

## Hanson's Red Hill Quarry Assessment of Fauna Values



Hooting Frog *Heleioporus barycragus* (Photo: S. Cherriman)

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## EXECUTIVE SUMMARY

As part of plans to continue to develop the existing quarry operated by Hanson Construction Materials Pty Ltd (Hanson) at Red Hill, Bamford Consulting Ecologists was commissioned to undertake an assessment of the fauna values of the site. The aims of this assessment were to determine the fauna present or likely to be present, comment on the significance of this fauna, discuss impacts and propose measures by which impacts could be ameliorated.

A literature review of the fauna of the region was carried out using standard databases and reference books, as well as personal experience, to generate a list of vertebrate species and significant invertebrate species expected to occur in the area. A field survey was then undertaken in December 2006, with work carried out at five locations across the proposed development site.

Field investigations included transect sampling for frogs, reptiles, birds and small mammals, cage and Elliott trapping for mammals in selected areas, and searching for significant and short range endemic invertebrates species. Opportunistic observations on fauna were maintained at all times. Surveys confirmed the presence of expected species and provided information on the ecology, habitat and patterns of distribution that helped in the assessment of impacts.

The literature review identified 187 species of vertebrate species that may occur in the vicinity of the proposed quarry development area, these include: 13 frogs, 52 reptiles, 95 birds and 27 mammals. A total of 3 frogs, 19 reptiles, 37 birds and 12 mammals were recorded during the December 2006 survey.

Potential impacts of the proposed development upon the fauna can be related to features of the assemblage and its ecology such as the presence of significant species, the locations of significant habitats, the ecological processes that affect the fauna and the patterns of faunal biodiversity across the landscape. The regional context is also important. These are discussed below.

### *Significant species*

The vertebrate assemblage includes 8 species of high conservation significance (CS1, listed under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* and/or Western Australian *Wildlife Conservation Act 1950*), 8 species listed as priority by the Department of Environment and Conservation (CS2) and 44 species considered to be locally significant because of the pattern of distribution (CS3). One of the species, a gecko, is of uncertain taxonomic affinities and a specimen was collected for examination at the WA Museum.

### *Significant habitats*

Significant habitats are areas of soils, vegetation types and/or landform that are important for significant species or biodiversity. The project area is unusual in having a great range of habitat types within a small area, making it difficult to identify habitats that are especially limited in distribution compared with other habitats on the site. For example, eucalypt woodland and forest is extensive but highly variable, with some areas supporting Wandoo and others with a dense understorey of *Dryandra*.

Both are important in different ways. Habitats that are especially distinctive, important for fauna and locally rare, however, are:

- Eucalypt woodlands, especially those including Wandoo;
- Granite outcrops;
- Heaths around granite outcrops;
- Lower slopes of hills where water is concentrated;
- Temporary creeks including Susannah Brook.

These habitats are considered to be locally rare because while they form a distinctive part of the landscape of the western escarpment, they are typically fragmented and small in area.

#### *Ecological processes*

- Levels of predation. Introduced predators such as Foxes and Cats can impact upon some native species, and the abundance of these predators can increase in association with resource development projects. Measures to avoid encouraging Foxes and Cats, and possibly control measures, should be considered. Control of such species could be a positive impact on some native fauna.
- Roadkill and other increased mortality may be a concern for species displaced by clearing operations.
- Connectivity of habitat. May be a concern if quarrying operations fragment connectivity between the northern areas of remnant vegetation and John Forrest National Park.
- Fire. Increases in the frequency or extent of fires should be avoided.

#### *Regional context*

The site is located in a valley on the western slopes of the Darling Scarp and is therefore similar in many respects to valleys to the north and south. Except for the existing quarry the valley is substantially undisturbed. Similar landforms are protected in John Forrest and Walyungah National Parks and the Darling Range Regional Park.

#### *Recommendations*

There is a number of ways in which impacts upon fauna can be managed and the following recommendations are made:

1. Development footprints should be minimised where practicable.
2. Habitat fragmentation should be avoided. If possibly, corridors of habitat should be retained and enhanced around quarrying and stockpile areas.
3. Management of feral fauna should be undertaken as part of the project, including educating personnel not to encourage feral species.
4. A fire management plan should be developed, including educating personnel to be careful to avoid starting fires. The quarrying operations need to have the capacity to control fires.
5. Fauna roadkills should be reported, especially if they involve significant species.
6. Personnel need to be made aware of significant fauna species likely to be encountered.
7. Personnel need to be made aware in general of the sensitivity of the local environment.

8. Lighting should be shielded and designed to minimise impacts upon fauna.

Some further investigations are recommended, including:

- If the gecko *Diplodactylus* aff. *polyophthalmus* proves to be an undescribed taxon, further field work will be required to determine its distribution on the Hanson property and nearby.
- Sampling for Short Range Endemic invertebrates needs to be carried out in winter when many of these species are active.

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## **INTRODUCTION**

Hanson Construction Materials Pty Ltd (Hanson) operates the Red Hill hard rock quarry on Toodyay Road, Red Hill (see Figure 1), and proposes to continue to develop the site to the north and north-east of the current quarry pit. Hanson also proposes to extend the area of the existing stockpile and dispatch area. The proposed development will increase the quarry disturbance footprint by approximately 80 ha in the long-term. The expected life of the proposed development is around 100 years.

Habitat loss from the proposed development has the potential to be permanent as rehabilitation potential of quarries is in general limited. There are also issues relating to spread of diseases, introduced animals, disturbance/loss of habitats that are small in extent, fragmentation of habitat and direct mortality. Some potential exists for conservation benefits through management activities such as feral animal control and fire management.

As part of the Environmental Impact Assessment process for this proposal, Bamford Consulting Ecologists was commissioned to conduct a literature review and field survey to assess the potential impact of continued quarry development upon terrestrial fauna. The purposes of this assessment were to:

- produce a list of fauna species observed or predicted to occur on the site;
- identify species of conservation significance that might occur;
- identify significant or sensitive habitats within the proposed development area; and
- make management recommendations.

This report details the findings of the survey and provides management recommendations to reduce the impact on fauna species.

## **METHODS**

### **Report structure**

The approach taken in this assessment comprises a literature review and predictive assessment of the fauna of conservation significance that are likely to be impacted by the proposed quarry operations. This ‘desktop’ study was followed by a field survey to confirm the presence (or assess the likelihood of presence) of these conservation significant species, to develop an understanding of the fauna (and fauna related issues) of the general area and to collect data that may assist in the environmentally responsible planning of the project. This process then allows an assessment of the potential impacts to fauna of the proposed project to be made and for amelioration measures to be suggested and discussed.

The report is structured to reflect the above.

The ‘Results’ section begins with an overview and list of all vertebrate fauna likely to be present on the site (based on a literature review). This is followed by detailed information and a risk assessment of the subset of vertebrate species that are considered to be of conservation significance in the project areas. An overview of the

conservation significant invertebrates that are likely to occur is then provided. Finally, the results of the field surveys are presented and analysed.

The 'Discussion' synthesises the results of the literature review and field surveys under several main headings:

- Impacting processes
- Significant species
- Significant habitats
- Processes
- Patterns of biodiversity
- Measures of abundance for monitoring

The report concludes with a summary of recommendations for the management of fauna during the development of the proposed Hanson quarry project.

