

YANCHEP SUN CITY PTY LTD

VERTEBRATE FAUNA ASSESSMENT

**ST ANDREWS ESTATE (SOUTHERN
PRECINCT), YANCHEP**



VERSION 2

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1. INTRODUCTION

1.1 Purpose and Scope

ATA Environmental was commissioned by Yanchep Sun City Pty Ltd to undertake a Level 2 Vertebrate Fauna Assessment within the St Andrew's Structure Plan area (Southern Precinct) and to make management recommendations on fauna related issues that should be addressed during the development of this site. The Southern Precinct area is zoned for urban development and a central city area.

The fauna survey was undertaken in accordance with the Environmental Protection Authority (EPA) *Terrestrial Biological Surveys as an Element of Biodiversity Protection Position Statement No. 3* (EPA 2002) and ATA Environmental's interpretation of *Guidance for Assessment of Environmental Factors: Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia, No. 56* (EPA 2004). These statements require a Level 2 fauna assessment for developments with impacts that are assessed as either 'moderate' or 'high' in the bioregion of the proposed project area.

A Level 2 assessment involves undertaking either a detailed or comprehensive on-site fauna survey in addition to a desktop study. Environmental variables that contribute to 'moderate' or 'high' impacts are the size of the area (e.g. 1-10ha is moderate, and > 10ha is high), potential for rare or range restricted fauna in the area, whether the area contains habitat of ecological or conservation significance, whether the area serves as an ecological refuge for fauna species or the area supports populations of statutory protected species (e.g. those listed under JAMBA/CAMBA treaties). Based on these criteria in the EPA *Guidance Statement No. 56* a Level 2 assessment is required.

This report includes:

- a review of the Western Australian Museum (*FaunaBase*) on-line database to identify potential vertebrate fauna within the area;
- a search of the Department of Environment and Conservation (DEC) Threatened and Priority Species database to identify potential scheduled and threatened species within the region;
- a search of the Commonwealth's on-line database to identify fauna species of national environmental significance that are protected under the *Environment Protection and Biodiversity Conservation Act 1999* potentially occurring within the area;
- a review of the published and unpublished literature that ATA Environmental could access to provide a list of fauna that have potential to occur in the region;
- a description of the fieldwork methodology and results;
- discussion on the potential impacts of the development on the fauna and fauna habitat; and
- management recommendations to minimise potential impacts of the development on the fauna.

The fauna and faunal assemblages on the Swan Coastal Plain are quite well known, particularly for vertebrates, with general information on the distribution and habitats available for frogs, reptiles, mammals and birds. The region has also been well surveyed with comprehensive fauna survey information available for Whiteman Park (Arnold *et al.*, 1991),

Bold Park (How, 1998), and Perth Airport (Western Australian Museum surveys; Alan Tingay & Associates, 1993), as well as a number of small remnants of native vegetation in urban areas (How & Dell, 2000; How, 1998; How *et al.*, 1996; Cooper, 1995; Harvey *et al.*, 1997; Western Australian Museum, 1978).

The primary purpose of this investigation was therefore to confirm the faunal assemblages predicted for the Yanchep area based on the Swan Coastal Plain data.

1.2 Study Area

The study area comprises approximately 670ha of land adjacent to the Yanchep townsite and identified as the St Andrew's Structure Plan area, as shown in Figure 1.

The study area is situated approximately 50km north of the Perth Central Business District and mainly comprises cleared land and areas of remnant native vegetation. The study area is bounded by the proposed Mitchell Freeway easement and Yanchep National Park to the east, Lot 303 Two Rocks Road to the west, Bush Forever Site 289 to the south and Toreopango Avenue to the north.

1.3 Climate

The Yanchep-Two Rocks area experiences a warm mediterranean climate with hot dry summers and mild wet winters. Air temperatures are similar to those experienced in Perth, where mean daily maximum temperatures vary from 30°C in summer to 17.5°C in winter, and mean daily minimum temperatures vary from 18.5°C in summer to 9.1°C in winter (Bureau of Meteorology, 2005).

Rainfall in the area occurs mostly during the winter months, with monthly totals during this period occasionally in excess of 100mm. Monthly rainfall of up to 50mm may occur in the remaining months. Previous long-term records indicate that the average annual rainfall is around 670mm collected from a private residence in Yanchep. This is low when compared to an average annual rainfall of 843mm derived from data collected since 1985 at the Wanneroo Post Office. The reason for this disparity is potentially due to mild drought conditions prevailing at the time of data collection.

Winds are an important climatic factor in the Yanchep-Two Rocks area as much of the landscape in the study area has been constructed by aeolian (wind driven) deposition and is particularly susceptible to the erosive powers of the wind if the natural vegetation is removed. During the summer months winds blow from the east to south-east in the morning (4am to midday) and from the south-west in the afternoon (1pm to 6pm), due to the local sea breeze. Alternatively, winter is characterised by north-westerly storm winds that back to the west and south-west, interspersed with calmer periods. These storms are related to the passage of low-pressure systems which attack the south-west portion of the state due to the northerly location of the anticyclone system. Major storms during winter, involving 70km/h winds for periods of 6 hours to 24 hours, occur 2-10 times per year.

Occasionally, in the period summer to autumn, tropical cyclones migrate further southwards than normal and may bring gale force winds to the Yanchep-Two Rocks coastline. During these events winds up to 130km/h are often experienced.

1.4 Landform and Geology

The coastal land from Two Rocks to the Moore River features two major geological units which are expressed by a variety of conspicuous landforms. The Tamala Limestone is the older geological unit and extends from the vicinity of Wanneroo Road in the east, out to sea to the west where it outcrops as a series of reefs.

On land, the Tamala Limestone forms a series of rounded ridgelines and intervening depressions known as the Spearwood Dune System. These features are aligned roughly south-east to north-west and are most obvious a few kilometres inland from the coast. In one valley between these ridges, caves and depressions are common. Some of these depressions are filled with water (e.g. Loch McNess).

The Tamala Limestone is covered over much of the region by Safety Bay Sand. This is a younger geological unit than the Tamala Limestone and is still actively accumulating along the coastline. It forms a large variety of landforms known as the Quindalup Dune System. The most conspicuous of these landforms are tall dunes which are either covered with vegetation or consist of loose mobile sand. Wind action is slowly moving the areas of mobile sand inland.

Some of the oldest of the Quindalup Dunes extend a long way inland as long crescentic ridges. These were originally formed by wind action but they are now stable and are slowly converting to limestone. Another conspicuous landform in the Yanchep-Two Rocks area are isolated conical hills.

1.6 Vegetation

The western portion of the study area contains vegetation representative of the Old Quindalup Dune Heath Q2 dune vegetation type. It is a fairly narrow strip inland of, and often intermixed with, the younger Quindalup Dunes in the Yanchep-Two Rocks area. The typical vegetation type of the Q2 dunes, *Melaleuca systena*/*Acacia lasiocarpa*, was not recorded in the study area and occurs between Two Rocks and The Spot, north of Two Rocks and directly south of the Yanchep townsite.

The most extensive Quindalup Dune vegetation type in the Yanchep-Two Rocks area is the *Melaleuca systena* Heath on Q1 dunes. Although restricted in distribution in the study area, the Q1 vegetation type extends from close to the coast up to 6km inland to the north of the Two Rocks townsite. In the study area the Q1 vegetation type is restricted to narrow bands, intermixed with Spearwood vegetation types. It is anticipated, that a significant area of the Q1 vegetation, particularly north and south of Yanchep Beach Road, has largely been cleared for agriculture or remains in a degraded condition.

The shallow sand over limestone and outcropping limestone Alliance vegetation types are mainly distributed in the central and eastern portion of the study area. In the study area the *Dryandra sessilis* Heath occurs on flat areas of limestone and low hills while the tall jagged limestone hills support *Melaleuca huegelii* and Mallee eucalypt species.

The deeper sand over limestone Alliance vegetation types are located in the central and eastern regions of the study area and include the Banksia Woodlands and isolated stands of Tuart trees. Pockets of exposed and shallow limestone are scattered throughout the study area, however there is a distinct transition between the vegetation found on the limestone and the deeper sands.

2. METHODOLOGY

2.1 Database Searches

A desktop search of the Western Australian Museum database, *FaunaBase*, was used to develop a list of potential bird, reptile, mammal and amphibians in the general area. The search area was bounded by latitude 31.5° – 32°S, and longitude 115.5° - 116°E. Marine species (e.g. seals and whales) and predominantly marine and freshwater species (e.g. petrels, albatrosses, pelicans, cormorants, darters, sea turtles) presented in the search of *FaunaBase* along with obvious exotics, have not been considered as the proposed development does not include either a marine or freshwater habitat. This large search area was used, as there was limited data in *FaunaBase* for the specific study area and the habitats represented at the study area are similar to those in the quadrant described by the latitudes and longitudes selected. *FaunaBase* records numerous species as being caught in the Perth metropolitan area, when they are actually specimens that have been held in captivity in the Perth metropolitan area (e.g. Perth Zoo) or have been transported to the metropolitan area. In addition, there are records of species in *FaunaBase* that have disappeared from the Swan Coastal Plain. Most of these species have been deleted from the list of species likely to be found on the Yanchep site.

Other, more general texts were also used to provide supplementary information including Tyler *et al.* (2000) for frogs; Storr *et al.* (1983, 1990, 1999, 2002) for reptiles; Johnstone and Storr (1998; 2004) and Storr and Johnstone (2003) for birds; and Strahan (2000) for mammals. In addition, a number of published and unpublished reports for fauna surveys on the Swan Coastal Plain have been used to provide a regional context for the small vertebrate assemblages sampled in the study area.

Collectively these sources of information were used to create lists of species expected to utilise the study area. It should be noted that these lists include species that have been recorded in the general region, but are vagrants, and are generally not found in the area because of a lack of suitable habitat (e.g. water birds). Vagrants can be recorded almost anywhere. Many of the bird, mammal, reptile and amphibian species have specific habitat requirements that may be present in the general area but not in the specific study area. Also, the ecology of many of these species is often not well understood and it can sometimes be difficult to indicate those species whose specific habitat requirements are not present in the study area. As a consequence some species will be included in the list produced from these database searches but will not be present in the actual study area.

A search of the Department of Environment and Conservation's (DEC's) Threatened Fauna database was undertaken to identify potential scheduled and threatened species in the region. A search of the Commonwealth *Environment Protection and Biodiversity Conservation (EPBC) Act 1999* online database was also undertaken for the area 31.5° 00' to 32° S, and longitude 115.5° to 116° E to identify species of conservation interest to the Commonwealth Government.

2.2 Regional Data

The study area occurs on Quindalup and Spearwood dunes. Alan Tingay & Associates (1996) described three major faunal habitats in the area: old Quindalup heath, limestone heath and Banksia woodland, with smaller areas of Tuart woodland on the Spearwood dunes. In recent years considerable fauna survey effort has been undertaken on the northern Swan Coastal Plain in vegetation supported by Quindalup and Spearwood dunes. To prepare a composite list of species that might be found in the area and species preferred habitats the following literature was reviewed:

- Alan Tingay & Associates (1991) *Response to Draft North-West Corridor Structure Plan, Department of Planning & Urban Development (February 1991), Yanchep Structure Plan, Vertebrate Fauna Survey*. Unpublished report, Perth. *
- Alan Tingay & Associates (1996) *Alkimos - Eglinton Vertebrate Fauna Survey, October 1996*. Unpublished report, Perth. *
- Alan Tingay and Associates (1997) *Alkimos-Eglinton Vertebrate Fauna Survey October 1996*, Unpublished report, Perth. *
- Alan Tingay & Associates (1998a) *Moore River South, Vertebrate Fauna Survey, November 1997*. Unpublished report, Perth.
- Alan Tingay & Associates (1998b) *Yanchep Sun City, Environmental Assessment for the Rezoning of lots 201 and 202 Breakwater Drive, Two Rocks to Rural Community*. Unpublished report, Perth.
- Alan Tingay & Associates (1999a) *Shire of Wanneroo, Town Planning Scheme No. 1, Amendment 787, Yanchep - Two Rocks, Environmental Review*. Unpublished report, Perth. *
- Alan Tingay & Associates (1999b) *Pt Lot 2 Burns Beach, Vertebrate Fauna*. Unpublished report, Perth. *
- Bamford, M.J. (1998) *Report on a Vertebrate Survey at Burns Beach*. Unpublished report to ATA Environmental, Perth.
- Biota Environmental Sciences (2000) *Lot 52 Burns Beach Road Fauna Survey*. Unpublished report to ATA Environmental, Perth. *
- Bush B, Maryan B, Browne-Cooper R, Robinson D (1995) *A Guide to the Reptiles and Frogs of the Perth Region*. University of Western Australia Press, Perth.
- Chapman A, Dell J, Johnstone R and Kitchener DJ (1977) A Vertebrate Survey of Cockleshell Gully Reserve, Western Australia. *Records of the Western Australian Museum* Supplement No. 4, 1-87.
- Chapman, A. and Kitchener, D.J. (1977) II Mammals of Cockleshell Gully Reserve and Adjacent Areas, *Records of the Western Australian Museum*, Supplement No 4, 15-35.
- Davidge C. (1979) A Census of a Community of Small Terrestrial Vertebrates. *Australian Journal of Ecology* 4, 165-170.
- Dell J., How R.A. and Burbidge A.H. (2002) *Vertebrate Fauna of Tuart Woodlands*. In Tuart (*Eucalyptus gomphocephala*) and Tuart communities. Eds BJ Keighery and VM Longman pp. 254-276. Perth Branch, Wildflower Society of Western Australia: Perth.
- Dell, J. and Chapman, A. (1977a) IV Reptiles and Frogs of Cockleshell Gully Reserve, *Records of the Western Australian Museum*, Supplement No 4, 75-86.
- Dell, J. and Johnstone, R.E. (1977b) III Birds of Cockleshell Gully Reserve and the Adjacent Areas, Western Australia, *Records of the Western Australian Museum*, Supplement No 4, 37-73.
- Department of Conservation and Land Management. (1993) *Fauna studies in Water Supply Reserve 34537, Adjacent to Neerabup National Park*. Unpublished report, Perth. *
- *ecologia* Environmental Consultants (1997) *Cervantes – Jurien Coastal Road, Consultative Environmental Review*, unpublished report, Perth.
- Halpern Glick Maunsell (2005a) *Coastal Road – Lancelin to Cervantes Biological Survey*. Unpublished report, Perth.
- Halpern Glick Maunsell (2005b) *Wedge and Grey Biological Survey*. Unpublished report, Perth.
- Harvey M.S., Dell J., How R.A and Waldock J.M. (1997) *Ground Fauna of Bushland Remnants on the Ridge Hill Shelf and Pinjarra Plain Landforms, Perth, Report to the Australian Heritage commission NEP Grant N95/49*. Unpublished report, Perth.

