council, following community consultation, and must be consistent with the intent of the Local Planning Scheme. LPP's are complementary to the provisions of a Local Planning Scheme and the latter prevails in the event of any conflict with an adopted policy.

Council is required to have due regard to the provision of LPP's and the objectives which the policy is designed, however LPP's are advisory only and are intended to be used to guide Council's discretion when making decisions on planning proposals.

A LPP can assist local government to establish appropriate responses to protect the natural area, for example, the following objectives can be achieved through the preparation of a LPP:

- Protect, maintain and enhance the viability of habitats, ecological communities, flora and fauna, and genetic diversity.
- Ensure land use and development in proximity to or contains a natural area is compatible with the long-term maintenance and conservation of that area, and will not have deleterious effect on biodiversity.
- Assist in achieving the conservation goals and targets as established in an LGA's Local Biodiversity Strategy.

City adopted methods:

Local Planning Policy No.1 – Landscape Features and Tree Retention:

This is a City-wide Policy which outlines the minimum requirements for investigation and management of significant trees and landscape features that must be addressed in an orderly and proper manner at each stage of the planning framework including district and local structure planning stages, and subdivision applications.

The Policy is designed to ensure that:

- a) an appropriate level of information concerning significant trees and landscape features is provided at each stage of the planning framework; and
- b) retention of significant trees and landscape features are optimised through the strategic and statutory planning framework to retain the character of the area.

7.1.3 Planning overlays

Overlays are generally used to delineate areas according to their significance for biodiversity protection (e.g. map of biodiversity hotspots, including ecological corridors). Developing a spatial layer within Council databases that recognises areas of environmental protection that contain high biodiversity, riparian or habitat values within the City can provide certainty to

developers, landholders and Council staff about when and what needs to be considered in a development application.

Overlays may overlap conventional boundaries of zones, which may include land in several different zones. The planning overlays are the appropriate mechanism for managing multiple natural values requiring different planning responses.

City adopted methods:

City's LPS2 and scheme maps do not contain 'overlay' provisions.

7.1.4 Conservation covenants

A covenant is a voluntary, legally binding protection agreement that is registered on the title of the land. Covenant is binding to the current and future landowners, for example obligating them look after their property's ecological values.

Conservation covenants usually place 'permanent' restrictions on what activities landholders can undertake on their land, for example, landholders are often prevented from clearing native vegetation.

City adopted methods:

City does not have any registered conservation covenants.

7.2 *Non-regulatory*

7.2.1 Conservation Incentives

The use of incentives can be an effective means of encouraging and motivating people to participate in biodiversity conservation management. Incentives can be financial or non-financial, including education, and are a popular tool of environmental programs. Incentives can assist landowners to offset the time and financial cost of managing areas of bushland and biodiversity.

There are many advantages of using incentives to encourage biodiversity management, for example:

- An incentive approach is non-regulatory, and less controversial than regulation.
- Encouraging voluntary participation can often attract those who would otherwise not be willing to participate.
- Incentives can provide positive and tangible on-ground biodiversity outcomes.

LGAs promote incentives, including educational incentives that will be industry relevant and easy-to-use. Its aim generally is:

- To increase the capacity and commitment of landholders and the community to conduct best practice land management practices.
- To work with landholders to create ecological corridors between existing remnant patches of vegetation, aiding the movement of fauna through the landscape.
- To reduce or end the effects of grazing by stock on remnant vegetation through exclusion fencing.

- To increase knowledge of ecosystem services provided by native vegetation and biodiversity, and increase changes in behaviour that lead to best-practice management of those ecosystem services.
- To promote private land covenants and land acquisition within identified linkages and other priority areas.
- To promote the incremental establishment of vegetation linkages across cleared landscapes using vegetation rehabilitation, shelterbelts and targeted revegetation programs.
- To promote best-practice weed removal and management techniques to minimise impacts on native habitats.
- To promote the importance of wetlands and riparian vegetation including its rehabilitation.

City adopted methods:

City does not provide conservation incentives to its residents to participate in biodiversity conservation management.

7.2.2 Education and Extension

Some LGAs actively do involve in providing ongoing educational programs that take account of outcomes and recommendations. These include:

- Organising field days at demonstration sites;
- Developing and distributing resource kits to communicate specific best-practice management methods; and
- Facilitation of a reference group of community and other interested stakeholder groups

In some cases, LGAs employ officers to deliver biodiversity extension services to the community and landholders. These include:

- Support the implementation of voluntary conservation, restoration, and management of species and habitat by individuals and community groups by assisting with the search for grant funding and providing technical support.
- Education programs and provision of on-ground advice.
- Advice on threatened species and conservation management, and provision of background information.
- Advice and information on effective management of ecosystem services.
- Advice on weed identification, weed management, bush regeneration, revegetation and animal pest control.
- Providing information and training.
- Advice on forms of assistance available to manage biodiversity values.
- Information of ecosystem services and biodiversity, including best-practice management of wetlands.