### **Level of assessment**

The fauna assessment and report preparation were carried out with reference to guidance and position statements published by the WA Environmental Protection Authority (EPA) on fauna surveys and environmental protection, and Commonwealth Biodiversity Legislation (e.g. EPA 2002; e.g. EPA 2004). Reference was also made to guidelines for mining proposals published by the Department of Industry and Resources (DoIR 2006). The report synthesises the results of a literature review and field survey and is classified as a Level 2 survey (desktop study, reconnaissance and detailed survey) according to the EPA Position Statement No. 3 (EPA 2002).

### **Survey limitations**

The aim of fauna investigations in the process of Environmental Impact Assessment is to identify how fauna might be affected by a proposed development. The aim is not to produce a list of species confirmed to be present; what matters with respect to fauna are: ecological processes that may be impacted and upon which fauna depend (eg. hydrology, fire); significant habitats (eg. habitat distribution and linkage, rare habitats, habitats that support high or unusual biodiversity, habitats with a unique ecological role); and significant species. Also of interest are impacts upon regional biodiversity (EPA 2004).

Assessing potential impacts with respect to the above parameters requires familiarity with the landforms and vegetation types of a site, and sufficient information on the fauna to be able to predict what species might be present and how those species, especially significant species, might utilise the landscape. For the purposes of this review, the vertebrate fauna species likely to be present have been listed and the presence of many of those species has been confirmed; errors are likely to be a matter of inclusion rather than omission. Environmental preferences of many of these species are well-documented in the literature, especially for significant species. Sufficient field-work has been carried out in the general area for important habitats and processes to be recognised. The major limitations to these investigations relate to the lack of work in winter and early spring, when some seasonal species may be active. This limitation, and other issues identified from the results of the survey, are discussed below (see Conclusions and Recommendations).

## Personnel

The following personnel were involved in field investigations:

- Dr Mike Bamford *BSc (Biol.), Hons(Biol.), PhD(Biol.)*
- Mr Ian Harris *BSc (Cons. Biol./Env. Sci.)*
- Mr Simon Cherriman *Bsc (Biol)*
- Mr Simon Pawley

The report was prepared by Ian Harris and Mike Bamford. Assistance with the identification of reptiles and invertebrates was received from WA Museum staff: Brad Maryan and Mark Harvey respectively.

## Licences and permits

The field surveys were conducted under the Department of Environment and Conservation (DEC) Regulation 17 licence number SF005654.

## Site description

Hanson's quarry is situated on Toodyay Road, Red Hill. The three main areas surveyed are discussed below and are indicated on Figure 2:

Area A – Proposed stockpile extension area, consisting mainly of open woodland of *Eucalyptus wandoo* and *Eucalyptus accedens* with dense understorey, including *Hakea incrassata*, *Hakea undulata* and *Hakea trifurcata* on clay over shallow granite. (Vegetation Assemblage 5 based on report by Mattiske Consulting). There are also areas of open woodland of *Eucalyptus marginata* and *Corymbia calophylla* over a dense understorey of *Hakea incrassata*, *Allocasuarina humilis* and *Hakea undulata* on sandy soils over granite. Some small areas dominated by Proteaceae – Myrtaceae heaths exist in association with granite outcrops.

Area B – Proposed quarry pit development area (westerly), consisting mainly of open forest of *Allocasuarina fraseriana*, *Eucalyptus marginata* and *Corymbia calophylla* over low understorey including *Gravillea wilsoni*, *Hibbertia hypericoides* and *Hakea spp* on sandy gravel. Vegetation Assemblage 7 based on report by Mattiske Consulting). Parts of this area have been exposed to a fire in recent years and as such much of the understorey and fallen logs have been removed. *Dryandra sessilis* over laterite forms a dense understorey in the burnt areas.

Area C – Proposed quarry pit development area (northerly) is dominated by a mosaic of lithic complexes on exposed granites to patches of open to closed heath of Proteaceae and Myrtaceae species, including *Hakea incrassata*, *Hakea undulata*, *Allocasuarina humilis*, *Dryandra armata* var. *armata* and *Hypocalymma angustifolium* on exposed granites. Vegetation Assemblage 1 based on report by Mattiske Consulting). Area C slopes down to Susannah Brook with a narrow margin of associated riparian vegetation. Susannah Brook is seasonal with some pools persisting into summer.

## Literature search/Sources of information

A list of fauna that would be expected to occur in the vicinity of the Hanson quarry project was generated by searching available databases and literature. These include:

- the Western Australian Museum's (WAM) 'Faunabase'.
- Birds Australia's (BA) database for the second Atlas of Australian Birds.

- the Department of Environment and Conservation's (DEC) Threatened and Priority Fauna Database.
- the federal Department for the Environment and Heritage's (DEH) Environment Protection and Biodiversity Conservation (EPBC) database (EPBC Protected Matters Search Tool).
- the information and species distribution maps provided by Tyler *et al.* (2000), Storr *et al.* (1983; 1990; 1999), Wilson and Swan (2003), Cogger (2000), Johnstone and Storr (1998), Strahan (1995), Menkhorst and Knight (2004) and Churchill (1998).
- publications and reports specific to the area, including Bush *et al.* (1995), Dell (1983), and an unpublished species list from trapping in John Forrest National Park in spring 1990 and autumn 1991 (Ninox Wildlife Consulting).
- the consultants' previous experience of the region's fauna (based on surveys carried out in the general area).

The database searches conducted and the areas searched are shown below:

Database	Type of records held in database	Areas searched
Faunabase (WAM)	Records of fauna specimens held in the WA Museum. Includes historical data.	31.7242S, 115.4883E and 32.2486S, 116.4565E
Atlas II Database (BA)	Records of bird observations in Australia, 1995-present.	32 0000S, 116 0000E to – 31 0000S, 117 0000E
Threatened and Priority Fauna Database (DEC)	Information and records on Threatened and Priority fauna species in Western Australia.	31.75°S, 116.00°E 32.00°S, 116.10°E
Environment Protection and Biodiversity Conservation (EPBC) database - EPBC Protected Matters Search Tool (DEH)	Records on matters protected under the EPBC Act, including threatened species and conservation estate.	31.81024S, 116.05108E, 31.83778S, 116.05108E, 31.83778S, 116.08499E, 31.8102S, 116.08499E

Because the proposed quarry development project will not encounter marine systems under Commonwealth control, obligate marine animals were excluded from the results presented here. Similarly, obligate waterbirds were largely excluded from the species lists because of the low occurrence of water bodies in the near vicinity.

## Field surveys

### *Dates of survey*

The field survey was conducted from 15<sup>th</sup>-23<sup>rd</sup> December 2006. Work consisted of trapping for frogs, reptiles and mammals; bird surveys; maintaining an annotated bird list of all bird records; spotlighting; mist netting and acoustic surveys for bats. Short range endemic (SRE) invertebrate and threatened/priority vertebrate fauna searching were also carried out. Opportunistic observations were made at all times. The dates of each survey and the range of work conducted are shown below. Locations where sampling was carried out are indicated on Figure 2. During the survey period, weather was initially hot with warm nights, but conditions cooled towards the end of the period. No rainfall was recorded.

### *Trapping for frogs, reptiles and mammals*

Pitfall, funnel, small box (Elliott) and cage traps were used to sample the amphibian, reptile and mammal fauna of the project area. The trapping regime implemented in the December 2006 field survey is summarised in Appendix 1.

#### *Pitfall and funnel trapping*

Trapping transects were established at five sites:

Site A – 10 locations (between 412 692E, 6 477 830N and 412 806E, 6 477 540N) In Area A (proposed stockpile extension area). Traps in Jarrah and Wandoo forest with a shrubby understorey on gravelly loam.