- How R.A. (1998) Long-term Sampling of a Herpetofaunal Assemblage on an Isolated Urban Bushland Remnant, Bold Park, Perth. *Journal of the Royal Society of Western Australia* 81, 143-148. *
- How R.A and Dell J. (2000) Ground Vertebrate Fauna of Perth's Vegetation Remnants: Impact of 170 years of Urbanization. *Pacific Conservation Biology* 6, 198-217. *
- How R.A., Harvey M.S., Dell J, and Waldock J.M. (1996) *Ground Fauna of the Urban Bushland Remnants in Perth, Report to the Australian Heritage Commission NEP Grant N93/04*. Unpublished report, Perth. *
- Ninox Wildlife Consulting (1990) *Eglinton Beach Resort an Appraisal of the Vertebrate Fauna*. Unpublished report, Perth. *
- Storr, G.M. and Johnstone R.E. (1988) Birds of the Swan Coastal Plain and Adjacent Seas and Islands. *Records of the Western Australian Museum*, Supplement, No 28.
- Western Australian Museum (1978) *Faunal Studies of the Northern Swan Coastal Plain*. Western Australian Museum, Perth.
- Western Australian Museum and Biota Environmental Sciences (2004) *Assessment of Vertebrate Fauna of the Muchea Air Weapons Range (MAWR) Muchea, WA*.

Of these reports, ten were selected as providing useful information about the potential vertebrate fauna in the study area. These reports have been highlighted with an asterisk (*) above. Data provided for Bold Park (How, 1998), was deemed useful as it provided a long term dataset for a Quindalup Dune system with vegetation similar to that found on the study site. Alan Tingay & Associates (1991 and 1996) vertebrate fauna survey reports for the North-West Corridor Structure Plan area and Alkimos-Eglinton area was considered relevant. Two reports prepared by Alan Tingay & Associates for the Shire of Wanneroo – Amendment 837 (1999b) and Amendment 787 (1999a) to the Town Planning Scheme for the Yanchep – Two Rocks area also contained useful data of the potential vertebrate assemblages in the Quindalup – Spearwood Dunes system in the region. How and Dell's (2000) report on terrestrial vertebrates in Perth's remnant vegetation plots also contained some useful information. Data from study sites in Hepburn Heights, Trigg Bushland Reserve and Mount Claremont Bushland from this report (also see How *et al.*, 1996) were used, as these sites were on either Quindalup or Spearwood Dune systems and the vegetation was similar to that at the study site. Data from a report prepared by the staff of the Department of Conservation and Land Management (CALM 1993) for the area adjacent to the Neerabup National Park and Ninox's (1990) report on the vertebrate fauna at the proposed Eglinton Beach Resort were also used. The Ninox data come from summaries contained in Alan Tingay & Associates (1999b). The Eglinton Beach Resort area surveyed has similar soils and vegetation to that at Alkimos-Eglinton. Biota Environmental Sciences (2000) and Bamford's (1998) reports on the fauna of the Burns Beach area were also used in the compilation of the species list for the site.

Taxonomy and nomenclature for fauna species used in this report are mostly those used in *FaunaBase* which presumably follows Aplin and Smith (2001) for amphibians and reptiles, How *et al.* (2001) for mammals, and Johnstone and Storr (1998, 2004) for birds. Where data have been referred to in the appendices, ATA Environmental has presumed that the identification and nomenclature were correct at the time of printing these reports. ATA Environmental has not verified any of these listed species with the Western Australian Museum.

2.3 Trapping

A ten day fauna trapping program was conducted between 14 and 24 November 2005. All fauna surveys were conducted under a licence issued by DEC (# SF 5182). A number of individuals were vouchered with the Western Australian Museum to confirm identification (Appendix 1).

In addition to the cleared or highly degraded areas, there are two broad habitat types (Banksia woodland and Dryandra shrubland on limestone) in the study area from a fauna perspective. Trapping sites 1, 2, 3 and 5 were located in the Banksia woodlands and trapping site 4 was located in the Dryandra shrubland. The allocation of trapping effort reflected the relative abundance of each habitat type.

A series of trapping arrays were set up within the different habitat types across the study site (called 'sites'). Each trapping array consisted of one 150mm diameter stormwater pipe pit-trap (500mm deep), one 20L bucket pit-trap and two-pairs of funnel traps (4) located along a 10m drift fence (300mm high) and 2 Elliott traps. The Elliott traps were placed within 5m of the drift fence. Site 1 consisted of 20 arrays, site 2, 3, 4 and 5 each consisted of 15 arrays. In addition, 20 cage traps were located at sites 1, 3 and 4. All trapping arrays were spread approximately 20m apart. The location of each trap site is shown in Figure 2.

Table 1 shows the trapping effort conducted for each site. Sites 1, 2, 3 and 5 were open for 10 nights and site 4 open for nine nights. A total of 6860 trap-nights were conducted between 14-24 November 2005.

**TABLE 1
NUMBER OF TRAP NIGHTS PER TRAPPING SITE CONDUCTED AT YANCHEP**

Site	Trap type			
	Pit-trap nights	Funnel-trap nights	Elliott trap nights	Cage trap nights
1	400	800	400	200
2	300	600	300	-
3	300	600	300	200
4	270	540	270	180
5	300	600	300	-
TOTAL	1570	3140	1570	580

2.4 Avifauna Surveys

Avifauna surveys were conducted from sunrise on 17, 18, and 21-23 November 2005 for approximately five person hours, and opportunistically throughout the whole survey period between 14-24 November 2005. The order of avifauna sites for the survey was rotated to minimise activity period bias. All birds were identified by their call or direct observation.

Trees that may contain hollows suitable for nesting were searched for during the bird surveys and at other times during the survey.

2.5 Spot-lighting Survey

Spot-lighting targets a particular suite of fauna such as nocturnal reptiles and mammals (e.g. pythons, rabbits), that often do not readily get caught by other means and provides useful supplementary data to the trapping program. Large, predominantly nocturnal mammals (e.g. foxes, kangaroos, cats, etc) are often also observed during these searches.

Spot-lighting was conducted on five evenings (16-18, 19 and 21 November 2005). Spot-lighting was conducted from a slow moving vehicle (~5km/hr) using head torches and a high powered hand-held spot-light. Each survey lasted approximately 2hrs and included the tracks, gravel and bitumen roads in the vicinity of the trapping sites. All trapping sites were investigated during each evening search.

2.6 Bat Surveys and Non-Systematic Searches

Night surveys of bat species active in the study area were undertaken using an Anabat II recorder during the spot-lighting surveys. The Anabat II recorder was set up in fly ways within each habitat type and left for approximately 45 minutes. It is acknowledged by ATA Environmental that some bat species may not be recorded during this 45 minute period, however many of the bats likely to be present will be active during this period.

Hand searching using rakes, digging out holes and opportunistic sightings of reptiles, mammals and amphibians in the study area were also recorded.

2.7 Local Knowledge

Locals, particularly those with an interest in the natural environment (e.g. CALM rangers, wildlife carers), can provide useful information about the fauna in the area. As a consequence, an effort was made to talk with knowledgeable locals about the fauna in the study areas. Local CALM staff and members of a local environmental group were contacted to seek out information on survey reports, or species records for the study and adjacent areas. The study area is located to the west of the Yanchep National Park

2.8 Survey Staff

Dr Scott Thompson (ATA Environmental), Dr Graham Thompson (Terrestrial Ecosystems) and Ryan Phillips, conducted the fauna survey with assistance from Sean Stankowski, Dr Jess Oates, Cale Alexander, Edward Swinhoe, Stephen van der Wiele, Chris Clemente and Rhys Felton. The report was written by Dr S. Thompson. Drs S and G Thompson have considerable experience in undertaking fauna surveys in various areas of Western Australia, including the Swan Coastal Plain.

2.9 Limitations

The vertebrate survey at Yanchep was conducted over ten days during November 2005. The trapping effort varied among sites due to the time taken to dig in pit-traps and lay out Elliott, cage and funnel traps.

Conclusions and management recommendations regarding the vertebrate faunal diversity have been made based on the results obtained from this survey, data from other surveys and

from unpublished reports conducted in the region. These data have been assessed in a regional context using information from *FaunaBase* and the available literature. It is acknowledged that multiple surveys conducted in different seasons, repeated over several years are necessary to cater for temporal variations in the faunal assemblage, however, in this circumstance it is ATA Environmental's opinion that adequate data have been collected to assess the potential impact of the proposed development on the terrestrial vertebrate fauna.

Different trap types sample the small vertebrate assemblage differently (Thompson, Thompson and Withers, 2005). Unlike many of the earlier terrestrial fauna surveys, this trapping program used funnel traps which resulted in a more complete survey of the area. Large reptiles and mammals are infrequently caught in the traps used, however, their size is such they are more likely to be seen than many smaller cryptic species.

Most burrowing frog species are typically only surface active after rains (Thompson, Thompson, *et al.*, 2003b). Frogs were caught and observed during the survey as there was some light rain on a couple of evenings. Based on the database search results, frog species potentially caught in the area are not considered likely to be of significant conservation concern.

The weather was fine with the maximum temperature most days greater than 28°C enabling most species of reptile and mammal to be sufficiently active to be caught in traps. The results are therefore not likely to be limited by daily weather conditions, as the days were suitable for trapping reptiles and small mammals.

This survey was undertaken in accordance with a Level 2 assessment as suggested in the Environmental Protection Authority (EPA) *Position Statement No. 3 Terrestrial Biological Surveys as an Element of Biodiversity Protection* (EPA, 2002) and ATA Environmental's interpretation of the EPA *Guidance for Assessment of Environmental Factors: Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia, No. 56* (EPA, 2004).

The EPA *Guidance for Assessment of Environmental Factors: Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia, No. 56* (EPA, 2004) suggests that fauna surveys may be limited by many variables (Table 2). Limitations associated with each of these variables are assessed in Table 2.

TABLE 2
FAUNA SURVEY LIMITATIONS AND CONSTRAINTS

Possible limitations	Constraint (yes/no); significant, moderate or negligible	Comment
Competency and experience of the consultant carrying out the survey	No	The lead scientist has appropriate training, experience and mentoring in vertebrate fauna identification and surveys. Other members of the survey team are also qualified and experienced.
Scope	No	A variety of trapping techniques, opportunistic sightings, digital recording and hand foraging techniques were used to characterise the faunal assemblage. The weather was suitable throughout the survey period to adequately survey fauna.
Proportion of fauna identified, recorded and/or collected	No	All species captured have been previously recorded in the area. More individuals were trapped in this assessment than other similar surveys previously conducted indicating that adequate trapping was conducted. A complete inventory of vertebrate species present would only be achieved by multiple surveys repeated over multiple seasons and multiple years. This was not necessary given the previous surveys conducted in the northern Swan Coastal Plain, its proximity to Yanchep National Park and other developments.
Sources of information	No	Vertebrate fauna information was available using the Western Australian Museum <i>FaunaBase</i> , and published and unpublished reports conducted in the region.
Proportion of the task achieved	No	The conservation value of the area has been demonstrated by this survey and results from other surveys conducted in the region. It is unlikely that further survey work would substantially increase the species richness for reptiles or mammals in the area. Further surveys may increase the bird species list for the study area.
Timing/weather/season/cycle	No	The timing of the survey was in accordance with GS 56. Surveying at other times of the year may have resulted in additional species or a slightly different assemblage, however, is unlikely to make a significant difference to our interpretation of the conservation significance of the site.
Disturbances which affected results of the survey	No	No significant disturbances took place during the survey, which would affect the results or conclusions.
Intensity of survey effort	No	The intensity of trapping was adequate as indicated by species accumulation curves and comparison with other surveys previously conducted in the region. The trapping effort significantly exceeded that of other similar surveys previously conducted in the region.
Completeness	No	Trapping was conducted in each of the two major habitat types.
Resources	No	Adequate resources were available.
Remoteness and/or access problems	No	There were no access or remoteness issues.
Availability of contextual information on the region	No	WA Museum fauna database, Department of Environment and Conservation Threatened and Priority species lists, multiple surveys in region, consultants personal experience.

3. RESULTS

3.1 Overall

Thirty one (31) species and 595 individual reptiles and mammals were trapped over the course of the spring survey. An additional 59 species of birds and 2096 individuals were observed as part of systematic bird surveys.

3.2 Fauna Habitats

Large sections of the site are significantly weed infested or degraded, with areas containing rubbish and car bodies. The increased amounts of grass and weed species have resulted in a low fauna habitat value for these areas. However, within the remaining vegetated portions of the site, there are two broad fauna habitats that cover the entire study area. It is acknowledged that there may be more vegetation types, however the structural composition and not actual species is important when describing fauna habitats. The fauna habitats can be broadly described as Banksia woodland (Plate 1a, b and c) and Dryandra shrubland on limestone (Plate 2a, b and c). These habitats contain the normal range of variations in soil and vegetation that would be expected across a landscape of this size.

3.3 Nocturnal Searches

Nocturnal searches indicated a high number of rabbits and Western Grey Kangaroos in the study area. No bat activity was observed or recorded. A single *Strophurus spinigerus*, three *Heliophorous eyrei* and one *Limnodynastes dorsalis*, were the only herpetofauna observed during the nocturnal searches. Although only two foxes and three cats were observed spotlighting, multiple sets of cat and fox tracks were observed each morning indicating that they were both active throughout the area.

3.4 Avifauna

Bird species sighted within the vicinity of the study area are listed in Table 3 and Appendix 2. It should be noted that the Indian Ocean and associated beach is approximately 2km to the west of study area and there are wetland systems to the south and east. Birds that frequent the sea, beach or these wetlands occasionally fly over the study area but do not forage or nest in this area. Species presented in the search of *FaunaBase* and in other reports for the region have been included in the appendices. It is acknowledged that some of these species are unlikely to use the site because of a lack of suitable habitat (e.g. marine and freshwater birds, salt lake specialists, darters, gulls and terns, ibis and spoonbills, etc).

A list of 100 species could be found in the general locality, however, not all of these species are expected to be observed, forage or nest in the general area. There are always going to be vagrants present in an area because of unusual weather (e.g. flooding, storms). Of these 100 species, 59 species and 2096 individuals were observed in the vicinity of one of the five sites. A number of bird species have been reported in the general region that were not recorded in *FaunaBase* for the search area. This is to be expected as species lists for the region are compiled over many years and many of the species listed have seasonal shifts in foraging and breeding sites.

Table 3 shows the most probable habitat in which each of these species is likely to be recorded on the site. Habitat data for each species comes from Storr and Johnstone (1988) and

Johnstone and Storr (1998; 2004). The two major habitat types on the study site (Banksia Woodland and Dryandra shrubland on limestone) are most similar to Habitats 5 and 2 respectively.