City adopted methods:

1. Natural Areas Management Plan 2014-2024:

The Natural Areas Management Plan 2014-2024 (Management Plan) through appropriate management practices preserves and improves both the community values and biodiversity values existing in the City managed reserves. The City actively manages 21 natural area

reserves comprising coastal, woodland and wetland communities totalling an area of 240 hectares, ranging from smaller reserves in urban areas to larger reserves in rural and semi-rural areas.

The Management Plan prioritises management issues and threats facing each reserve, and investigates and implements suitable methods to control these issues and threats. The management programs include:

- weed control program,
- access control,
- retention, regeneration and revegetation,
- fire management and fuel reduction program,
- pest and biosecurity program, and
- community education and volunteer program

Through the Management Plan, the City promotes Community Education and Volunteer programs. These include Bush Kids Club and Friends/Bushcare Groups. The City has also developed a 'volunteer toolkit' to help guide volunteer engagement processes.

The Management Plan considers cultural, social, heritage, environmental, scientific and practical issues and values to manage the reserves. Table 11 illustrates the City managed reserves and its characteristics.

Table 11 City Managed Reserves

Reserve Name	Area (Ha)	MRS	TPS	Vesting	Bush Forever Site
Clementi Road Reserve	33.6	Rural	Rural A	Parks and Recreation	Section of BF268
Challenger Beach	3.3	Parks and Recreation	MRS	Recreation and Dune Protection	Section of BF268
Postans	1.1	HVWP Redevelopment Area	MRS	Public Recreation	-
Hendy Road	4.9	HVWP Redevelopment Area	MRS	Public Recreation	-
Depot Swamp	6.3	Parks and Recreation	MRS	Council Depot	Section of BF349
Gentle Road /Golf Course	101.2	Parks and Recreation	MRS	Recreation	Section of BF349
Sloans Reserve	12	Parks and Recreation	MRS	Parks and Recreation	Section of BF349
Wildflower Reserve	15.5	Urban 'C' Class Reserve	Parks & Recreation	Parks and Recreation	BF272

Homestead Ridge (x 3)	7.9	Urban	Park, Recreation and Drainage	Parkland	
Millar Road	19.3	Rural		Public Recreation	Section of BF349
Banksia Road	26.7	Rural 'C' Class Reserve	Rural A Landscape Protection Zone NE corner	Public Recreation and Drainage Rifle Range	
Lake Magenup	27.1	Parks and Recreation and Water Catchment	MRS	Public Recreation	
Chalk Hill	0.7	Parks and Recreation	MRS	Chalk Hill Tourist Lookout	Section of BF349
Bertram Sanctuary	6.8	Conservation and Parks and Recreation	Residential	Conservation and Public Recreation	
Belgravia Dampland	8.4	Parks and Recreation	Residential	Public Recreation	
Henley Reserve	25	Parks and Recreation	Residential	Public Recreation	
Parmelia Reserves (x2)	8.2	Parks and Recreation	MRS	Public Recreation	BF67
Kwinana Beach (Wells Park)	0.9	Parks and Recreation	MRS	Crown Land	
Squires Ave	0.8	Parks and Recreation	Residential	Parks, Recreation and Drainage	-
Thomas Oval	21.7	Parks and Recreation	MRS	Parks and Recreation	Section of BF349

2. Environmental Plan 2011 – 2016

The Environmental Plan provides a five year environmental management programs addressing key issues such as Climate Change, Biodiversity, Built Environment, Water (Quality and Conservation), Land (Contamination), and Waste. The overall aim of this Plan is to promote effective environmental management practices to manage and protect Kwinana's natural areas for the benefit of current and future generations.

8.0 Conclusion

The City is situated in one of the world's biodiversity hot spots, the southwest of Western Australia. This region is considered as one of the world's top 25 biodiversity hotspots due to its high species richness and the level of threat under which it is being placed (Myers *et al.*, 2000). As discussed earlier, currently the biodiversity in the region is under threat from a variety of sources, but mostly human instigated.

In the above context, the City has a primary role to play in community leadership/education, supporting volunteers and conducting its own business in an environmentally responsible way under various statutory frameworks. Integration of local biodiversity conservation objectives into the City's planning and policy framework is the key to ensuring decision-making is transparent and consistent.

A hierarchy of actions, both statutory and non-statutory, taken at the City level and supported by State Planning Framework could help guide decision-makers making well-informed decisions with respect to the retention, protection, and management of the biodiversity and conservation areas.

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