Site B – 10 locations (between 412 222E, 6 478 257N and 412 460E, 6 478 118N) In Area B (proposed quarry pit development area (westerly)). Traps in Jarrah and she-oak forest with an understorey of *Dryandra sessilis* thicket on gravelly sandy-loam.

Site C – 10 locations (between 412 436E, 6 478 463N and 412 638E, 6 478 768N) In Area C (proposed quarry pit development area (northerly)). Traps in Jarrah forest with some Marri and Wandoo, passing through thickets of *Hakea trifurcata* and heath in area of shallow soil over granite. Granite boulders present at eastern end. Soils variable from sandy-loams to clays.

Site D – 10 locations (between 412 421E, 6 478 734N and 412 677E, 6 478 985N) In Area C. Traps in Jarrah and Wandoo forest with a shrubby understorey. Some exposed granite. Soils variable from sandy-loams to clays.

Site E – 10 locations (between 412 376E, 6 479 011N and 412 593E, 6 479 179N) In Area C. Traps in heath over shallow soil interspersed with exposed granite, but patches of wandoo in deep soil between rocky areas. Soils variable but mostly sandy loams with some grey clays.

Locations of each pitfall trap is given in Appendix 2a and locations in relation to vegetation communities are given in Appendix 2b.

All transects were positioned so that they intercepted differing vegetation communities and soil types. This landscape approach is designed to maximise the number of vegetation and soil associations sampled whilst allowing analysis of the results in a landscape context. Importantly, this approach samples ecotones (transitions between vegetation and soil types).

Pitfall traps were 40L PVC buckets with a flywire-covered drainage hole in the base. A 25cm high flywire drift-fence extended 2.4m to one side of the pit and 1.2m to the other side of the pitfall. Traps were located at approximately 25 m intervals along the transect, depending on substrate.

Funnel traps were *c.* 15cm wide and 60cm long, with a funnel entrance diameter of 5cm. Funnels were set up at the end of the 2.4m pitfall drift fence, with the funnel entrance bisected by the fence. Funnel traps were covered with shade cloth or vegetation to provide shelter for captured animals.

### *Cage and Elliott trapping*

Three Cage and Elliott trap transects were established between the following locations:

Area A – 412 710E, 6 477 557N to 412 829E, 6 477 826N to 412 928E, 6 477 837N.

Area B – 412 259E, 6 478 184N to 412 175E, 6 478 455N.

Area C – 412 634E, 6 478 562N to 412 415E, 6 479 294N.

Each transect consisted of 15 Elliott (*c.* 80 x 100 x 325mm) and 15 cage traps (*c.* 180 x 180 x 600mm). They were placed under vegetation at 20m intervals and baited with a mixture of rolled oats, peanut paste and tinned sardines. Cage traps were also covered with a hessian bag to provide cover for captured animals.

### *Bird surveys*

In conjunction with the checking of traps, systematic bird surveys were undertaken along each of the pitfall trapping transects by recording and counting birds within 25m of each pitfall (a 'point transect' count, see Recher 1988). Birds seen or heard outside the 25m radius survey zone were also noted.

### *Annotated bird lists*

In addition to the systematic bird surveys, an annotated bird list was maintained. This list was a record of all bird species recorded on each survey (from systematic or opportunistic observations), with notes on their abundance or location where appropriate. Such opportunistic observations can be important for listing significant bird species.

### *Nocturnal surveys (spotlighting and bat surveys)*

Nocturnal surveys were undertaken on the evening of 21<sup>st</sup> December. Spotlighting (for nocturnal animals) surveys were undertaken on foot, generally in the vicinity of the proposed quarry pit development area, concentrating on granite outcrops surrounded by dense heath and eucalypt woodland. The survey commenced within an hour of sunset and continued for between one and three hours.

Bats were surveyed by two methods: mist netting and acoustic survey. Mist nets were erected at two sites within the proposed quarry pit development area, with both nets along an existing access track at locations: 412 521E, 6 478 937N and 412 548E, 6 478 796N.

Attempts to detect bats were also made by using an ultrasonic detector during mist netting activities. Echolocation calls were recorded using the Anabat system (Titley Electronics, Ballina, NSW), where calls are recorded through the Anabat II Bat Detector onto an Edirol R1 Wave/MP3 digital recorder. Recorded calls are subsequently played back through a ZCAIM unit (Titley Electronics, Ballina, NSW) into Anabat software to analyse the call characteristics. However, the only calls recorded were recognised to species from sound and flight characteristics, so call analysis were not undertaken.

### *Short range endemic (SRE) invertebrates*

Short range endemic invertebrates are species with restricted distributions. Harvey (2002) notes that the majority of species that have been classified as short-range endemics have common life history characteristics such as poor powers of dispersal or confinement to discontinuous habitats. Several groups, therefore, have particularly high instances of short-range endemic species: Gastropoda (snails and slugs), Oligochaeta (earthworms), Onychophora (velvet worms), Araneae (mygalomorph spiders), Isopoda (slaters) and Diplopoda (millipedes). Some SRE invertebrates, including millipedes, scorpions and slaters, can be found by targeted searching as well as sometimes being caught in pitfall traps designed for vertebrates. Searching was carried out by turning over logs and rocks and searching through soil excavated when diggings pitfall traps. Such searching is usually more effective under cool moist conditions than in early summer, however, and further searching is recommended (see below).

### **Nomenclature and taxonomy**

As per the recommendations of EPA (2004), the nomenclature and taxonomic order presented in this report are based on the Western Australian Museum's *Checklist of the Vertebrates of Western Australia*. The authorities used for each vertebrate group are: amphibians and reptiles (Aplin and Smith 2001), birds (Christidis and Boles 1994; Johnstone 2001), and mammals (How *et al.* 2001).

### **Assessment of conservation significance**

The conservation status of fauna species is assessed under Commonwealth and State Acts such as the *Commonwealth Environment Protection and Biodiversity Conservation Act* (EPBC Act) 1999 and the *Western Australian Wildlife Conservation Act* 1950. The significance levels for fauna used in the EPBC Act are those recommended by the International Union for the Conservation of Nature and Natural Resources (IUCN 2001). The *WA Wildlife Conservation Act* 1950 uses a set of Schedules but also classifies species using some of the IUCN categories. These categories and Schedules are described in Appendix 3.

The EPBC Act also has lists of migratory species that are recognised under international treaties such as the China Australia Migratory Bird Agreement (CAMBA), the Japan Australia Migratory Bird Agreement (JAMBA) and the Bonn Convention (The Convention on the Conservation of Migratory Species of Wild Animals). The list of migratory species under the EPBC Act has been revised to include species only, thus excluding family listings (DEH, pers. comm.). Those species listed in JAMBA are also protected under Schedule 3 of the *WA Wildlife Conservation Act*. There is a separate list of marine species under the EPBC Act, but this only applies to land and waters under Commonwealth management. Therefore, marine listings are not included in this report.

The Department of the Environment and Heritage (DEH, formerly Environment Australia) has also supported the publication of reports on the conservation status of most vertebrate fauna species: reptiles (Cogger *et al.* 1993), birds (Garnett and Crowley 2000), monotremes and marsupials (Maxwell *et al.* 1996), rodents (Lee 1995) and bats (Duncan *et al.* 1999). The Threatened Species and Communities Section of Environment Australia has also produced a list of Threatened Australian

Fauna, although this list is effectively a precursor to the list produced under the EPBC Act. These publications also use the IUCN categories, although those used by Cogger *et al.* (1993) differ in some respects because this report pre-dates categories reviewed by Mace and Stuart (1994) and revisited since by IUCN (2001).