TABLE 3
BIRD SPECIES LIKELY TO BE FOUND IN THE STUDY AREA WITH A COMMENT ON HABITAT PREFERENCE, DIET AND MOVEMENT PATTERNS

Species		Number recorded in systematic surveys on site	Suitable habitat type *	Comments on habitat [†] , diet and movement patterns*
Acanthizidae (Thornbills, Flycatchers, Gerygones)				Some occupy tree-tops others are found mostly in the undergrowth and heathlands. Most are vagrants and migratory. Most are insectivorous.
<i>Acanthiza apicalis</i>	Inland Thornbill	8	2, 3, 4, 6, 7	Thickets and scrub, tall heathlands.
<i>Smicromis brevirostris</i>	Weebill	11	7, 8	Open Eucalypt forests, woodlands and scrub.
<i>Acanthiza chrysorrhoa</i>	Yellow-rumped Thornbill	9	1, 3, 4, 5, 6, 8, 10	Open woodlands, near dense shrubs, forages on the ground in open spaces.
<i>Acanthiza inornata</i>	Western Thornbill	28	3, 5, 6, 7, 8	Jarraah, Marri, Melaleuca woodlands, scrub .
<i>Gerygone fusca</i>	Western Gerygone	35	7, 8	Eucalypt forests, melaleuca woodlands, migratory.
<i>Sericornis frontalis maculatus</i>	White-browed Scrubwren	13	3, 6, 7	Thickets.
Accipitridae (Kites and Eagles)				Diurnal birds of prey normally with large home ranges, feeding on lizards, rodents, birds and carrion.
<i>Accipiter cirrocephalus</i>	Collared Sparrowhawk	1	5, 6, 7, 8	Well-wooded areas normally around water, partly migratory.
<i>Accipiter fasciatus fasciatus</i>	Brown Goshawk	2	5, 6, 7, 8	Well-wooded areas, forests, thickets, migratory.
<i>Aquila audax</i>	Wedge-tailed Eagle		1, 5, 7, 10	Lighted wooded areas and farmland, feeds on carrion, reptiles, mammals, sedentary, high nest fidelity.
<i>Aquila morphnoides</i>	Little Eagle	3	all sites	Tuarts, vicinity of rivers and lakes, feeds on lizards and mammals.
<i>Circus assimilis</i>	Spotted Harrier		1, 5, 8, 10	Lighted wooded areas, feeds on lizards and rodents.
<i>Circus approximans</i>	Swamp Harrier	3	1, 5, 8, 9, 10	Lighted wooded areas, swamps and woodlands .
<i>Elanus caeruleus</i>	Black-shouldered Kite	4	1, 3, 5, 10	Open or lightly wooded areas, farmlands, migratory, feeds on lizards and mammals.
<i>Haliastur sphenurus</i>	Whistling Kite	2	9, 10 but any areas	Wetlands and wet farm lands, feeds on carrion and birds, is

Species		Number recorded in systematic surveys on site	Suitable habitat type *	Comments on habitat [†] , diet and movement patterns*
				mostly migratory.
<i>Hamirostra isura</i>	Square-tailed Kite		3, 5, 8	Eucalypt woodlands, scrub and forests, feeds on birds and bird eggs, migratory breeding visitor to south-west.
<i>Haliaeetus leucogaster</i>	White-bellied Sea-Eagle		any area along the coast	Coastal areas and estuaries, feeds on fish and birds, territorial.
<i>Pandion haliaetus</i>	Osprey		any area along the coast	Coastal areas, seldom inland, feeds on fish. Migratory but will return to the same nest to breed.
Aegothelidae (Owlet-Nightjar)				
<i>Aegotheles cristatus</i>	Australian Owlet-nightjar		5, 6, 7, 8	Well-wooded areas, insectivorous.
Apodidae (Swifts)				
<i>Apus pacificus</i>	Fork-tailed Swift		over all areas	Insectivorous, prey captured in the air. Migratory.
Artamidae (Woodswallows)				
<i>Artamus cinereus</i>	Black-faced Woodswallow	2	5, 8	Insectivorous, prey captured in the air. Sparsely wooded areas, partly migratory.
<i>Artamus cyanopterus</i>	Dusky Woodswallow		5, 6, 7, 8	Eucalypt forest and woodlands, partly migratory.
<i>Artamus personatus</i>	Masked Woodswallow		3, 5, 8	Mainly in open and lightly wooded areas, nomadic.
Campephagidae (Cuckoo-shrikes)				
<i>Coracina novaehollandiae</i>	Black-faced Cuckoo-shrike	12	3, 5, 6, 7, 8	Feed on insects and are mostly migratory. Eucalypt forests, woodland and scrubs, feeds on insects, migratory.
<i>Lalage tricolor</i>	White-winged Triller		3, 5, 8	Lightly wooded areas, dunes, insectivorous, nomad and migratory.
Caprimulgidae (Nightjar)				
<i>Eurostopodus argus</i>	Spotted Nightjar		5, 8	Nocturnal insect eaters. Sparsely wooded area.

Species	Number recorded in systematic surveys on site	Suitable habitat type *	Comments on habitat ⁺ , diet and movement patterns*
Casuariidae (Emu)			
<i>Dromaius novaehollandiae</i> Emu	9	1, 3, 5, 8, 10	Shrubland, Banksia, heathlands, feeds on seeds and fruits.
Columbidae (Pigeons and Doves)			
<i>Columba livia</i> Rock Dove (Domestic Pigeon)		10	Feed on vegetable matter, seeds, fruits and flowers. Buildings and wheat silos, exotic, seed eater.
<i>Ocyphaps lophotes</i> Crested Pigeon	15	1, 5, 8, 10	Lightly wooded area.
<i>Phaps chalcoptera</i> Common Bronzewing	14	1, 3, 5, 8, 10	Lightly and moderately wooded areas, mobile.
<i>Phaps elegans</i> Brush Bronzewing		3	Dense shrubland.
<i>Streptopelia chinensis</i> Spotted Turtle-Dove		1, 3, 5, 8, 10	Well-wooded areas, suburbs, exotic, feeds on seeds.
<i>Streptopelia senegalensis</i> Laughing Turtle-Dove	2	1, 3, 5, 8, 10	Lighted wooded areas, suburbs, exotic, feeds on seeds.
Corvidae (Crows and Ravens)			
<i>Corvus coronoides</i> Australian Raven	34	all areas	Omnivorous, some are scavengers. Suburbs, farmland, lightly wooded areas, scavenger, also feeds on insects and carrion.
Cracticidae (Butcherbirds and Magpie)			
<i>Cracticus tibicen</i> Australian Magpie	74	3, 5, 8, 10	Feed on lizards, small birds and insects. Lightly wooded areas, feeds on insects.
<i>Cracticus torquatus</i> Grey Butcherbird	4	2, 5, 6, 7, 8	Scrub, thickest and woodlands, feeds on small birds, insects and lizards.
<i>Strepera versicolor</i> Grey Currawong		1, 2, 3, 5, 6, 7, 8	Eucalypt forests and woodlands, coastal heath, feeds on insects, snails, fruit and berries.
Cuculidae (Cuckoos)			
<i>Cacomantis flabelliformis</i> Fan-tailed Cuckoo		5, 6, 7, 8	Feed on invertebrates, invertebrate larvae, most are migratory. Well-wooded areas from Karri to Acacia, eats earthworms and caterpillars, migratory.
<i>Cuculus pallidus</i> Pallid Cuckoo		3, 5, 6, 10	Woodlands, shrublands and farmland, migratory.
<i>Chrysococcyx basalis</i> Horsfield's Bronze Cuckoo	1	3, 5, 6	Woodlands and shrublands, migratory.

Species		Number recorded in systematic surveys on site	Suitable habitat type *	Comments on habitat [†] , diet and movement patterns*
<i>Chrysococcyx lucidus</i>	Shining Bronze Cuckoo		5, 6, 7, 8	Well-wooded areas, feeds on caterpillars and beetles, migratory.
Dicruridae (Fantails and Flycatchers)				Feed on insects, can be both sedentary and migratory.
<i>Grallina cyanoleuca</i>	Magpie-lark	2	1, 3, 5, 8, 10	Lakes, swamps, sparsely vegetated areas, feeds on insects.
<i>Myiagra inquieta</i>	Restless Flycatcher		5, 8, 10	Open forests, woodlands near waterways, feeds on insects.
<i>Rhipidura fuliginosa</i>	Grey Fantail	34	3, 5, 6, 7, 8	Edges of dense shrublands, resident and migratory.
<i>Rhipidura leucophrys</i>	Willie Wagtail	11	5, 8, 10	Lightly wooded areas, urban area, feeds on insects, is sedentary and migratory.
Falconidae (Falcons)				Most are carnivorous, some are vagrants, others are migratory.
<i>Falco berigora</i>	Brown Falcon	2	3, 5-8	Lighted wooded areas, feeds on insects, reptiles and birds, partly migratory.
<i>Falco cenchroides</i>	Australian Kestrel	1	3, 5-8	Open and sparsely wooded areas, feeds on insects, lizards and birds, migratory.
<i>Falco longipennis</i>	Australian Hobby	1	3, 5-8	Lightly wooded areas, feeds on small birds, resident and migratory.
<i>Falco peregrinus</i>	Peregrine Falcon		all areas	Cliffs along the coast, rivers and ranges, feeds on birds.
Alcedinidae (Kookaburras and Kingfishes)				Carnivorous, either territorial or migratory.
<i>Dacelo novaeguineae</i>	Laughing Kookaburra	9	5-8	Well-wooded areas, feeds on insects and reptiles, exotic.
<i>Todiramphus sanctus</i>	Sacred Kingfisher	1	5-9	Wooded areas near water courses, feeds on reptiles, fish, migratory.
Hirundinidae (Swallows)				Feed on aerial insects, most are migratory.
<i>Cheramoeca leucosternus</i>	White-backed Swallow	3	5, 8, forage over all areas	Open and sparsely wooded areas, inland coastal dunes, partly migratory.

Species		Number recorded in systematic surveys on site	Suitable habitat type *	Comments on habitat [†] , diet and movement patterns*
<i>Hirundo neoxena</i>	Welcome Swallow	20	5, 8, forage over all areas	Open and sparsely wooded areas, buildings, migratory.
<i>Hirundo nigricans</i>	Tree Martin		5, 8, forage over all areas	Wooded areas, near water, migratory.
Laridae (Gulls and terns)				
<i>Larus novaehollandiae</i>	Silver Gull		coastal areas	Everywhere there is food on the coastal plain, sedentary unless breeding.
Maluridae (Fairy-wrens, Grasswrens)				
<i>Malurus lamberti</i>	Variiegated Fairy-wren	24	2, 3, 4	Insectivorous, live on ground, shrubs and long grass. Coastal scrub, feeds on insects.
<i>Malurus leucopterus</i>	White-winged Fairy-wren	23	1, 2, 3, 4, 5	Open scrub land, lightly wooded areas, feeds on insects and seeds.
<i>Malurus splendens</i>	Splendid Fairy-wren	204	2, 3, 4, 6, 7	Coastal scrub and thickets, feeds on insects.
<i>Stipiturus malachurus westernensis</i>	Southern Emu-wren		2, 3, 6	Low dense scrub land, heathlands, feeds on insects, spiders.
Meliphagidae (Honey eaters)				
<i>Acanthorhynchus superciliosus</i>	Western Spinebill	4	1, 2, 3, 5, 6	Feed on nectar in flowering trees and shrubs and insects, both migratory and sedentary. Woodlands, shrublands, urban areas, feeds on nectars and insects, sedentary.
<i>Anthochaera carunculata</i>	Red Wattlebird	36	5, 8	Open Eucalypt and forests, feeds on nectar and insects, partly migratory.
<i>Anthochaera lunulata</i>	Western Wattlebird		3, 5-8	Tall shrublands, Eucalypt forests, heath and Banksia, feeds on nectar and insects, nomadic feeds on insects and nectar.
<i>Epthianura albifrons</i>	White-fronted Chat	15	1, 3, 4, 10	Open areas, farmlands, waterside areas.
<i>Lichenostomus ornatus</i>	Yellow-plumed Honeyeater		1, 3, 5	Forests and woodlands, Eucalypts, feeds on insects and nectar.
<i>Lichenostomus virescens</i>	Singing Honeyeater	10	2, 3, 5, 6	Edges of thickets, open scrub, urban areas, feeds on insects

Species		Number recorded in systematic surveys on site	Suitable habitat type *	Comments on habitat ⁺ , diet and movement patterns*
				and nectar.
<i>Lichmera indistincta</i>	Brown Honeyeater	193	2, 3, 5, 6	Shrublands, suburbs, woodlands, feeds on nectar and insects.
<i>Manorina flavigula</i>	Yellow-throated Miner		1, 3, 5, 10	Open scrub and Eucalypt and Banksia woodlands, feeds on insects, nectar, fruit.
<i>Phylidonyris melanops</i>	Tawny-crowned Honeyeater	9	1, 2, 3, 5	Heathlands and low shrubs, feeds on nectar, flowers and insects, nomadic.
<i>Phylidonyris nigra</i>	White-cheeked Honeyeater	109	1, 2, 3, 5-8	Proteaceae, coastal heath, scrubs and thickets, Banksia woodlands, feeds on nectar and insects.
<i>Phylidonyris novaehollandiae</i>	New Holland Honeyeater	152	1, 3, 5, 6, 8	Flowering shrubs, urban areas, near water, feeds on nectar, fruit, seeds and sap, is mostly sedentary.
Meropidae (Rainbow Bee-eater)				Migratory, insectivorous.
<i>Merops ornatus</i>	Rainbow Bee-eater	26	1, 3, 10	Lightly wooded areas, insectivorous, migratory.
Motacillidae (Pipit)				
<i>Anthus australis</i>	Australian Pipit	31	1, 3, 10	Coastal beaches and dunes, heathlands, sparsely vegetated areas feeds on insects, vagrant and sedentary.
Neosittidae (Sittella)				Search bark of trees for insects and spiders, probably sedentary.
<i>Daphoenositta chrysoptera</i>	Varied Sittella		5, 8	Open forests and woodlands, feeds on insects and spiders.
Pachycephalidae (Whistlers and Shrike-thrush)				Insectivorous, mostly searching branches and stems, non-migratory.
<i>Colluricincla harmonica rufiventris</i>	Grey Shrike-thrush	1	3, 5, 8	Open forests, woodlands, thickets, feeds on insects.
<i>Pachycephala pectoralis</i>	Golden Whistler		3, 5-8	Thickets and shrubs of Acacia, Melaleuca, Eucalypt woodlands.
<i>Pachycephala rufiventris</i>	Rufous Whistler	19	5-8	Woodlands, thickets, feeds on insects.