In Western Australia, the Department of Environment and Conservation (DEC) has produced a supplementary list of Priority Fauna, being species that are not considered Threatened under the WA Act but for which the Department feels there is cause for concern. Some Priority species, however, are also assigned to the IUCN Conservation Dependent category. Levels of Priority are described in Appendix 3. Assessments in this report are based on the most recent version of the DEC priority list (June 2006).

Fauna species included under conservation acts and/or agreements are formally recognised as of conservation significance under state or federal legislation. Species listed only as Priority by DEC, or that are included in publications such as Garnett and Crowley (2000) and Cogger *et al.* (1993), but not in State or Commonwealth Acts, are also of recognised conservation significance. In addition, species that are at the limit of their distribution, those that have a very restricted range and those that occur in breeding colonies, such as some waterbirds, can be considered of conservation significance, although this level of significance has no legislative or published recognition and is based on interpretation of distribution information. The WA Department of Environment (formerly the Department of Environmental Protection, DEP) used this sort of interpretation to identify significant bird species in the Perth metropolitan area as part of Perth Bushplan (DEP 2000).

On the basis of the above comments, three levels of conservation significance are recognised in this report:

- *Conservation Significance (CS) 1:* Species listed under State or Commonwealth Acts.
- *Conservation Significance (CS) 2:* Species not listed under State or Commonwealth Acts, but listed in publications on threatened fauna or as Priority species by DEC.
- *Conservation Significance (CS) 3:* Species not listed under Acts or in publications, but considered of at least local significance because of their pattern of distribution. This level may have links to preserving biodiversity at the genetic level (EPA Position Statement No. 3, EPA 2002). For example, if a population is isolated but a subset of a widespread (common) species, then it may not be recognised as threatened, but may have unique genetic characteristics. Species on the edge of their range, or that are sensitive to impacts such as habitat fragmentation, may also be classed as CS3.

In addition to these statuses, species that have been introduced (INT) are indicated.

## RESULTS

### Overview - vertebrates

The literature review identified 189 species of vertebrate that may occur in the vicinity of the proposed Hanson quarry development site. This total includes 13 frogs, 52 reptiles, 95 birds and 29 mammals (Tables 1 to 4). In addition, several freshwater fish may move upstream along nearby Susannah Brook during winter, but this watercourse was virtually dry during the study. Native freshwater fish likely to use the brook are not of conservation significance, although potential impacts on the watercourse and downstream wetlands are considered below.

The vertebrate assemblage is typical of the Darling Scarp and is notable for the wide range of species so close to Perth, the presence of coastal plain species that are at the inland limit of their range in valleys of the western scarp, several species that are virtually restricted to the scarp and several species that are at the western limit of their range. Much of the assemblage is made up of widespread species.

Results of the field survey are summarised in Table 6, with raw data on captured animals in Appendix 6. In total, 114 captures were made from 21 species including: 2 frogs, 2 dragons, 35 geckoes, 2 pygopodids, 20 skinks, 3 snakes and 50 mammals. Some other frog, reptile and mammals species were observed only, while all bird records were made by observation.

### *Amphibians*

Of the 13 amphibian species (Table 1) likely to occur in the immediate vicinity of the project area, 10 have been recorded in John Forrest National Park and only three were recorded during the survey of the project area. This reflects the dry seasonal conditions, and there is little doubt that the majority of the remaining species are present in the project area. The only frog caught in the project area was the Hooting Frog *Heleioporus barycragus*, pitfalled at Sites A and D, while the two tree-frogs were observed along Susannah Brook. The Hooting Frog is of Conservation Significance level 3 (see below).

The amphibian species expected to occur in the project area can survive without permanent water and most are exclusively terrestrial as adults. All but the Turtle Frog *Myobatrachus gouldii*, however, require water in which to breed. Most of the frog species are widespread in the South-West, but the frog assemblage is notable for the presence of species restricted to the scarp (the Bleating Frog *Crinia pseudinsignifera* occurs only along the scar in the Perth area and Hooting Frog is confined to the scarp).

### *Reptiles*

Of the 52 reptile species likely to occur in the vicinity of the project area, 19 were recorded during the field survey and 22 had previously been observed in nearby John Forrest National Park. The project area list included 9 species not recorded in the National Park, while 11 species were recorded in the National Park but not in the project area. This sort of difference is a feature of short surveys for reptiles as many species are difficult to find, and recording species is often a matter of luck. The

difference between the two surveys does not mean that the reptile assemblages are greatly different.

The reptile assemblage in the project area is rich because the position of the site, on the western edge of the escarpment, and the presence of sandy soils around the granite areas, means that the location can support reptiles from the coastal plain and the scarp. Species typically restricted or mostly restricted to the coastal plain are: Fry's Worm-Lizard *Aprasia repens*, the legless-lizard *Pletholax gracilis*, and the skinks *Ctenotus fallens* and *Morethia lineocellata*. Species restricted to the scarp in the region are: Ornate Dragon *Ctenophorus ornatus*, Clawless Gecko *Crenadactylus ocellatus*, Wheatbelt Stone Gecko *Diplodactylus granariensis*, the gecko *Diplodactylus polyophthalmus*, Beautiful Gecko *Diplodactylus pulcher*, Granite Worm-Lizard *Aprasia pulchella*, Dell's Skink *Ctenotus delli*, the skinks *Eremiascincus richardsonii*, *Hemiergus intialis* and *Lerista distinguenda*, Stimson's Python *Antaresia stimsoni* and the Southern Death-adder *Acanthophis antarcticus*. Bush *et al.* (1995) discusses the distribution in the Perth area of these species. Some of the species associated with the scarp are also widespread to the east, such as the Wheatbelt Stone Gecko, while the remaining species are generally widespread across the coastal plain and scarp at least in the Perth region.

Numbers of captures on the sites were too low for statistical analyses (Table 6), but Site B (in Area B, Jarrah forest over *dryandra sessilis* thicket) had the lowest numbers of species and captures of reptiles. There was a trend for more species and more individuals in Sites C, D and E, near the granitic areas. Site A had a similar number of species to the sites near granitic areas, but fewer individuals caught.

Eleven reptiles species are of conservation significance although seven of these are significant only at the local level (CS3). These species are discussed below.

### *Birds*

The list of bird species expected to occur in the project area (Table 3) has been limited to those species likely to make regular use of the site and for which the site may be significant in supporting local populations. Thus, species that may occur as vagrants, including most waterbirds, have been excluded. Of the 95 species expected, 37 were recorded during the survey and 50 were recorded in John Forrest National Park in 1990/1991. Nine of the species recorded in the project area were not recorded in the National Park, but they are known regularly from the western scarp (Dell 1983).

The expected assemblage of birds is not species rich and the list of 37 species recorded during the survey is low in comparison with surveys with similar effort but in regions where there are wetlands. Wetlands provide habitat for additional species, both waterbirds and species that occur in productive vegetation around wetlands. The assemblage is broadly typical of the western escarpment with a few species either recorded or very likely to be present that have some specific habitat requirements. Notable are species associated with heathland (Tawny-crowned Honeyeater *Phylidonyris melanops* and Southern Emu-wren *Stipiturus malachurus*) and species associated with riparian vegetation (Red-winged Fairy-wren *Malurus elegans* and Red-eared Firetail *Stagonopleura oculata*). Of these four species only the Red-eared Firetail was observed, but the Southern Emu-wren has previously been recorded in heathland on the opposite side of Toodyay Road (M. Bamford, unpubl. data).