Species		Number recorded in systematic surveys on site	Suitable habitat type *	Comments on habitat ⁺ , diet and movement patterns*
Pardalotidae (Pardalotes)				
<i>Pardalotus punctatus</i>	Spotted Pardalote		7, 8	Eucalypt woodland and forests, feeds on insects in the mid and upper canopy of forests, migratory.
<i>Pardalotus striatus</i>	Striated Pardalote	4	7, 8	Eucalypt woodlands and forests, feeds on insects, forages in the canopy foliage, migratory.
Petroicidae (Australian Robins and Flycatchers)				
<i>Eopsaltria australis griseogularis</i>	Yellow Robin		3, 5-8	Well-wooded areas, thickets, shrubs, Eucalypt understorey.
<i>Petroica cucullata</i>	Hooded Robin		3, 5-8	Lightly wooded areas, edges of thickets.
<i>Petroica goodenovii</i>	Red-capped Robin		3, 5-8	Mainly in tea-tree, plantations of Tuart, migratory.
<i>Petroica multicolor</i>	Scarlet Robin	3	5-8	Banksia and Eucalypt woodlands, sedentary.
Phasianidae (Quail and Pheasant)				
<i>Coturnix novaezelandiae</i>	Stubble Quail	7	1, 2, 3, 5, 8, 10	Swamp margins, sparsely wooded coastal areas, nomadic.
Podargidae (Tawny Frogmouth)				
<i>Podargus strigoides</i>	Tawny Frogmouth	1	5-8	Well-wooded areas.
Psittacidae (Parrots and Cockatoos)				
<i>Cacatua roseicapilla</i>	Galah	116	5, 8, 10	Lightly wooded areas, farmland, suburbs, feeds on seeds of a wide range of plants.
<i>Cacatua sanguinea</i>	Little Corella	14	5, 8, 10	Lightly wooded areas, farmland, suburbs, feeds on seeds of a wide range of plants.
<i>Calyptorhynchus latirostris</i>	Carnaby's Black Cockatoo	240	5-8	Eucalypt woodlands and forests, feeds on proteaceous shrubs – including in heath and shrubland habitats, migratory.
<i>Neophema elegans</i>	Elegant Parrot		5-8, 10	Cleared farmlands, lakes and swamps, sedentary, feeds on seeds or grasses and shrubs.

Species		Number recorded in systematic surveys on site	Suitable habitat type *	Comments on habitat [†] , diet and movement patterns*
<i>Neophema petrophila</i>	Rock Parrot		coastal dunes, 1, 2	Coastal area, beaches and dunes, feeds on seeds and fruits on beach and samphire areas.
<i>Platycercus spurius</i>	Red-capped Parrot		5-8	Eucalypt forests, feeds on seeding marri and other Eucalypts.
<i>Platycercus zonarius</i>	Australian Ringneck Parrot	67	5-8	Woodlands, suburbs, forests, feeds on Eucalypt, <i>Banksia</i> , <i>Grevillea</i> and other seeds and flowers.
<i>Polytelis anthoepus</i>	Regent Parrot		5, 8, 10	Farmlands, lighted treed areas, feeds on Acacia seed and germinating wheat and ripening orchard fruit.
<i>Trichoglossus haematodus</i>	Rainbow Lorikeet		5-8	Treed areas, exotic, feeds on pollen and nectar.
Strigidae (Hawk Owls)				Nocturnal, feeds on birds, mammals, reptiles.
<i>Ninox novaeseelandiae</i>	Southern Boobook		5-8, 10	Well-wooded areas, feeds on small rodents, insects, migratory.
Sylviidae (Songlarks and Reed-warblers)				
<i>Cincloramphus mathewsi</i>	Rufous Songlark		3, 5	Lightly wooded areas with good grass cover, feeds on insects, migratory.
Threskiornithidae (Ibises and Spoonbills)				
<i>Threskiornis spinicollis</i>	Straw-necked Ibis	92	5, 8, 9, 10	
<i>Threskiornis molucca</i>	Australian White Ibis		5, 8, 9, 10	Open areas.
Turnicidae (Button quail)				Feed on seeds and insects.
<i>Turnix varia</i>	Painted Button-Quail		3, 5-8	Well-wooded Tuart forests, scrubs, thickets, non-migratory.
Tytonidae (Owls)				Nocturnal, feeders on birds and mammals.
<i>Tyto alba</i>	Barn Owl	2	5, 8, 10	Lightly wooded area, migratory.
Zosteropidae (Silvereye)				

Species	Number recorded in systematic surveys on site	Suitable habitat type *	Comments on habitat ⁺ , diet and movement patterns*
<i>Zosterops lateralis</i> Silvereye	321	All areas	Thickets and scrub, urban areas, feeds on insects and spiders, migratory and resident.

+ Habitat types, diet and movement patterns are mostly taken from Johnstone and Storr (1998; 2004)

* Individual species accounts need to be read in conjunction with comments for the family

* **Habitat types referred to in Table 3**

1. Low open heath
2. **Low closed heath**
3. Shrublands
4. Sedges/herbs
5. **Low open woodlands with a limited understorey**
6. Low closed woodlands with a dense understorey
7. Forest with dense understorey
8. Forest with limited understorey
9. Wetland
10. Cleared

3.5 Reptiles

Reptile species caught at Yanchep during the November 2005 survey are listed in Tables 4 and 5 and Appendix 2. Twenty-seven species of reptiles were caught during the field survey. Two-hundred and eighty of the 410 individuals recorded from captures were caught in funnel traps, 75 in bucket pit-traps, 28 in pipe pit-traps, 16 in cage traps and 11 in Elliott traps (Table 3). Species in *FaunaBase* likely to be caught in the region are listed in Appendix 2 along with reptile species reported as being caught in the region in similar habitats during other fauna surveys.

3.6 Mammals

Larger mammal species (e.g. kangaroos and rabbits) are unlikely to be caught in pit, funnel, Elliott or cage traps, but their scratchings, burrows and scats provide evidence of their presence in an area. Spot-lighting at night is also a useful method of detecting the presence of many of these species. Mammals caught during the November 2005 survey and in the vicinity of the five trapping sites are shown in Tables 4 and 5, and Appendix 2. Two species of mammals were caught, House Mice (*Mus musculus*) and Honey Possums (*Tarsipes rostratus*). Numerous rabbits, two foxes and three cats were sighted in the night searches. In addition to the nocturnal observations, one Western Brush Wallaby (*Macropus irma*) was observed at site 2. This is an important observation as few Western Brush Wallabies are observed on the Swan Coastal Plain.

ATA Environmental recorded no bats on the study area. However, bat activity is influenced by ambient conditions including light pollution that was evident across some of the site at the time of the survey.

3.7 Amphibians

Other than freshwater puddles found around the golf course or the occasional cattle trough there is no permanent freshwater on the study site. Therefore, it is highly unlikely amphibian species whose habitat is closely linked with permanent water will be present.

Amphibian species caught at Yanchep during the November 2005 survey are listed in Tables 4 and 5, and Appendix 2. Two species of amphibians (*Heleioporus eyrei* and *Limnodynastes dorsalis*) were caught during the field survey. Of the 131 individuals caught, 36 were caught in funnel traps, 67 in bucket pit-traps and 28 in pipe pit-traps (Table 3). An additional four individuals were recorded spotlighting. Species in *FaunaBase* likely to be caught in the region are listed in Appendix 2 along with species reported as being caught in the region during other surveys.

TABLE 4
NUMBER OF INDIVIDUALS RECORDED IN EACH TRAPPING AREA

	Site 1 – Banksia woodland	Site 2 – Banksia woodland	Site 3 – Banksia woodland	Site 4 – Dryandra shrubland on limestone	Site 5 – Banksia woodland
Reptiles					
Agamidae (Dragons)					
<i>Pogona minor</i>	3		3	1	3
<i>Rankinia adelaidensis</i>				1	
Elapidae (Front fanged Snakes)					
<i>Brachyuropsis semifasciatus</i>		4			1
<i>Demansia psammophis</i>	1		1	3	1
<i>Echiopsis curta</i>			2	1	2
<i>Neelaps bimaculatus</i>	1				1
<i>Neelaps calonotos</i>			1		
<i>Parasuta gouldii</i>	2	1			
<i>Pseudonaja affinis</i>	2		1	2	
<i>Simoselaps bertholdi</i>		2	1		1
Gekkonidae (Geckoes)					
<i>Strophurus spinigerus</i>	5			2	
Scincidae (Skinks)					
<i>Cryptoblepharus plagiocephalus</i>	7	2	1		
<i>Ctenotus australis</i>	17	11	14	13	12
<i>Ctenotus fallens</i>	41	24	27	25	22
<i>Cyclodomorphus celatus</i>	3	3		4	2
<i>Egernia napoleonis</i>		2			
<i>Hemiergis initialis</i>		3			
<i>Hemiergis quadrilineata</i>	5	1	4		2
<i>Lerista elegans</i>	3	9	5	10	1
<i>Menetia greyii</i>		2	3	3	2
<i>Morethia lineocellata</i>	10				
<i>Tiliqua occipitalis</i>	5		1	5	9
<i>Tiliqua rugosa</i>	13	10	17	11	5
Typhlopidae (Blind snakes)					
<i>Ramphotyphlops australis</i>		2			
Pygopodidae (Legless Lizards)					
<i>Aprasia repens</i>	1		1	1	1
<i>Delma fraseri</i>					1
<i>Lialis burtonis</i>	3	3	3	1	
Mammals					
<i>Mus musculus</i>	8	15	11	7	5
<i>Tarsipes rostratus</i>				4	3
Amphibians					
<i>Helioporous eyrei</i>	44	9	6	2	3
<i>Limodynastys dorsalis</i>	14	13	14	13	16
Number of species	20	18	19	19	20
Number of individuals	188	116	116	109	93

TABLE 5
NUMBER OF INDIVIDUALS CAUGHT IN VARIOUS TRAP-TYPES

	Bucket pit-traps	Pipe pit- traps	Funnel traps	Elliott traps	Cage traps
Reptiles					
Agamidae (Dragons)					
<i>Pogona minor</i>	1	1	7		
<i>Rankinia adelaidensis</i>			1		
Elapidae (Front fanged Snakes)					
<i>Brachyuropsis semifasciatus</i>	1	2	2		
<i>Demansia psammophis</i>			6		
<i>Echiopsis curta</i>	1	1	3		
<i>Neelaps bimaculatus</i>			2		
<i>Neelaps calonotos</i>			1		
<i>Parasuta gouldii</i>	1	1	1		
<i>Pseudonaja affinis</i>			5		
<i>Simoselaps bertholdi</i>	1		3		
Gekkonidae (Geckoes)					
<i>Strophurus spinigerus</i>		1	6		
Scincidae (Skinks)					
<i>Cryptoblepharus plagiocephalus</i>	2	6	2		
<i>Ctenotus australis</i>	4	2	60		
<i>Ctenotus fallens</i>	14	5	118	1	
<i>Cyclodomorphus celatus</i>	2	2	8		
<i>Egernia napoleonis</i>			1	1	
<i>Hemiergis initialis</i>	2		1		
<i>Hemiergis quadrilineata</i>	5		7		
<i>Lerista elegans</i>	21	1	6		
<i>Menetia greyii</i>	6	1	2		
<i>Morethia lineocellata</i>	2	1	7		
<i>Tiliqua occipitalis</i>	2	1	10	4	
<i>Tiliqua rugosa</i>	6	2	9	5	16
Typhlopidae (Blind snakes)					
<i>Ramphotyphlops australis</i>	2				
Pygopodidae (Legless Lizards)					
<i>Aprasia repens</i>	2	1	1		
<i>Delma fraseri</i>			1		
<i>Lialis burtonis</i>			10		
Mammals					
<i>Mus musculus</i>	16	21	1	8	
<i>Tarsipes rostratus</i>	5	2			
Amphibians					
<i>Helioporous eyrei</i>	34	11	18		1
<i>Limnodynastys dorsalis</i>	33	17	18		
Number of species	22	19	29	5	2
Number of individuals	163	79	317	19	17

3.8 Fauna Assemblage Similarity

Morisita-Horn similarity indices for all combined captures are presented in Table 6. Site 1 is adjacent to Yanchep National Park and represents high quality Banksia woodland habitat. Site 4 is the most dissimilar of all sites, however, all similarity index scores were higher than 0.7, indicating that the differences were not large. Sites 2, 3 and 5 are very similar (>0.85 similarity) to each other.

TABLE 6
MORISITA-HORN SIMILARITY INDEX SCORES FOR THE REPTILE ASSEMBLAGES
AMONG THE FIVE SITES

	Site 2	Site 3	Site 4	Site 5
Site 1	0.796	0.788	0.716	0.731
Site 2		0.94	0.917	0.851
Site 3			0.947	0.913
Site 4				0.916

3.9 Fauna Assemblage Diversity

There are a number of indices used to measure and compare biodiversity between ecosystems. Log series diversity (Fishers Alpha) is used to compare the diversity in rehabilitated sites with the adjacent undisturbed areas because of its good discriminating ability, low sensitivity to sample size, and its simplicity to calculate (Kempton and Taylor, 1974; Magurran, 1988). Its low sensitivity to sample size is a result of its greater dependence on the number of species of intermediate abundance and it is relatively unaffected by rare or common species (Magurran, 1988). Log series diversity was chosen instead of Simpson's and Shannon diversity indices because the Shannon diversity index is only moderately insensitive to sample size (Hayek and Buzas, 1997; Magnussen and Boyle, 1995; Magurran, 1988), and both Shannon and Simpson's diversity indices have only moderate discriminating ability (Magurran, 1988).

When using the log series diversity index, Site 5 was the most diverse and site 1 the least diverse when comparing reptile assemblages (Table 8). Sites 2, 3 and 4 were very similar. Site 5 captured 20 species, from 93 individuals, whereas Site 1 captured 20 species from 188 individuals. Sites 2, 3 and 4 caught 18 or 19 species and between 109 and 116 individuals (Table 4).

Site 2 has the highest diversity when comparing Simpson's diversity index scores, however this may be influenced by the relative proportion of singletons (only a single individual of one species was recorded) caught at each of the trapping sites (Site 2 only had two singletons for 18 species and 116 captures).

TABLE 7
DIVERSITY INDEX SCORES FOR THE REPTILE ASSEMBLAGES AMONG THE FIVE SITES

	Fisher's Alpha	Shannon-Wiener (H)	Simpson index D
Site 1 – Banksia Woodland	5.3477	2.389	7.717
Site 2 – Banksia Woodland	6.565	2.505	10.026
Site 3 – Banksia Woodland	6.6229	2.402	8.651
Site 4 – Dryandra Shrubland on limestone	6.8786	2.462	9.117
Site 5 – Banksia Woodland	7.8724	2.446	8.685

3.10 Species of National Environmental Significance under the *EPBC Act 1999*

Numerous species of birds were identified as having national environmental significance under the *EPBC Act 1999* within the search grid co-ordinates. However, the vast majority of these are marine or coastal species that are likely to inhabit the marine environment to the west of the study site, and are unlikely to breed or forage on site. These birds have not been considered. The remaining species that may be found in the area are listed in Table 8. The only species of particular conservation interest under the *EPBC Act* likely to be found in the area are Carnaby's Black-Cockatoo and the Rainbow Bee-eater. The Chuditch, although recorded in the region is unlikely to inhabit the site due to a lack of suitable habitat and lack of recent records.