Bird observations made while checking traps each day (Table 8) provide some measure of comparative abundance between the sites. Site D (Jarrah and Wandoo forest with a shrubby understorey; some exposed granite) was notable for the largest numbers of sightings and of species, but even this site had only 21 of the 37 species observed during the survey. Site B (Jarrah and she-oak forest with an understorey of *Dryandra sessilis* thicket), which was poor for reptiles, had a high number of sightings of birds but only 14 species observed.

Bird species of conservation significance make up a high proportion of the expected assemblage (38 of the 95 species), but this is strongly influenced by the recognition of species that have declined in the Perth area (DEP 2000). Significant species are discussed below.

### *Mammals*

The Mammal assemblage expected in the project area (Table 4) includes 29 species, of which 7 are introduced. Of the 29 species, only 12 were recorded during the survey compared with 11 in John Forrest National Park in 1990/1991. Five of the species recorded in the project area were not recorded in the National Park while four recorded in the National Park were not found in the project area. However, all these species are expected to be present in both areas. At least a further 6 mammal species are considered to be locally extinct (ie. species that no longer occur in the area but were present at the time of European settlement, see Table 5). High rates of extinction among mammals is typical of mainland Australia and has been associated with a wide range of factors, including changes in fire regimes, introduced predators and competition with introduced herbivores (including livestock) (Burbidge and MacKenzie 1989).

Bats make up 41% of the native mammal species expected to be present but the presence of only two species in the project area was confirmed during night-work (Gould's Wattle Bat *Chalinolobus gouldii* and White-striped Freetail Bat *Tadarida australis*). Small, non-flying native mammal species were well-represented for a site so close to Perth, with both the Western Pygmy-possum *Cercartetus concinnus* and Honey Possum *Tarsipes rostratus* recorded in the project area. These two species were not recorded in John Forrest National Park in 1990/1991, although they are almost certainly present there. Native mammals not recorded in the project area but expected to occur are almost certainly present, although perhaps not continuously. For example, the Rakali or Water-Rat *Hydromys chrysogaster* may visit the area when Susannah Brook is flowing.

The distribution of mammal captures (Tables 6 and 7) was complex, with site A having the most mammal species recorded in pitfall traps, but Sites C and D having the greatest number of captures. This was because of Honey Possums *Tarsipes rostratus* being abundant in the heath close to exposed granite. Site B was notable with 10 of the 12 Mardo *Antechinus flavipes* captures; 5 in pitfalls and 5 in Elliott traps. Site B was also the only site where the Brush-tailed Possum *Trichosurus vulpecular* as recorded.

Mammal species of conservation significance make up half of the expected assemblage (11 of the 22 native species), and this value would be higher were it not

for the local extinction of several significant species (Table 5). As was the case with birds, the majority of significant species are classed as Conservation Significance level 3 (locally significant) as the site is so close to Perth and very few native mammal species persist in urban areas. Significant species are discussed below.

### *Invertebrates*

Studies on invertebrates were restricted to species belonging to groups known to include short range endemic species (Harvey 2002). The following invertebrates were collected and identifications and notes provided by the WA Museum (M. Harvey pers. comm.).

Scorpion *Urodacus novaehollandiae*. Widespread in the south-west of Western Australia.

Snail *Bothriembryon* sp. A damaged shell that could not be identified to species. The genus is widespread in the south-west of Western Australia.

Millipede *Dinocambala ingens* (Iulomorphidae). A large species mostly confined to the western Darling Scarp in the vicinity of Perth. This is a short ranger endemic and Figure 3 illustrates the distribution of WA Museum records of the species. Outlying locations on the coastal plain and Garden Island are considered to be erroneous (M. Harvey pers. com.). The single live specimen collected and a number of fragments of dead specimens were all under rocks on the edge of granite outcrops near Site E.

The millipede *D. ingens* is not of listed conservation significance (CS1 or CS2) but is locally significant (CS3) because of its restricted distribution in a region where development and high levels of disturbance can be expected. One significant invertebrate, the scorpion-fly *Austromerope poultoni*, appears on the DEC threatened species list for the area (Appendix 4) and is discussed below. Further work in winter when many invertebrates are active is suggested under recommendations (see below).

### **Species of conservation significance**

Of the 189 species of vertebrates that may occur in the vicinity of the proposed quarry pit development area, there are 59 species of conservation significance (8 CS1, 9 CS2 and 42 CS3 species). In addition, one invertebrate species of conservation significance was returned from the DEC database search and one was recorded. Of the 61 species of conservation significance (59 vertebrate and 2 invertebrates) that may occur in the project area, 24 vertebrate and 1 invertebrate species were recorded during the survey. The results of the DEC and EPBC database searches (for species of conservation significance) are presented in Appendices 4 and 5 and the significant species are indicated on Tables 1 to 4. Table 9 provides additional information on each conservation significant species, such as the reason for its significance and the importance of the project area for it.

The number of conservation significant species in each of the vertebrate classes is:

Amphibia (Frogs)	1 (0 CS1, 0 CS2, 1 CS3)
Reptilia (Reptiles)	9 (1 CS1, 2 CS2, 6 CS3)
Aves (Birds)	38 (5 CS1, 3 CS2, 30 CS3)
Mammalia (Mammals)	11 (2 CS1, 4 CS2, 5 CS3)

Significant species within each of these groups are discussed below, with additional information on species listed under the EPBC Act.

### *Amphibians*

Of the 13 frog species that may occur in the project area (Table 1), one is considered to be of conservation significance, the Hooting Frog *Heleioporus barycragus* (CS3). The Hooting Frog is listed as being of conservation significance, because the project area is considered to be at the northern extent of its known range. It has a restricted distribution from near Bullsbrook to near Collie (Tyler *et al.* 2000). It was recorded from Sites A and D (see Table 6) within the survey area. Both these sites are high in the landscape and adults of this species are terrestrial, but Susannah Brook is probably suitable breeding habitat for the species. The quarry development proposal is likely to impact this species due to loss of upland habitat, and there are potential impacts upon breeding habitat if Susannah Brook is disturbed. There is intended to be a buffer of at least 50m along the brook and water quality is to be maintained.

### *Reptiles*

Of the nine reptile species listed as significant that may occur in the project area (Table 2), four were recorded: the South-West Carpet Python *Morelia spilota imbricata* (reported as being present by Hanson staff) (CS1), the blind snake *Ramphotyphlops pinguis* (CS3), the Wheatbelt Stone Gecko *Diplodactylus granariensis* (CS3) and the legless lizard *Pletholax gracilis* (CS3). The unidentified gecko *Diplodactylus* aff. *polyophthalmus* may be significant but further work is to be carried out to determine its relationship with recognised species. Most of the significant reptile species are associated with granite areas and/or gravelly sands and accompanying vegetation associated with granites. Note that the Ringed Brown Snake *Pseudonaja modesta* (CS3) may be extinct in the Perth area and is listed (as locally extinct) by DEP (2002) but is not mentioned by Bush *et al.* (1995). It therefore seems very unlikely that this species occurs in the project area. The quarry development proposal will result in localised impact on these species due to habitat loss. Habitat fragmentation may be significant for the Carpet Python as it probably occurs at a low population density.

### *Birds*

Birds are well-represented among species of conservation significance; 38 of the 61 species of conservation significance are birds. Nearly half (38) of the 89 native bird species that may occur in the project area are of conservation significance. Conservation significant birds include 30 species that have declined in the Perth region (DEP 2000) and 14 of these were recorded during the field survey (Table 3). Bird species of higher conservation significance (ie. CS1 and CS2) are also present or expected to occur. These include two species of owls and three species of black-cockatoos. No owls were observed and only one of the black-cockatoos was observed during the field survey, the Forest Red-tailed Black Cockatoo *Calyptrorhynchus banksii naso*. The other two species of black-cockatoo are likely to be regular visitors. The project area provides foraging habitat for black-cockatoos in the form of eucalypts (particularly Marri) and proteaceous heath, and may be visited by owls, but generally lacks the large trees that may contain hollows for breeding. The Rainbow Bee-eater *Merops ornatus* (migratory under the EPBC Act) is almost certainly present as a breeding visitor, although it was not observed in December 2006. Although of

high conservation significance, this species is widespread in south-west WA. For many of the birds, the project area provides continuity of habitat along the western scarp between John Forrest National Park and the Darling Range Regional Park.

### *Mammals*

Significant mammal fauna are also well-represented; 11 of the 22 native mammal species that may occur in the project area are of conservation significance (Table 4). Four conservation significant species were recorded in the project area. The presence of apparently large populations of the Mardo *Antechinus flavipes*, dunnart *Sminthopsis gilberti*, Western Pygmy-possum *Cercartetus concinnus* and Honey Possum *Tarsipes rostratus* so close to Perth is locally significant. The Quenda was not observed and its distinctive foraging excavations were not found, but it is reported by community members to occur along Susannah Brook upstream of the Hanson property. As was noted for birds, the project area provides continuity of habitat along the western scarp between John Forrest National Park and the Darling Range Regional Park.

### *Invertebrates*

The single invertebrate species of conservation significance returned by the DEC database search, the scorpion-fly *Austromerope poultonii* (CS2; priority 2), was not recorded. Fathfull *et al.* (1985) indicate that it is probably restricted to forested areas in the south-west, but mention a record from near Darlington. *A. poultonii* is terrestrial and most commonly-encountered in winter. Faithfull *et al.* (1985) recorded it in pitfall traps in Jarrah and Wandoo forest, and in heath. Suitable habitat is therefore present in the project area and the site is probably at the northern limit of the species' range.

In addition, the millipede *Dinocambala ingens* is of local significance (CS3) because it is a short range endemic and much of its range lies in areas where development and disturbance have occurred or are likely, although the western Darling Scarp also includes a number of conservation reserves. Typically for a SRE invertebrate, *D. ingens* was found associated with a discontinuous habitat: granite outcrops and associated gravelly sands. There may be other SRE invertebrates associated with this habitat and further searches for such species are to be carried out in winter 2007.

### *EPBC listed species*

Species :	<i>Haliaeetus leucogaster</i>	Conservation status:	<b>CS1</b>
Common name:	White-bellied Sea-Eagle		
Habitat:	Marine coasts and major river systems		
Notes:	Listed as migratory under the EPBC Act and included in the search of the EPBC database, but very unlikely to be present in the project area.		

Species :	<i>Calyptorhynchus latirostris</i>	Conservation status:	<b>CS1</b>
Common name:	Carnaby`s Cockatoo (Short-billed Black-Cockatoo)		
Habitat:	Open forests and woodlands, Kwongan heath, sand plains, suburban vegetation and pine plantations.		
Notes:	Listed as Endangered under the EPBC Act and Schedule 1 (Endangered) of WA Wildlife Conservation Act. <i>C. latirostris</i> occurs in the south-west of Western Australia, approximately south-west of a line between the Murchison River (near Kalbarri) and Cape Arid National Park (east of Esperance). This species generally breeds in inland areas, moving to cooler, coastal areas for the non-breeding period (late spring to mid-winter). However, in recent years it has begun breeding at coastal sites, probably in response to the loss of inland sites. Land clearing and degradation has reduced available breeding sites (tree hollows) and fragmented breeding and feeding sites. Feral bees, galahs and corellas out-compete <i>C. latirostris</i> for nesting hollows. Illegal trapping and smuggling also threaten this species.		
Status on site:	Likely to be a regular non-breeding visitor, feeding in both woodland and heath areas. Breeding unlikely as there are few if any trees large enough to contain hollows suitable for the species.		
Impact:	Some loss of foraging habitat likely. Within the context of surrounding habitats reserved in National and Regional Parks, this impact will be minor.		

Species :	<i>Calyptorhynchus baudinii</i>	Conservation status:	<b>CS1</b>
Common name:	Baudin`s Cockatoo (Long-billed Black-Cockatoo)		
Habitat:	Jarrah, Marri and Karri forests, woodlands, coastal scrub.		
Notes:	Listed as Vulnerable under the EPBC Act and as Schedule 1 (Endangered) under the WA Wildlife Conservation Act. <i>C. baudinii</i> occurs in the deep south-west of Western Australia, approximately south-west of a line between Morangup (near Bullsbrook, north of Perth) and Waychinicup National Park (east of Albany). Birds generally breed in the Karri, Marri and Wandoo forests in the southern parts of the species` range and move north to the Darling Range and Swan Coastal Plain during autumn and winter (non-breeding period). Clearing for agriculture and logging has removed nesting and feeding trees for this species. Feral bees, galahs and corellas out-compete <i>C. latirostris</i> for nesting hollows.		
Status on site:	Likely to be a regular non-breeding visitor, feeding primarily in woodland areas. Breeding unlikely as there are few if any trees large enough to contain hollows suitable for the species.		
Impact:	Some loss of foraging habitat likely. Within the context of surrounding habitats reserved in National and Regional Parks, this impact will be minor.		

Species :	<i>Merops ornatus</i>	Conservation status:	<b>CS1</b>
Common name:	Rainbow Bee-eater		
Habitat:	Open woodlands, sand ridges, sand pits, riverbanks, beaches, dunes, cliffs, mangroves and man-made grassed fields.		
Notes:	Listed as Migratory under the EPBC Act. <i>M. ornatus</i> occurs year-around in the tropics, with a southward migration, to both south-eastern and south-western Australia, in early spring. Southern birds return north in autumn. When present, <i>M. ornatus</i> is common and prominent in natural and altered environments. The nest is a burrow often dug into slopes in disturbed areas, such as sand-pits and roadsides.		
Status on site:	Likely to be a regular breeding visitor in spring and summer. Could occur anywhere, but often forages over clearings and low vegetation adjacent to forest and digs its nest-burrow on raised slopes.		
Impact:	Some loss of foraging habitat likely. Within the context of surrounding habitats reserved in National and Regional Parks, this impact will be minor.		

Species :	<i>Dasyurus geoffroii</i>	Conservation status:	<b>CS1</b>
Common name:	Chuditch		
Habitat:	Wet and dry sclerophyll forest, mallee.		
Notes:	Listed as Vulnerable under the EPBC Act and Schedule 1 (Vulnerable) of the WA Wildlife Conservation Acts. Habitat alteration through clearing, grazing and changed fire regimes, competition with foxes and cats for food, predation by foxes, hunting, and poisoning all threaten <i>D. geoffroii</i> . This species occupies large home ranges (several hundred hectares), is highly mobile and appears able to utilise bush remnants and corridors.		
Status on site:	Not recorded, but individuals likely to pass through the project area and one or two animals may be resident. Would utilize all habitats.		
Impact:	Some loss of foraging habitat likely but this will be minor because the project area represents only part of the home range of a single animal. As home ranges overlap, several specimens could lose part of their home range. Within the context of surrounding habitats reserved in National and Regional Parks, this impact will be minor. However, movement of animals through the project area may be important for sustaining the species' population in the general area. The ability of the species to utilise bush remnants and corridors means that the effect of fragmentation can be reduced by retaining or enhancing vegetation corridors around quarry areas.		