3.11 Significant Fauna under the *WA Wildlife Conservation Act 1950-1979*

In Western Australia, all native fauna species are protected under the *Wildlife Conservation Act 1950-1979*. Fauna species that are considered rare, threatened with extinction or have a high conservation value are specially protected under the Act. In addition, some species of fauna are covered under the 1991 ANZECC convention, while certain birds are listed under the Japan and Australian Migratory Bird Agreement (JAMBA) and the China and Australian Migratory Bird Agreement (CAMBA). In addition to the above classification, DEC also classify fauna under five different Priority codes and rare and endangered fauna are classified under the *Wildlife Conservation (Specially Protected Fauna) Notice 2006* into four schedules of taxa. These are:

- Schedule 1* – Fauna which are rare or likely to become extinct and are declared to be fauna in need of special protection.
- Schedule 2* – Fauna which are presumed to be extinct and are declared to be fauna in need of special protection.
- Schedule 3* – Birds which are subject to an agreement between the governments of Australia and Japan relating to the protection of migratory birds and birds in danger of extinction which are declared to be fauna in need of special protection.
- Schedule 4* – Fauna that are in need of special protection, otherwise than for the reasons mentioned in Schedule 1, 2 or 3.

In addition to the above classification, the DEC also classifies fauna under five different priority codes:

- Priority 1* – Taxa with few, poorly known populations on threatened lands. Taxa which are known from few specimens or sight records from one of a few localities on lands

not managed for conservation. The taxon needs urgent survey and evaluation of conservation status before consideration can be given to declaration as threatened species.

Priority 2 – Taxa with few, poorly known populations on conservation lands, or taxa with several, poorly known populations not on conservation lands. Taxa which are known from few specimens or sight records from one or a few localities on lands not under immediate threat of habitat destruction or degradation. The taxon needs urgent survey and evaluation of conservation status before consideration can be given to declaration as threatened fauna.

Priority 3 – Taxa with several, poorly known populations, some on conservation lands. Taxa which are known from few specimens or sight records from several localities, some of which are on lands not under immediate threat of habitat destruction or degradation. The taxon needs urgent survey and evaluation of conservation status before consideration can be given to declaration as threatened fauna.

Priority 4 and 5 – Taxa in need of monitoring. Taxa which are considered to have been adequately surveyed or for which sufficient knowledge is available and which are considered not currently threatened or in need of special protection, but could if present circumstances change. These taxa are usually represented on conservation lands. Taxa which are declining significantly but are not yet threatened.

Threatened and Priority species listed under the *Wildlife Conservation Act* or DEC's database that may potentially occur in the region are listed in Table 8. Included are two Schedule 1 species, and two Schedule 4 species. Four species with a priority listing with DEC have also been predicted or recorded in the general area. The likelihood of species listed under government legislation or conservation programs being found at Yanchep are discussed below. There are a number of species classified as 'Significant Bird Species' in the Bush Forever (Government of Western Australia, 2000) program in categories 2, 3 and 4. These are shown in Appendix 2.

TABLE 8
SPECIES LISTED AS BEING SIGNIFICANT VERTEBRATE FAUNA BY THE
COMMONWEALTH OR STATE GOVERNMENTS AND PREDICTED TO OCCUR OR
RECORDED IN THE YANCHEP AREA

Species	Status under Wildlife Conservation Act	Status under Commonwealth <i>EPBC Act</i>	Potential to be found in the study areas
<i>Calyptorhynchus latirostris</i> (Carnaby's Black-Cockatoo)	Schedule 1	Endangered	<i>Recorded</i> during this survey
<i>Dasyurus geoffroii</i> (Chuditch)	Schedule 1	Vulnerable	<i>Recorded</i> in region but not on site
<i>Falco peregrinus</i> (Peregrine Falcon)	Schedule 4		<i>Recorded</i> in region but not on site
<i>Morelia spilota imbricata</i> (Carpet Python)	Schedule 4		<i>Recorded</i> in region but not on site
<i>Phascogale tapoatafa tapoatafa</i> , (Southern Brush-tailed Phascogale)	Priority 3		<i>Recorded</i> in the region but <i>unlikely</i> to be in study area

Species	Status under Wildlife Conservation Act	Status under Commonwealth EPBC Act	Potential to be found in the study areas
<i>Neelaps calonotos</i> (Black-striped Snake)	Priority 3		Recorded during this survey
<i>Macropus irma</i> (Western Brush Wallaby)	Priority 4		Recorded during this survey
<i>Isoodon obesulus fusciventer</i> (Southern Brown Bandicoot)	Priority 5		Recorded in region but not on site
<i>Merops ornatus</i> (Rainbow Bee-eater)		Migratory	Recorded during this survey

3.12 Significant Fauna Likely to be Recorded in the Study Areas

Below is a brief description of the preferred habitat of species listed in Table 8 and our assessment of the likelihood of these species being found on the study site.

***Calyptorhynchus latirostris* (Carnaby's Black-Cockatoo)** - This species inhabits the southwest of WA. Its preferred habitat is woodlands where it preferentially feeds on plants of the Proteaceae family. Carnaby's Black-Cockatoo occurs within the Perth metropolitan area and are seen in the urban fringe areas on a seasonal basis, utilising native bushland and suitable vegetation along roads, remnant vegetation, reserves and where suitable food is available. Carnaby's Black-Cockatoo were sighted on the site most days during the fauna survey. There are anecdotal reports of it breeding in the Yanchep National Park area. Both habitats surveyed were utilised on a daily basis for feeding. Alan Tingay & Associates (1996) and CALM (1993) reported sighting Carnaby's Black-Cockatoo in the Alkimos-Eglinton area. The DEC is concerned about the continued loss of habitat for this species in the south-west of WA and has listed it as a Schedule 1 species (Fauna that is rare or is likely to become extinct) under the WA *Wildlife Conservation (Specially Protected Fauna) Notice 2006*. It is also classified as Endangered under the *EPBC Act 1999*, and clearing the vegetation will most probably result in a significant loss of habitat and foraging sites for this cockatoo. This proposed development is likely to trigger a referral under the *EPBC Act 1999* for this species.

***Dasyurus geoffroii* (Chuditch or Western Quoll)** – Formally known from over 70% of Australia, the Chuditch now has a patchy distribution throughout the Jarrah forest and mixed Karri/Marri/Jarrah forest of south-west WA. Their habitat is described by Strahan (2000) as sclerophyll forest or dried woodland and mallee shrubland. They den in hollow logs and burrows and have also been recorded in tree hollows and cavities (www.calm.wa.gov.au/plants_animals/pdf_files/sp_chuditch.pdf). A search of *FaunaBase* indicated that they have been caught in the general vicinity, however, they are generally not found in the coastal dunes or abutting forests so they are unlikely to be in the area.

***Falco peregrinus* (Peregrine Falcon)** – This species is uncommon, although widespread throughout much of Australia, excluding the extremely dry areas and has a wide and patchy distribution. It shows a habitat preference for areas near cliffs along coastlines, rivers and ranges and within woodlands along watercourses and around lakes. It has been recorded in 2004 and 2005 in the Yanchep area by ATA Environmental, however, not on site during this survey. This species is listed as Schedule 4 (Other specially protected fauna) under the WA *Wildlife Conservation (Specially Protected Fauna) Notice 2006*. This species is expected to

be an infrequent visitor to the area and the loss of habitat is unlikely to have an impact on this species.

***Morelia spilota imbricata* (Carpet Python)** – The South-west Carpet Python is a large snake found across the south-west of Western Australia, north to Geraldton and Yalgoo, and east to Kalgoorlie, Fraser Range and Eyre. They inhabit forest, heath, or wetland areas and shelter in hollow logs or in branches of large trees. Carpet Pythons are often found in colonies, particularly when breeding in spring. This species is widespread within the southwest, but is not in high densities across its distribution. ATA Environmental has multiple anecdotal reports of them being caught on Pipidiny Road (DEC staff, amateur herpetologists). ATA Environmental has also sighted them around Yanchep, and they have been reported in the Burns Beach area (Biota Environmental Sciences, 2000) and as far north as Green Head all on the Quindalup Dune system. It almost certainly occurs occasionally in the study area.

***Phascogale tapoatafa tapoatafa* (Brush-tailed Phascogale)** - A search of *FaunaBase* indicated that *P. t. tapoatafa* has been caught in the general vicinity. It has a preference for dry sclerophyll forests and woodlands with sparse ground cover (Strahan, 2000). There are no data to suggest that it is likely to be found on the coastal dunes, and thus in the study area.

***Neelaps calonotus* (Black-striped Snake)** – This species occurs on dunes and sand plains vegetated with heaths and Eucalypt / Banksia woodlands. It feeds largely on skinks and its distribution is restricted and threatened by urban development. It was recorded in Banksia woodland in the study area. How and colleagues (How, 1998; How *et al.*, 1996) reported finding them in similar habitat in the Bold Park area.

***Macropus irma* (Western Brush Wallaby)** – The Western Brush Wallaby was very common in the early days of settlement, however, its range has been seriously reduced and fragmented due to clearing for agriculture and there is a significant decline in abundance within most remaining habitats. It is now distributed across the south-west of WA from north of Kalbarri to Cape Arid. The optimum habitat is open forest or woodland, particularly favouring open, seasonally wet flats with low grasses and open scrub thickets (www.calm.wa.gov.au/plants_animals/pdf_files/sp_western_brush_wallaby.pdf). Alan Tingay & Associates (1996) also reported it in the area and DEC staff (1993) reported them in the reserve adjacent to Neerabup National Park. One Western Brush Wallaby was observed in Banksia woodland at site 2.

***Isoodon obesulus fusciventer* (Quenda or Southern Brown Bandicoot)** - The Quenda's preferred habitat is dense scrub and undergrowth. They will often feed in adjacent forest and woodland and in areas of pasture and crop land lying close to dense cover. This species has been recorded in the vicinity of the study area in *FaunaBase*. ATA Environmental has trapped Quenda in coastal dunes north of Yanchep (1km west of the study site) in habitat similar to the dense heath sections of the study area and Biota Environmental Sciences (2000) reported them in the Burns Beach area. Quenda therefore are likely to be in the study area but in low numbers. If they are in the study area they could be in any of the habitats that have a dense understorey, including the closed heath or dense shrublands.

***Merops ornatus* (Rainbow Bee-eater)** – The Rainbow Bee-eater is a migratory bird that arrives in the south-west of WA in late September – early October and nests in a burrow dug in the ground. This species is listed as a Migratory species under the *EPBC Act* It was recorded nesting on site in multiple locations across all habitat types during November 2005. It is found in a wide variety of sandy habitats on the Swan Coastal Plain and has also been recorded in most other surveys in the region.. There are many other suitable foraging and breeding sites for this species in the general vicinity. Individuals that forage and breed in this area will move to find alternative suitable habitat within the area.

Of the species listed under Commonwealth and State government legislation requiring special protection due to their vulnerability Carnaby's Black Cockatoo, Carpet Python, Black-striped Snake, Western Brush Wallaby, Southern Brown Bandicoot and Rainbow Bee-eater were recorded on or adjacent to the site. The Chuditch and Peregrine Falcon may be found in the region, however, are unlikely to utilise or rely on the study area for survival.

No significant trees containing hollows suitable for breeding Carnaby's Black-Cockatoos were recorded on site, however, there are many available to the east of the study area in Yanchep National Park. Anecdotal reports suggest that Carnaby's Black Cockatoos may have bred in the region in the past, however, breeding has not been confirmed by DEC or the WA Museum since the large fire which covered much of Yanchep National Park and surrounding region in summer 2003/2004. An inspection of the general area within a 10km radius of the site indicated that there were other areas in either private or government ownership that have similar vegetated habitats.

Carnaby's Black-Cockatoos were observed feeding most days on site, in both the Banksia and Dryandra vegetation. Although they utilise the site they have a range of alternative feeding and roosting areas in the region, including Yanchep National Park.

The Rainbow Bee-eater was recorded breeding in the study area, however, it has a range of alternative foraging and nesting areas in the region and is unlikely to be adversely affected by clearing.

The Southern Brown Bandicoot, and Carpet Python if present in the area and the Black Striped Snake, will most probably be lost if the bushland is cleared. The Western Brush Wallaby will almost certainly try to move to adjacent areas (e.g. National Park). Whether this happens will depend on the land clearing plan. Elsewhere on the Swan Coastal Plain government regulators have required that habitat containing bandicoots is set aside and protected, and if this is not possible, then a trapping program is put in place prior to the vegetation clearing to catch and relocate as many of the Southern Brown Bandicoots as possible. Relocations are not always successful, even into habitats where bandicoots are known to exist. It is therefore suggested that the proponent for this development seeks direction from DEC to determine what action is required to protect any bandicoots in the area. The same situation applies to the Western Brush Wallaby.

3.13 Introduced and Feral Animals

A number of introduced and feral animals were recorded for the study area (Appendix 2). Mice (*Mus musculus*), cats (*Felis catus*) and foxes (*Vulpes vulpes*) were observed and fresh daily tracks identified on the sand tracks indicated there are a number of individuals in the area. Clearing of the land may force the fox and cat populations into the adjacent urban area or Yanchep National Park, which could have an impact on the native fauna in these areas.

4. DISCUSSION

4.1 Survey Adequacy

There are numerous statistical tools available to estimate species richness. Species accumulation curves are the most often cited (e.g. How and Cooper, 2002; How and Dell, 2004; McKenzie, Rolfe *et al.*, 2000; Thompson, Withers *et al.*, 2003b) indicator of the adequacy of a fauna survey effort to inventory a particular area in WA and are regularly used in the literature as a method of assessing the adequacy of survey effort to inventory a site (Colwell and Coddington, 1994; Hayek and Buzas, 1997; Moreno and Halffter, 2000; Soberón and Llorente, 1993).

Species accumulation curves, or collectors' curves, plot the cumulative number of species discovered within a defined sampling area with increasing levels of survey effort. Species accumulation curves provide a measure of species inventory efficacy and completeness, and can be used for comparison among surveys based upon standardised sampling protocols (Moreno and Halffter, 2000). Species accumulation curves are also useful in estimating the minimum sampling effort required to reach a satisfactory level of completeness in a survey as judged by the proportion of the species in the area detected (Moreno and Halffter, 2000).

Numerous models have been discussed in the literature for species accumulation curves (see Diaz-Frances and Soberon, 2005; Soberón and Llorente, 1993; Thompson, Withers *et al.*, 2003b). Species accumulation curves are normally based on some uniform measure of detection (e.g trap-hours, hours of observations, pit-trap nights).

The trapping effort undertaken at Yanchep was sufficient to record greater than 90% of the trappable species in the area. The averaged species accumulation curves for the overall captures (Chart 1), captures in Banksia Woodland (Chart 2), captures in Dryandra shrubland (Chart 3) and recorded avifauna during systematic searches (Chart 4) show that the number of species trapped (or recorded systematically) approximates the predicted species richness for each area. Thirty-one species of a predicted 33 species for all trap sites (Chart 1), 30 of a predicted 31 for Banksia Woodland (Chart 2), 19 of a predicted 22 in Dryandra shrubland (Chart 3) and 59 of a predicted 63 avifauna (Chart 4) were recorded during the survey.