## DISCUSSION

### Faunal assemblage and impacts

With 189 vertebrate species predicted to be present, of which 69 were recorded and three were reported by staff or nearby residents, the project area supports a diverse faunal assemblage. In a survey of the adjacent John Forest National Park, Ninox Wildlife Consulting (1991) recorded 91 species of vertebrate fauna. This included 7 species of frogs, 11 reptiles, 9 birds and 4 mammals not recorded at Hanson's quarry,

possibly reflecting the time of survey and weather conditions, as well as the stochastic nature of animal sampling (Tables 2 – 4).

The faunal assemblage reflects its location on the western edge of the escarpment and the range of vegetation/landform types present. Thus, the assemblage includes elements from the coastal plain as well as species more typical of the northern escarpment, and a few species that are more commonly associated with the Wheatbelt. Fauna habitats are diverse within a small area, and the presence of Wandoo as well as heaths of gravelly sands around granite outcrops, and a seasonal watercourse, all contribute to assemblage richness.

Impacts of the development proposed by Hanson's are related to interactions between the development, the landscape and the faunal assemblage. Impacts may be primarily due to habitat loss, such as will occur in quarrying and infrastructure areas, including stockpile sites and haul roads. There may also be issues due to roadkill of fauna, particularly during the initial stages of development (eg clearing) when fauna may be relocating away from disturbance. Fragmentation of habitat and loss of connectivity will reduce the potential for movement of fauna and ultimately genetic exchange within species. The maintenance of habitat corridors within the confines of the proposed development area will be paramount in reducing the effects of fragmentation. Of particular importance is the remnant native vegetation lying east of the existing (disused) Herne Hill Quarry and that lying east of the current Red Hill Quarry. These provide connectivity around the project area between John Forrest National Park and the Darling Range Regional Park. Susannah Brook also provides a corridor through Lot 11. Changes in the abundance of feral species may also arise as an issue, particularly if site hygiene is not maintained. Anecdotal evidence suggests that there is a feral cat population at the nearby Red Hill landfill site and this population could act as a source, with individuals migrating to the Hanson quarry in search of food. Nearby residents report that a small flock of feral goats inhabits the area.

The significance of impacts can therefore be related not only to features of the assemblage and its ecology such as the presence of significant species, but to the locations of significant habitats, the ecological processes that affect the fauna and the patterns of faunal biodiversity across the landscape. The significance of impacts also needs to be viewed in a regional context. Impacts under these key headings are discussed below. Table 10 summarises impacts based upon the EPA's Guidance statement No 56 (EPA 2004).

### **Significant species**

Significant vertebrate species present or likely to be present have been discussed above. What is notable is that the site has a rich fauna of significance especially at the local level because it is so close to Perth, with many species, especially among the mammals and birds, being locally extinct in the Perth area. Important features of the site for significant fauna are the range of habitats present, especially areas of Wandoo and heaths of gravelly sands close to exposed granite. Susannah Brook is also important. There is limited nesting habitat for significant species such as the black-cockatoos. The site is also important in providing continuity of habitat for significant fauna along the western escarpment. Significant species may be affected by loss and fragmentation of habitat.

## **Significant habitats**

Significant habitats are areas of soils, vegetation types and/or landform that are important for significant species or biodiversity. They are often small in extent and as a general rule, rare habitats are likely to be of particular interest with respect to impact assessment compared with common or widespread habitats. Within the project area, several habitats stand out as significant because they are important for significant species and/or biodiversity. These are:

- Granitic outcrops, particularly where the rock formations are well developed to create micro-habitats, providing habitat for species such as Carpet Pythons, Ornate Dragons and possible Dell's Skink.
- Eucalypt woodlands, especially those that include Wandoo. These provide habitat for some mammals and feeding habitat for significant bird species such as: Carnaby's Black-Cockatoo, Baudin's Black-Cockatoo and the Forest Red-tailed Black Cockatoo.
- Heaths of gravelly sands close to areas of exposed granite, important for many reptile, bird and mammal species, and potentially supporting short range endemic invertebrates.
- Lower slopes of hills where water is concentrated, creating seasonal pools and dense vegetation. Such areas are important for a number of locally significant bird species.
- Temporary creeks including Susannah Brook, important for breeding by frogs and with potential downstream influences.

Of these habitat types, the disturbance footprint of the proposed development covers mostly areas of granite outcrops with associated heaths on gravelly sands, and eucalypt woodlands. The regional representation of significant habitats is important and these habitats are not unique to the areas proposed for development, as the project area lies within a region where there is a complex of granite outcrops and eucalyptus woodlands with interspersing heath. Because the project area is within the complex of the Darling Scarp, the species encountered on site are expected to be well represented throughout adjacent areas. These include reserves such as John Forrest National Park, the Darling Range Regional Park and Walyungah National Park.

## **Ecological Processes**

Ecological processes that affect fauna and may be affected by the proposed development include hydrology, levels of predation, patterns of mortality, connectivity of habitat and fire. These are discussed below.

### *Hydrology*

Surface runoff may be important for the maintenance of dense vegetation on the lower slopes of the ridges. Quarrying and infrastructure can affect patterns of runoff. Runoff from roads can lead to localized mortality of vegetation, especially if saline water is used for the suppression of dust, and where roads disrupt surface drainage patterns. Ponding of water can also create habitat, but in general alteration to natural drainage patterns is undesirable. Susannah Brook is a significant habitat and downstream impacts may result if flows along the brook are significantly altered.

### *Levels of predation*

Predation by introduced species has contributed to the local extinction of some mammal species across much of the region. A secondary impact of any resource development project can be changes in the abundance of feral species, particularly predators such as Foxes and Cats. These can be attracted by food scraps or deliberately encouraged by some staff. They can also gain improved access to habitat along tracks and roads. Given the presence of species thought to be sensitive to feral predators (Brush-tailed Possum, Honey Possum and Pygmy Possum), measures to avoid encouraging Foxes and Cats, and possibly control measures, should be considered. Control of feral species as part of the development may have a positive impact upon native fauna affected by feral predators.

### *Patterns of mortality*

Changes in patterns of mortality can be significant for species that occur at low population densities. In the project area, the Echidna is one such species and is known to be sensitive to roadkill. Some species are also attracted to lights that can result in animals becoming disoriented and striking buildings. The death of very large numbers of invertebrates around lights is commonly observed and the impact of this mortality is not understood.

### *Connectivity of habitat*

Connectivity of habitat can be a major concern with resource development projects often leading to fragmented landscapes. While the project area supports a great deal of continuous habitat, there are also areas that may become isolated as part of the proposed development. This is mainly an issue with the large areas of vegetation to the north of the current quarry operations. Careful planning of the proposed development is required to maintain upland habitat corridors between the Darling Range Regional Park and John Forrest National Park, located to the south of the current operations. By maintaining such corridors, fauna movements could be maintained both up-slope and also along Susannah Brook. Species most likely to be adversely impacted by fragmentation are those that occur at low densities and/or are poor at dispersing. Species that occur at low densities are liable to local extinction from the loss of a few individuals and movements between habitat patches can be important for maintaining populations. The two pythons (Stimson's Python and Carpet Python) are likely to be sensitive to such local extinction. Other species that may be reliant upon movement between patches of suitable habitat for the maintenance of populations include some reptiles, birds with limited dispersal abilities such as the Southern Emu-wren, small mammals and short range endemic invertebrates such as the millipede *Dinocambala ingens*.