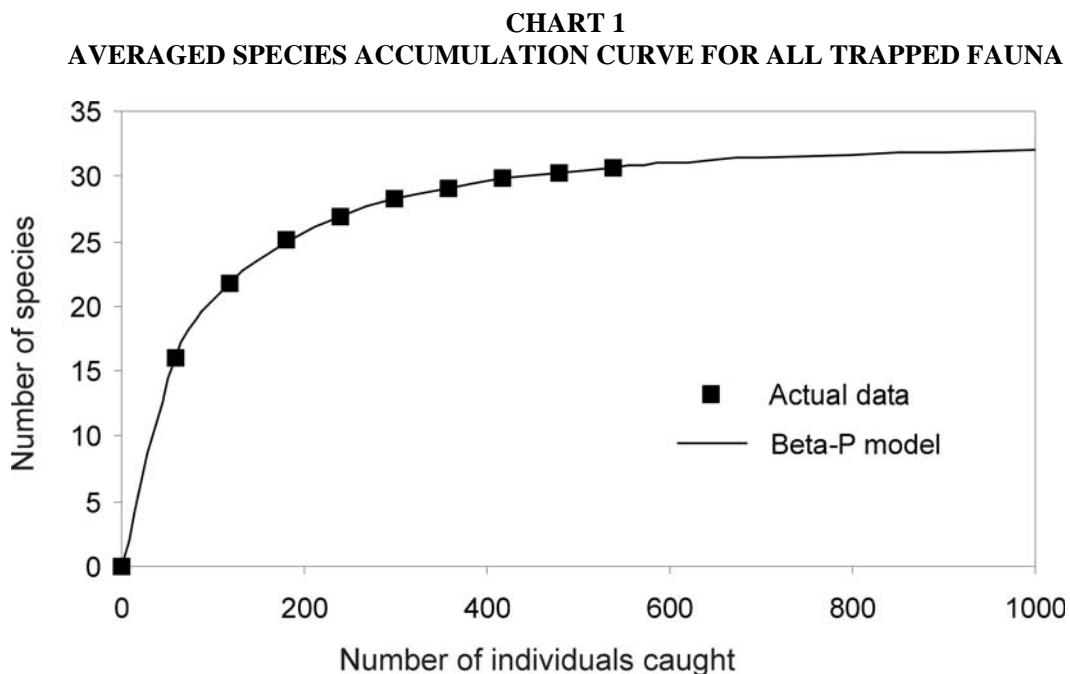


CHART 2
AVERAGED SPECIES ACCUMULATION CURVE FOR ALL TRAPPED FAUNA IN
BANKSIA WOODLANDS

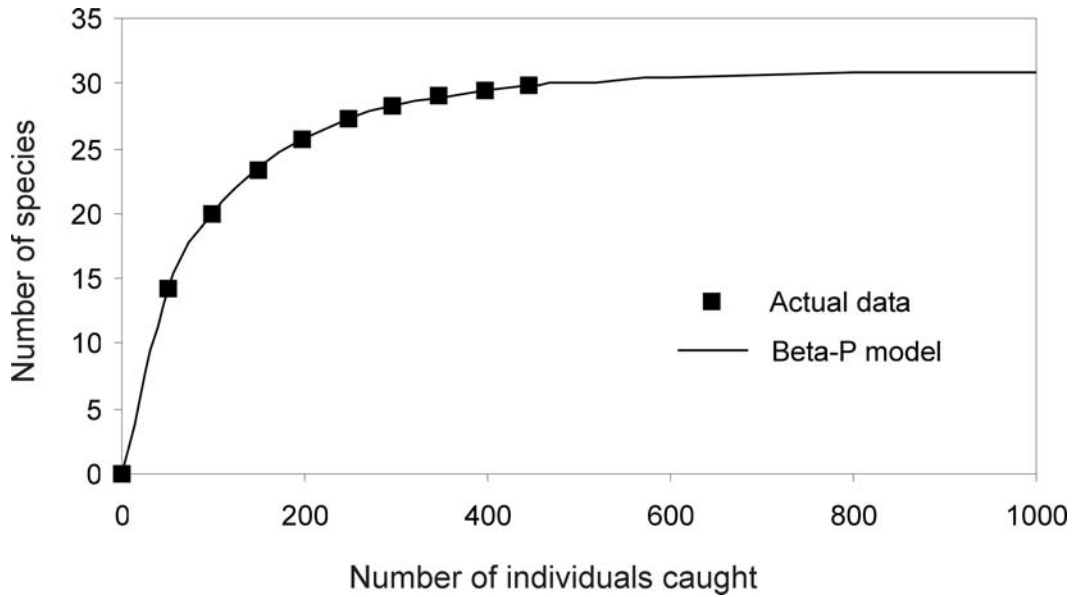


CHART 3
AVERAGED SPECIES ACCUMULATION CURVE FOR ALL TRAPPED FAUNA IN
DRYANDRA SHRUBLANDS

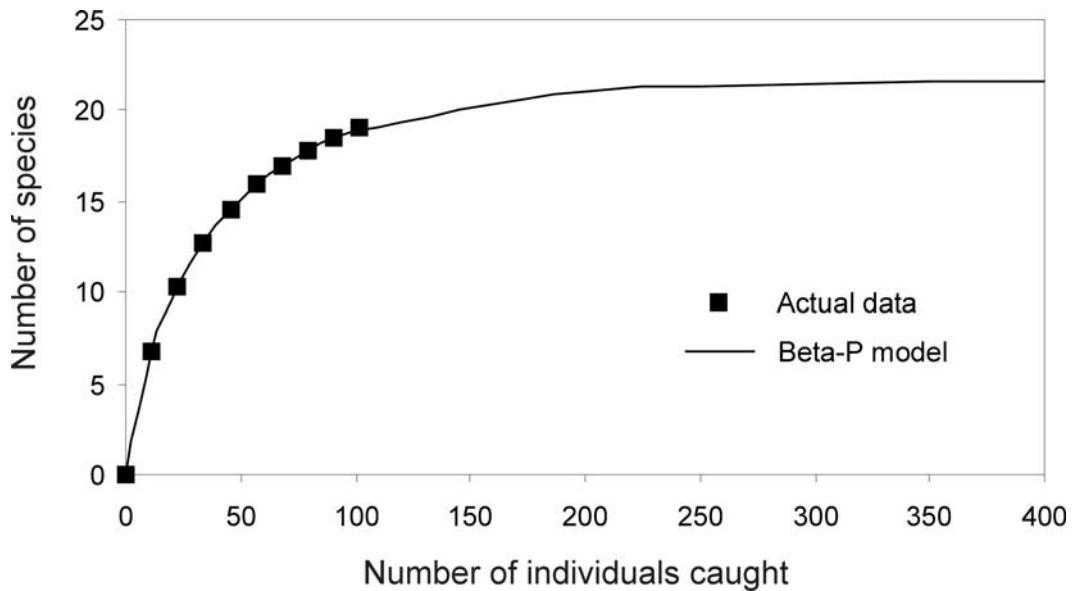
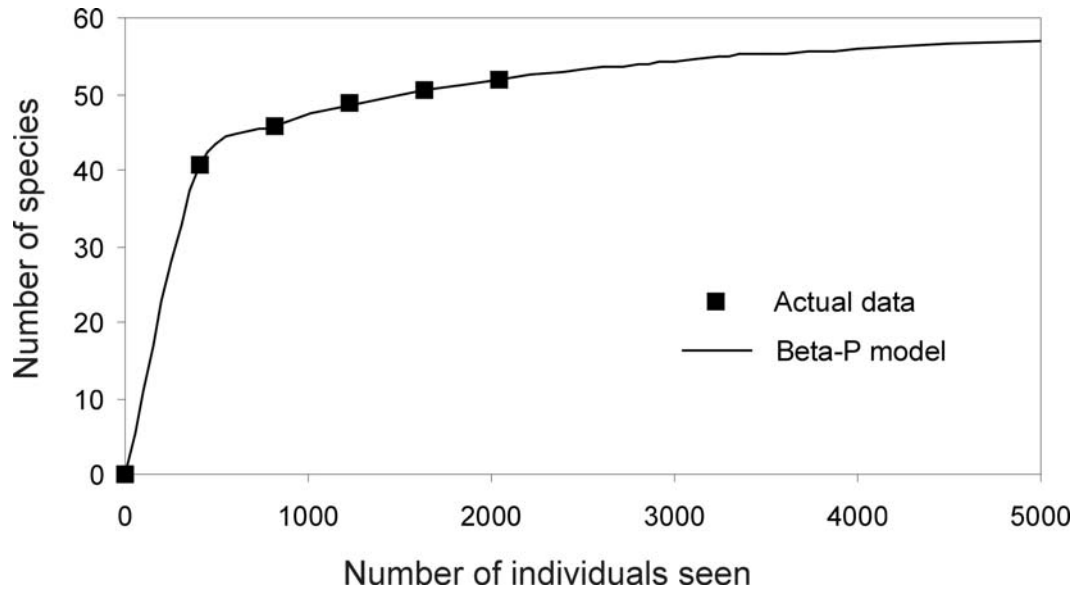


CHART 4
AVERAGED SPECIES ACCUMULATION CURVE FOR AVIFAUNA RECORDED IN
SYSTEMATIC SEARCHES



A complete inventory of the terrestrial vertebrate species present would only be achieved by multiple surveys repeated over multiple seasons and multiple years. This is not considered necessary for this remnant bushland as it is surrounded by current development and the Yanchep National Park and large portions of the site are already significantly degraded. Additional survey effort for birds would increase the number of bird species recorded, however, it is highly unlikely that additional species of conservation significance would be detected, and as such there is no case for additional bird surveys.

The trapping effort undertaken at Yanchep during November 2005 was more intense and used a wider variety of trap types when compared to other surveys in the region (Table 9).

TABLE 9
COMPARISON OF TRAP TYPE AND INTENSITY OF SURVEYS UNDERTAKEN IN
THE REGION

Trap type						Survey location and source
Bucket Pit-trap nights	Pipe-pit trap nights	Funnel trap nights	Elliott trap nights	Cage trap nights	Total trap nights	
785	7585	3140	1570	580	6860	This survey
115	115		400	80	710	Alan Tingay and Associates (1997)
224			440	40	704	Alan Tingay and Associates (1998)
250			220	80	550	Alan Tingay and Associates (1999b)
310*	311*		918	240	1779	Biota Environmental Sciences (2000)
	180				180	Burbidge, A., H. and Boscacci, L.J. (1989)
22	132		66		220	Department of Conservation and Land Management. (1993).
200*	199*		1120	114	1633	Halpern Glick Maunsell (2000a)
90*	95*		500	24	709	Halpern Glick Maunsell (2000b)
432			1440	144	2016	Western Australian Museum and Biota Environmental Sciences (2004)

*Estimate based on conversation with consultant as the exact pit-trap used is not clear.

In addition to increased trapping effort, ATA Environmental used funnel traps, which are a trapping strategy that have not been employed in fauna surveys until relatively recently. Funnel traps significantly increase the overall abundance of captured animals and catch species that would not normally be caught in pit and cage traps. Additional survey effort would no doubt increase the species count for the study areas, however, as How (1998) and Thompson, Withers, *et al.* (2003b) indicate, terrestrial fauna surveys for the purpose of preparing environmental impact assessment in WA have almost never undertaken sufficient trapping effort to adequately assess species diversity at undisturbed sites.

Catch rates were highest for reptiles in funnel traps and then 20L bucket pit-traps. This is similar to capture patterns for reptiles in the Goldfields and elsewhere across Western Australia (Thompson and Thompson, 2005, Thompson and Thompson, unpubl. data). Seven species were caught only in funnel traps (six of which are snakes or legless lizards), and one species (*Ramphotyphlops australis*) was only caught in buckets. Had a diverse trapping strategy not been employed a number of species may not have been caught and the overall abundance of captures would have been significantly lower.

During the hot summer months in mesic and semi-arid sites that have a 'normal abundance' of reptiles, the catch rate for pit-traps is between 7 and 14 per 100 trap nights. In Perth capture rates vary between 2.6 and 5.0 reptile captures per 100 pit-trap nights depending on sampling period (How 1998). The reptile catch rate for Yanchep was approximately six individuals per 100 trap nights. This capture rate is slightly higher than How's (1998) work in Bold Park. Had a diverse trapping strategy not been employed a number of species may not have been caught (e.g. *Demansia psammophis*, *Neelaps bimaculatus*, *N. calonotos*, *Pseudonaja affinis*, *Lialis burtonis*, *Delma fraseri*) and overall number of captures would have been significantly lower.

The most abundant reptiles captures were *Ctenotus fallens* (138) and *C. australis* (66), and the next most abundant captures *Helioporos eyrei*, (64) and *Limnodynastes dorsalis*, (68).

4.2 Faunal Assemblage Comparisons with Other Studies

Numerous fauna surveys have been conducted in the region. A comparison of data collected during this survey and results of previous surveys from the area are in Appendix 2 and discussed below.

4.2.1 Avifauna

As with other areas on the Swan Coastal Plain, there is an abundance of bird species in vegetated areas on Quindalup and Spearwood dunes. Alan Tingay and Associates (1996) reported 58 species of birds in the area compared with 59 in this survey. Many of these species display seasonal shifts in their activity areas and are quite plastic in their habitat requirements. The bird species list presented by Alan Tingay and Associates (1996) is very similar to the bird species list for the Mt Claremont site in How, *et al.* (1996). The recorded species list for this survey is very similar to each of the previous surveys on the Swan Coastal Plain.

Preferred habitat descriptions for many bird species are often quite general (see Johnstone and Storr, 1998; 2004). Subtle habitat differences that are important to many species but not always evident to observers have the consequence that we often do not appreciate why a species is found in one location and not in another that to us look very similar. A further complicating factor is that in recording the presence of a bird species in an area, seldom do we note whether it was breeding or foraging or just passing through, and therefore could be considered a vagrant that would not typically be found in the area.

An examination of Table 3 (and Appendix 2) provides an indication of the species likely to be found in the study area and the abundance of individuals recorded during the survey. Based on the habitat descriptions contained in Johnstone and Storr (1998; 2004), information in the other cited reports (see Appendix 2) and personal knowledge, species have been linked with different habitat types found in the region. It must be appreciated that Johnstone and Storr's habitat descriptions are based on species records from all over Australia and many species are quite plastic in their habitat requirements and there are notable geographic variations. Also, some species may forage in a particular area and retreat or breed in another area and require a combination of habitat types to survive. For example, some species forage in open areas in close proximity to thickets and use the thickets as retreats. Other species are 'generalists' and will forage in a variety of habitats and will readily adapt to habitats created by human disturbance. It is therefore very difficult to place some species into a specific habitat.

Based on the data in Table 3, an on-site survey could potentially record up to 35 bird species in low open heath, 27 species in low closed heath, 61 species in shrublands, 19 species in sedges and herbs, 89 species in areas of low open woodlands and a limited understorey, 57 species in areas of low closed woodlands and a dense understorey, 55 species in forests with a dense understorey, 80 species in forests with a limited understorey, 16 species in wetlands (i.e. not adjacent to wetlands) and 36 species in the cleared areas. Based on this analysis shrublands, woodlands and forests with limited understorey would have the highest species richness. However, habitats containing high species richness are not always the most significant from a biodiversity perspective. The presence of rare and range restricted species and those unable to move to suitable habitat when land clearing commences are also of particular interest.

Many of the bird species likely to be seen in the area are migratory (see Table 3), and therefore only utilise the area for part of the year. Other species are sedentary, some of which have relatively small home ranges. Many of the seed and nectar feeding species are mobile or migratory and shift foraging areas to take advantage of plants that flower and seed in different areas at different times. Availability of suitable breeding sites is linked to the seasonal movement of many species of birds. Because migratory species only use an area for part of the year it does not diminish the importance of the habitat for these species. The consequence of habitat loss for migratory species can be the same as for the sedentary species. The removal of the vegetation will require all species that utilise

the area to find alternative suitable habitats. It is possible that the migratory species may find alternative habitats easier, and be less impacted on than the sedentary species, because they are used to moving between areas.

Insectivorous species that are sedentary (or residents) depend on the available resources in the area for the duration of their life. Loss of vegetation will require them to move or perish. There is a paucity of data to indicate what happens to sedentary Western Australian bird species that have limited activity areas when these areas are cleared of their vegetation and used for residential development. Some species and individuals will obviously remain in the remnant vegetation, many will seek new areas during the clearing and development stages (and could perish); some that move away may return to the area once the development and construction work has ceased. It is possible that the more sedentary species are generally more at risk than migratory species when land clearing commences.

4.2.2 Herpetofauna

Alan Tingay & Associates (1996) recorded *Limnodynastes dorsalis* in Quindalup heath on the Alkimos-Eglinton site. Data in similar Quindalup and Spearwood dune habitats suggest that three species may be present (*Heleioporus eyrei*, *Limnodynastes dorsalis* and *Myobatrachus gouldii*). These are all ground burrowing frogs. Many of these frogs will be lost if vegetation is cleared and as earth works are undertaken or predated on at a later date when they surface to forage and there is limited vegetation cover. Individuals in remnant vegetation plots will probably survive. The hot dry conditions in November 2005 were not ideal for catching amphibians and it is surprising that *Heleioporus eyrei* and *Limnodynastes dorsalis* were active in the evenings. Calls for *Heleioporus eyrei* were also heard in the evenings during the night searches.

An individual *Neelaps calonotos* (Listed as Priority 3 with DEC) was collected in the Banksia woodland habitat. These snakes are reliant on large areas of undisturbed habitat for survival and are under pressure from land clearing on the Swan Coastal Plain. Other species recorded during the survey were typical of the region.

Although not caught, fresh diggings and tracks from varanids were recorded. These were most probably from *Varanus gouldii*.

Clearing of the area will inevitably result in the loss of a large number of the small reptiles. Some of the larger snakes (and possibly goannas) may move to adjacent areas during the clearing process. However, because many of these larger reptiles retreat to logs, tree hollows and burrows, it is highly probable that the heavy machinery used during the clearing process will destroy these animals in their retreats. The smaller geckos, skinks, legless lizards and dragon lizards will be either lost during the clearing process or will subsequently be predated on because of a lack of suitable habitat. These small reptiles are unlikely to move to alternative suitable habitats that are hundreds of metres away.

To ensure the preservation of reptile assemblages currently in the Yanchep area a mosaic of habitat types would be required to be left as remnant vegetation plots. The survey of the remnant vegetation in the metropolitan area of the Swan Coastal Plain by How and Dell (1996; 2000) indicated that many of the reptiles will survive in remnant plots of vegetation surrounded by residential development. Strategic clearing and retention of remnant habitat may therefore preserve intact reptile assemblages on site.

4.2.3 Mammals

A lack of systematic sampling for bat species in the area, or the northern Swan Coastal Plain Quindalup-Spearwood dunes systems, means that it is not possible to confidently predict which species of bat might be found in the area. Limestone caves to the north, forested areas in the vicinity

to the north, south and east of site could also provide roosts for (insectivorous) bat species that forage in this area. Species that could occur in the area include: *Mormopterus planiceps* (Southern Freetail-bat), *Tadarida australis* (White-striped Freetail-bat), *Chalinolobus gouldii* (Gould's Wattle Bat), *Chalinolobus morio* (Chocolate Wattle Bat), *Nyctophilus geoffroyi* (Lesser Long-eared Bat) and *Vespadelus regulus* (Southern Forest Bat). The clearing of vegetation and the consequential reduction of prey availability will negatively impact on the foraging insectivorous bat species if they are present in the area.

An interesting record was the capture of seven Honey Possums (*Tarsipes rostratus*). They are not widespread and their distribution is likely to be limited by the availability of suitable foraging flowers (e.g. Banksia). However, in appropriate habitat types Honey Possums can be found in relatively high numbers. Although it is not listed under the *EPBC Act* or *WA Wildlife Conservation Act* these observations are important for the region.

Very high numbers of Western Grey Kangaroos were observed on site, particularly in the southern sections. This is largely due to the well watered lawns of the St Andrews Golf Course. The kangaroos feed on the fresh cut lawns during the evenings and move into the protected and shaded areas during the days.

Clearing much of the vegetation in the area is likely to impact on the two mammal species of significant conservation interest to the WA Government that are potentially found in the area (*I. obesulus fusciventer*, *M. irma*). Elsewhere on the Swan Coastal Plain government regulators have required that habitat containing bandicoots is set aside and protected, and if this is not possible, then a trapping program is put in place prior to the vegetation clearing to catch and relocate as many of the Southern Brown Bandicoots as possible. Relocations are not always successful, even into habitats where bandicoots are known to exist. It is therefore suggested that the proponent for this development seeks direction from CALM to determine what action is required to protect any bandicoots in the area. The same situation applies to the Western Brush Wallaby.

For other mammal species on the site, they will either move or perish during the clearing process. Large mammals such as the Western Grey Kangaroo will no doubt initially flee to adjacent areas. Whether they survive will depend on the size and suitability of the habitat they move to. The extent to which small mammals (e.g. *I. obesulus fusciventer*, *T. rostratus*) survive will depend on whether they survive the clearing of vegetation, and how much of, and which components of, the existing habitat remain in the remnant plots.

4.3 Assemblages with Ecological Significance

The EPA's Position Statement No 3, *Terrestrial Biological Surveys as an Element of Biodiversity Protection* (EPA, 2002) and Guidance Statement No. 56: *Guidance for the Assessment of Environmental Factors; Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia* (EPA, 2004) indicate that field survey data should be used to assess the impact of the development on species and ecosystems.

Thompson *et al.* (2003a) described the pit-trappable reptile assemblages for biotopes and heterogeneous habitats for numerous semi-arid, arid and mesic sites in Australia. Typically, heterogeneous sites have between 27 and 50 species and larger areas have higher species richness. Undisturbed semi-arid and mesic biotopes generally have between 17 and 35 reptile species (How, 1998; Thompson *et al.* 2003a). The composition of arid and semi-arid reptile assemblages is made up of mostly skinks and geckos, with less agamids and elapids, and fewer varanids, pygopods and blind snakes. The Bold Park coastal dunes also contain a relatively high number of skinks (12), fewer elapids (6) and less geckoes (2), pygopods (2), agamids (2), blind snakes (1) and varanids (1; How, 1989). A similar reptile species assemblage was recorded at Yanchep with 12 skinks, 8 elapids, 1 gecko, 3 pygopods, 2 agamids, and 1 blind snake.

The number of reptile individuals caught at Yanchep was higher than other surveys, but typical of the assemblage expected in the region. There were no characteristics of the reptile assemblage or the species recorded on site to indicate that the assemblage has particular conservation significance in the region. The collection of *Neelaps calonotos* is an important record for the area, given the development pressure in the region.

For small mammal species, sites with heterogenous habitat types typically have up to 15 trappable small terrestrial species and six to eight species of bats (McKenzie, Keighery, *et al.* 2000), and larger more habitat diverse sites can have a higher diversity (How and Cooper 2002). For biotopes or habitats that are less diverse, the number of small trappable mammal species is generally between five and eight (Masters 1993, How and Cooper 2000, unpublished data for the Goldfields). Although low, the species richness for small mammals at Yanchep was typical of what would be found on coastal habitats in WA.

There were a number of cats and foxes present in the area. This was expected as they are present in similar habitats elsewhere on the northern Swan Coastal Plain. Other than the presence of Western Brush Wallaby, Honey Possum and the Southern Brown Bandicoot, there are no characteristics of the mammal assemblage or the species recorded on site to indicate that the mammal assemblage has particular conservation significance in the region. In accordance with the DEC's current policy, an effort will need to be made to protect habitat that are important for the Western Brush Wallaby and the Southern Brown Bandicoot in the planning and clearing of the study area. Where this is not possible, a trapping program may need to be implemented to relocate animals.

It is particularly difficult to quantify bird assemblages at a site as there are appreciable temporal variations driven by seasonal effects, specific rain events and droughts (Maron, Lill, *et al.*, 2005). The bird assemblage recorded at Yanchep was typical of other surveys conducted in the region and desktop predictions from known distributions. The site is used by breeding Rainbow Bee-eaters, and Peregrine Falcons have been recorded in the region. A large number of Carnaby's Black-Cockatoos were recorded feeding in the Dryandra shrublands and Banksia woodlands most survey days. No trees suitable for breeding Carnaby's Black Cockatoos were located on site although anecdotal and unconfirmed reports of breeding have been made east of the site at Yanchep National Park.

4.4 Biodiversity Value

The EPA Position Statement No. 3 indicates an ecological assessment of a site must consider its biodiversity value at the genetic, species and ecosystem levels; and its ecological functional value at the ecosystem level (EPA 2002).

It is ATA Environmental's view that species of mammals, reptiles, birds and amphibians present or likely to visit the study area would also be present or visit other similarly vegetated areas in the region. Species of conservation interest have been addressed above. The presence of the Western Brush Wallaby, Carnaby's Black-Cockatoo, Black-striped Snake, Rainbow Bee-eater and possibly the Southern Brown Bandicoot is an important consideration for the proposed development and any potential impacts to these species should be minimised. The preparation and implementation of a fauna management plan detailing techniques to minimise the impacts on these species is recommended for the proposed development.

It is not possible to assess the biodiversity value at a genetic level based on the information available.

Areas of highest conservation value from a faunal perspective in the St Andrews site are the Banksia woodlands and Dryandra shrublands. Regionally, the highest species richness for birds is

likely to be in the shrublands, woodlands and forests with a limited understorey, but species richness is only one variable to consider in preserving biodiversity. The small sedentary, insectivorous species have a preference for a variety of habitats including dense shrubs, woodlands with open and dense understoreys. Areas supporting Proteaceae spp. are particularly important as a feeding resource for Carnaby's Cockatoo. As many of the avian species will be displaced into adjacent areas, it will be important to place the potential loss of vegetation communities into a regional context. Small mammals will generally have highest species richness in areas with dense low vegetation. The Southern Brown Bandicoot has a strong preference for habitats that have dense low vegetation, although the Western Brush Wallaby has a preference for open forests and woodlands. Reptiles will be distributed among a range of habitats with few in the open areas that have little vegetation cover. The Carpet Python will most likely be found in the more vegetated areas.

Most of the vertebrate species in the study area with special conservation status utilise a variety of habitats (Table 10). In terms of the conservation of significant fauna habitat, preserving the large unburnt areas of Banksia woodland and Dryandra shrubland with good connectivity or that are adjacent to Yanchep National Park is preferred. The open cleared and more degraded areas have little fauna value. Table 10 shows the preferred habitats of conservation significant species listed as potentially being found in the Yanchep region. ATA Environmental acknowledges that the habitats described in Table 10 are different to this study however, they can be grouped into more broad habitat types if faunal assemblages are being compared.

TABLE 10.
HABITAT POTENTIALLY USED BY SIGNIFICANT FAUNA IN THE REGION

		Carnaby's Cockatoo	Peregrine Falcon	Rainbow Bee-eater	Southern Brown Bandicoot	Western Brush Wallaby	Carpet Python	Black- striped Snake
1.	Low open heath		X	X		X	X	X
2.	Low closed heath		X		X		X	X
3.	Shrublands	X	X	X	X	X	X	X
4.	Sedges/herbs		X	X				
5.	Low open woodlands with a limited understorey	X	X	X		X	X	X
6.	Low closed woodlands with a dense understorey	X	X		X		X	
7.	Forest with dense understorey	X	X		X		X	
8.	Forest with limited understorey	X	X	X		X	X	X
9.	Wetland		X		X		X	
10.	Cleared		X	X				

The high quality Dryandra heath and Banksia woodland areas provide a feeding resource for Carnaby's Cockatoo, habitat for many small birds, reptiles and mammals and may include other conservation significant species. To maximise the usefulness of remnant habitat for the maintenance of bird, reptile and mammal assemblages in the area, the preservation of a few large, recently unburnt areas that contain a mosaic of diverse habitat types with high connectivity is preferable to many small plots that are not linked.

5. SUMMARY AND CONCLUSION

EPA Position Statement No. 3 *Terrestrial Biological Surveys as an Element of Biodiversity Protection* (EPA, 2002) and EPA *Guidance for Assessment of Environmental Factors: Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia, No. 56* (EPA, 2004) are the two documents that indicate the EPAs required level of fauna assessment. Position Statement No. 3 and Guidance Statement No. 56 indicate that for large scale developments with potentially significant impacts on the environment, and where there is likely to be alteration to, or clearing of large sections of the original vegetation, a 'comprehensive' survey of the terrestrial fauna for the site is required. The work presented here complies with ATA Environmental's interpretation of each of the EPA documents.

ATA Environmental undertook a comprehensive Level 2 vertebrate fauna assessment of the St Andrews Structure Plan area (Southern Precinct). ATA Environmental believes that sufficient information has been gathered to assess the potential impact of the proposed development on the terrestrial fauna and the impacted ecosystems. ATA Environmental can see no justification for additional surveys to be undertaken in the area.

The objective of the survey was to confirm the faunal assemblage predicted for the project area using information gathered from similar sites on the Swan Coastal Plain. The faunal assemblage that is present and which will be impacted on during the land clearing process, is unlikely to be different to that found in similar habitat located in the vicinity of this study area elsewhere in the region. On this basis, it can be concluded that the site does not contain habitat of high ecological significance from a faunal perspective or contain faunal assemblages that are ecologically significant. Bushforever Site 288 (Yanchep National Park) located to the east of the site and Bushforever Site 289 to the south of the site are protected under conservation or Government programs and provide patches of similar quality habitat in the immediate vicinity of the project area. However, the Banksia woodlands and Dryandra shrublands available on site are considered significant as they provide a high quality feeding resource for Carnaby's Black-Cockatoos.

The proposed clearing of habitat will result in a loss of the sedentary species and will force the more mobile ones to move to adjacent areas. Species may be able to move to the adjacent Yanchep National Park or Bushforever Site 289. Based on the information accessed in this assessment, and taking into account the quantity of similar habitat located in the vicinity of the sites to be cleared, this loss of common species is not considered to be significant to the biodiversity of the region.

Four species (Carnaby's Cockatoo, Western Brush Wallaby, Black-striped Snake, Rainbow Bee-eater) of conservation significance that are listed under the *EPBC Act 1999* or the *Wildlife Conservation Act 1950* were recorded during the survey. In addition, four other species of conservation significance (Southern Brush-tailed Phascogale, Peregrine Falcon, Carpet Python, Southern Brown Bandicoot) have been recorded in the adjacent areas but not on site in this survey or previous surveys. Each of these species may be impacted by the proposed clearing. A ninth species (Chuditch) is known from the region, but was not recorded by ATA Environmental during this survey.

Of the three species listed for the area under the *EPBC Act 1999* only Carnaby's Black-Cockatoo and the Rainbow Bee-eater were recorded on site. Rainbow Bee-eaters are widespread and the proposed development represents a small fraction of similar habitat in the region that they are able to utilise. ATA Environmental's assessment is that the clearing of the site is unlikely to have any significant impact on this species.

Carnaby's Black-Cockatoos were recorded feeding on site in large numbers with between 2 and 83 individuals observed each day. No significant trees containing hollows suitable for breeding Carnaby's Black-Cockatoos were recorded on site, however, a number of tree hollows are available in Yanchep National Park (per obs.). Anecdotal reports suggest that Carnaby's Black-Cockatoos

may have bred in the region in the past, however, breeding has not been confirmed since the large fire that covered much of Yanchep National Park and surrounding region in summer 2003/2004. Both the Banksia woodland and Dryandra shrubland habitats within the project area were utilised on a daily basis as a feeding site for Carnaby's Black-Cockatoos. Alan Tingay & Associates (1996) and CALM (1993) also reported sighting Carnaby's Black-Cockatoos in the Alkimos-Eglinton area. Carnaby's Black-Cockatoo is classified as Endangered under the *EPBC Act 1999*, and clearing the vegetation will result in a loss of habitat and foraging sites for this species. Although there are alternative feeding opportunities in the broader region, the amount of Banksia woodlands or Dryandra shrublands of a similar high quality protected under conservation or government programs in the immediate vicinity is limited. ATA Environmental therefore recommends that the proposal is referred to the DEW under the *EPBC Act 1999* given that the development is likely to affect feeding areas for Carnaby's Black-Cockatoo and nesting sites for Rainbow Bee-eaters.

The Black-striped snake and Western Brush Wallaby were recorded on site and the Carpet Python and Southern Brown Bandicoot are probably on site given that they were recorded in adjacent areas. Clearing of the Banksia Woodland and/or Dryandra shrubland habitats will significantly impact on these species if sufficient habitat is not retained.

The proposed development of the area provides an opportunity to put in place best practise environmental principles and retain high quality fauna habitat in the Banksia woodlands and Dryandra shrublands. These initiatives will help maintain the faunal diversity on site and minimise impacts on conservation significant species.

6. MANAGEMENT RECOMMENDATIONS

Large sections of the site are significantly weed infested or degraded, with areas containing rubbish and car bodies. The increased amounts of grass and weed species have resulted in a low fauna habitat value for these areas. In comparison, there are areas of Banksia woodland and Dryandra shrublands within the project area that have high fauna habitat value representative of the region. Clearing of these high quality fauna habitats will significantly impact on fauna (including conservation significant fauna) on site.

The proposed development of the site will result in the loss of fauna habitat. It is recommended that where possible, the clearing of vegetation is restricted to those areas that are already degraded and disturbed, and where possible areas of high quality fauna habitat are left within the development. Adoption of this recommendation will minimise the development's impact on fauna assemblages and species of conservation significance.

ATA Environmental recommends that;

- A referral to the DEW under the *EPBC Act 1999* is made for Carnaby's Black-Cockatoo and the Rainbow Bee-eater;
- A trapping program is put in place to capture and relocate Quenda prior to commencement of land clearing;
- If it is likely that the Western Brush Wallabies in the area will not be able to readily move to adjacent areas during the development, then a capture and relocation program should be implemented;
- A fauna relocation and management plan is prepared for all conservation significant species potentially located in the area;
- If clearing of vegetation from areas of high fauna habitat is considered significant and is unavoidable, a suitable offset plan should be developed.
- Areas that are disturbed but will remain as Public Open Space after the proposed development has been completed, should be rehabilitated where possible with local Banksia and Dryandra species to provide supplementary feeding habitat for Carnaby's Black-Cockatoo and to provide habitat or smaller mammals and reptile species to move into these areas; and
- Remnant vegetation plots left in the development site should be few in number and as large as possible with high connectivity.

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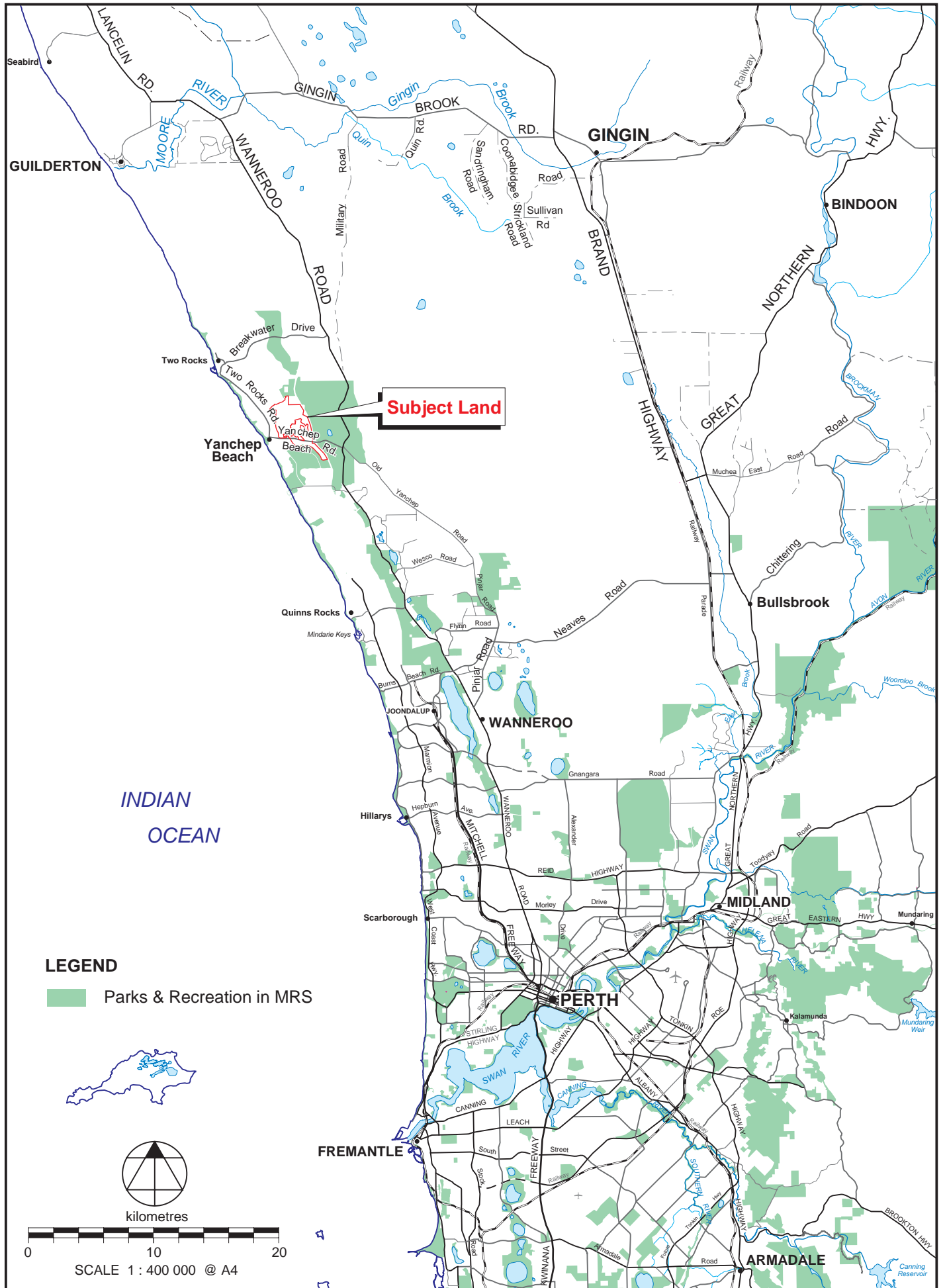
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FIGURES



APPENDICES

APPENDIX 1

DETAILS OF VOUCHERED SPECIMENS FOR WESTERN AUSTRALIAN MUSEUM

APPENDIX 2

**SPECIES OF VERTEBRATES LISTED IN A
FAUNABASE SEARCH OF QUADRAT LATITUDE
31.5° – 32° S AND LONGITUDE 115.5° - 116° E,
AND OTHER REPORTS ON THE NORTHERN
SWAN COASTAL PLAIN IN SIMILAR HABITATS**

Appendix 2.

Species Of Vertebrates Listed in a *Faunabase* Search of Quadrat Latitude 31.5° – 32° S and Longitude 115.5° - 116° E, and Other Reports on the Northern Swan Coastal Plain in Similar Habitats

Legend

E = Endangered

V = Vulnerable

S1 = Schedule 1 Wildlife Conservation Act 1950

S4 = Schedule 4 Wildlife Conservation Act 1950

P4 = Priority 4 taxa

P5 = Priority 5 taxa

L = species listed in legislation as having special conservation status because they are migratory

SB3 Bush Forever Significant Bird Species Category 3 (Bush Forever, 2000)

SB4 Bush Forever Significant Bird Species Category 4 (Bush Forever, 2000)

* locally extinct – Bush Forever (Government of Western Australia, 2000)

<i>Chrysococcyx lucidus plagosus</i>	X						X	X	X			X	X	X		1	2	X			X	X			X		X	
<i>Cuculus pallidus</i>	X									X	X	X				1	2										X	
Dicruridae (Fantails)																												
<i>Grallina cyanoleuca</i>	X								X		X					1	1	X	X	X	X							X
<i>Myiagra inquieta</i>	X	SB3																										
<i>Rhipidura fuliginosa</i>	X				X		X		X	X	X	X	3		2	5	X	X		X	X				X	X	X	
<i>Rhipidura leucophrys</i>	X				X		X		X	X		X	1	1	1						X				X			
Falconidae (Falcons)																												
<i>Falco berigora</i>	X	SB4					X																					X
<i>Falco cenchroides</i>	X				X	X	X	X	X	X			1	2							X	X			X	X		
<i>Falco longipennis</i>	X											X	X		1	1						X			X			
<i>Falco peregrinus</i>	X	S4, SB4					X																					
Halcyonidae (Kookabura and kingfishes)																												
<i>Dacelo novaeguineae</i>	X						X			X	X	X			1	1	1	X			X	X			X	X		
<i>Todiramphus sanctus sanctus</i>	X				X		X							1				X		X					X	X		
Hirundinidae (Swallows)																												
<i>Cheramoeca leucosternus</i>	X					X			X			X	1	1							X					X		
<i>Hirundo neoxena</i>	X					X			X			X	4	1							X				X	X		
<i>Hirundo nigricans</i>	X					X			X			X	18	1											X	X		
Laridae (Gulls and terns)																												
<i>Larus novaehollandiae novaehollandiae</i>	X								X						1													
Maluridae (Fairy-wrens)																												
<i>Malurus lamberti</i>	X	SB3				X															X				X			
<i>Malurus leucopterus</i>	X	SB3			X	X			X			X	4								X				X	X		

<i>Pachycephala rufiventris rufiventris</i>	X								X		X			X	X	X	X												X			X			X				
Pardalotidae (Pardalotes)																																							
<i>Pardalotus punctatus punctatus</i>	X														X																X			X					
<i>Pardalotus striatus</i>	X														X	X																	X	X					
Petroicidae (Robins)																																							
<i>Eopsaltria australis</i>	X																																						
<i>Petroica cucullata</i>	X		SB3						X								X																						
<i>Petroica goodenovii</i>	X																																						
<i>Petroica multicolor campbelli</i>	X		SB3														X	X																	X				
Phasianidae (Quail and pheasants)																																							
<i>Coturnix novaezelandiae</i>	X																																						
Podargidae (Tawny Frogmouth)																																							
<i>Podargus strigoides</i>	X																X	X																	X				
Psittacidae (Parrots and cockatoos)																																							
<i>Cacatua roseicapilla</i>									X		X	X	X	X	X																								
<i>Cacatua sanguinea</i>																																							
<i>Calyptrorhynchus latirostris</i>	X	E	S1, SB4						X	X		X																								X	X		
<i>Neophema elegans</i>	X																																			X			
<i>Neophema petrophila</i>			SB3																																				
<i>Platycercus spurius</i>	X																																			X	X	X	
<i>Platycercus zonarius</i>	X								X	X		X																									X	X	X
<i>Polytelis anthopeplus</i>	X																																						
<i>Trichoglossus haematodus</i>	X																																				X		
Strigidae (Owls)																																							

Reptiles																								
Agamidae (Dragon lizards)																								
<i>Pogona minor minor</i>	X		18	2	10	2	X	X			X	X	1	1	2	1	2		X	X	X	X	X	X
<i>Rankinia adelaidensis</i>	X		1	16	2							X		2								X		
Boidae (Pythons)																								
<i>Antaresia stimsoni stimsoni</i>	X																							
<i>Morelia spilota imbricata</i>	X	S4																					X	
Elapidae (Snakes)																								
<i>Brachyuropsis fasciolata</i>	X		4	1	2																			
<i>Brachyuropsis semifasciata</i>	X		14	2	1	5														X	X		X	
<i>Demansia psammophis reticulata</i>	X							X															X	
<i>Echiopsis curta</i>	X							X													X	X		
<i>Neelaps bimaculatus</i>	X		3	1	5	1					X		1							X			X	
<i>Neelaps calonotus</i>	X	P3	1	4	8	3																X		
<i>Parasuta gouldii</i>	X																							
<i>Pseudonaja affinis affinis</i>	X			1			X		X		X	1	1			1				X		X	X	X
<i>Simoselaps bertholdi</i>	X		26	24	52	20														X	X	X	X	X
Gekkonidae (Geckos)																								
<i>Christinus marmoratus</i>	X										X	X		3	2					X		X		X
<i>Crenadactylus ocellatus</i>	X										X			2										
<i>Diplodactylus alboguttatus</i>	X		1																					
<i>Strophurus spinigerus</i>	X		39	35	40		X		X			1									X	X	X	
Pygopodidae (Legless lizards)																								
<i>Aclys concinna concinna</i>	X																							
<i>Aprasia repens</i>	X		3	2		14				X		1				1				X	X	X	X	X