### *Fire*

There is evidence of fire in the native vegetation of the project area, particularly in Area B, where a reduced species count was observed, although that may be a site characteristic rather than a consequence of fire. Increased levels of human activity increase the chance of fires being started. Most Australian ecosystems survive and some even benefit from the occasional fire, but frequent or very extensive fires are undesirable. Unplanned fires are a special concern in fragmented landscapes where there is poor connectivity for animals to seek refuge and for recolonisation.

## **Patterns of biodiversity**

Patterns of biodiversity are patterns in the richness and diversity of the fauna across the landscape in relation to changes in landform, soils and vegetation. Biodiversity refers to all species; not just those that are significant. Biodiversity appeared to be higher in areas supporting Wandoo and in the heaths around granite outcrops. High in the landscape, such as at Site B, there were some significant species but biodiversity was only moderate.

## **Regional context**

The project area is located in a valley on the western slopes of the Darling Scarp and is therefore similar in many respects to valleys to the north and south. Except for the existing quarry the valley is substantially undisturbed. Similar landforms are protected in John Forrest and Walyungah National Parks, although some other valleys in the region are degraded by development. The opposite side of the valley contains similar vegetation and landforms and therefore can be expected to support a similar faunal assemblage. This area was visited during the field survey but no trapping was carried out. In a regional setting, the impact of loss of habitat on fauna populations may be of some significance, but such habitats are protected nearby. Long-term protection of the northern side of the valley within the Hanson lease would further reduce the significance of the loss of fauna habitat in the proposed development area. More significant than loss of habitat, however, may be the function of the project area in providing connectivity between John Forrest National Park to the south and the Darling Range Regional Park to the north.

## **CONCLUSIONS AND RECOMMENDATIONS**

The project area targeted for development supports a diverse fauna assemblage, therefore, fauna is likely to be impacted largely through loss of habitat, although there are other considerations such as changes in hydrology, roadkill and habitat fragmentation. The habitats of the project area are not unique, and the area lies within a region of the Darling Scarp where the most distinctive habitats are well-represented.

There is a number of ways in which impacts upon fauna can be managed and the following recommendations are made:

1. Development footprints should be minimised, particularly in areas of significant habitat;
2. Where possible, infrastructure should be planned to utilise cleared or disturbed sites, reducing the amount of clearing required;
3. Habitat fragmentation should be avoided. If possible, corridors of habitat should be retained throughout the project area. Particularly important is providing linkage between John Forrest National Park to the south and the Darling Range Regional Park to the north.
4. Hydrological impacts should be minimised, as both surface and sub-surface run-off affect habitats and fauna;
5. Management of feral fauna should be undertaken as part of the project, including educating personnel not to encourage feral species.

6. A fire management plan should be developed, including educating personnel to be careful to avoid starting fires. The quarrying operations need to have the capacity to control fires.
7. Fauna roadkills should be reported, especially if they involve significant species.
8. Personnel need to be made aware of the significance species that may occur in the area;
9. Personnel need to be made aware in general of the sensitivity of the local environment.
10. Lighting should be shielded and designed to minimise impacts upon fauna.

The fauna survey of December 2006 and desktop review have provided a detailed overview of the fauna of the project area and assessment of possible impacts from the proposed quarry development. Some further investigations, however, are recommended.

- If museum studies currently underway determine that the gecko *Diplodactylus* aff. *polyophthalmus* is an undescribed taxon, further field work will be required to determine its distribution on the Hanson property and nearby. Both specimens were collected in Wandoo woodland of the proposed stockpile extension area.
- Sampling for Short Range Endemic invertebrates was limited. Granite outcrops and associated heaths on gravelly sands are likely to be of importance for SRE invertebrates and studies during the winter should be undertaken. Many potential SRE invertebrates are active mainly in the cool, wet months.

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**Table 1.** Amphibians that may occur in the proposed Hanson quarry development area, and those recorded during the 2006 field surveys (\*). JF = recorded in 1990/1991 survey of John Forrest National Park. Status as described in Methods.

Species	Common Name	Status	December 2006	
<b>HYLIDAE (Tree frogs)</b>				
<i>Litoria adelaidensis</i>	Slender Tree Frog		*	JF
<i>Litoria moorei</i>	Motorbike Frog		*	JF
<b>MYOBATRACHIDAE (Ground frogs)</b>				
<i>Crinia georgiana</i>	Quacking Frog			JF
<i>Crinia glauerti</i>	Glauert's Frog			JF
<i>Crinia pseudinsignifera</i>	Bleating Frog			JF
<i>Geocrinia leai</i>	Lea's Frog			
<i>Heleioporus barycragus</i>	Hooting Frog	CS3	*	JF
<i>Heleioporus eyrei</i>	Moaning Frog			
<i>Heleioporus inornatus</i>	Chocolate Frog			JF
<i>Heleioporus psammophilus</i>	Marbled Frog			JF
<i>Limnodynastes dorsalis</i>	Pobblebonk			JF
<i>Myobatrachus gouldii</i>	Turtle Frog			
<i>Pseudophryne guentheri</i>	Günther's Toadlet			JF
<b>Number of Species</b>	<b>13</b>		<b>3</b>	<b>10</b>

**Table 2.** Reptiles that may occur in the proposed Hanson quarry development area, and those recorded during the 2006 field survey (\*). JF = recorded in the 1990/1991 survey of John Forrest National Park. Status as described in Methods. (+) indicates species reported by quarry staff.

Species	Common Name	Status	December 2006	Previous record
<b>AGAMIDAE (Dragons)</b>				
<i>Ctenophorus ornatus</i>	Ornate Dragon		*	
<i>Pogona minor</i>	Bearded Dragon		*	JF
<b>GEKKONIDAE (Geckoes)</b>				
<i>Christinus marmoratus</i>	Marbled Gecko			JF
<i>Crenadactylus ocellatus</i>	Clawless Gecko		*	JF
<i>Diplodactylus granariensis</i>	Wheatbelt Stone Gecko	CS3	*	JF
<i>Diplodactylus polyophthalmus</i>			*	JF
<i>Diplodactylus aff. polyophthalmus</i>			*	
<i>Diplodactylus pulcher</i>	Beautiful Gecko			
<i>Gehyra variegata</i>	Tree Dtella		*	JF
<i>Strophurus spinigerus</i>	Western Spiny-tailed Gecko		*	JF
<i>Underwoodisaurus milii</i>	Thick-tailed Gecko			JF
<b>PYGOPODIDAE (Legless lizards)</b>				
<i>Aprasia pulchella</i>	Granite Worm-Lizard			JF
<i>Aprasia repens</i>	Fry's Worm-Lizard			JF
<i>Delma fraseri</i>	Fraser's legless-Lizard		*	
<i>Delma grayii</i>	Gray's legless-Lizard			
<i>Lialis burtonis</i>	Burton's Snake-Lizard			
<i>Pletholax gracilis</i>		CS3	*	
<i>Pygopus lepidopodus</i>	Common Scaly-foot			
<b>SCINCIDAE (Skinks)</b>				
<i>Acritoscincus trilineatum</i>				JF
<i>Cryptoblepharus plagiocephalus</i>	Fence Skink		*	JF
<i>Ctenotus delli</i>	Dell's Skink	CS2		JF
<i>Ctenotus fallens</i>			*	
<i>Ctenotus impar</i>				
<i>Ctenotus labillardieri</i>	Red-legged Skink			JF
<i>Egernia kingii</i>	King's Skink			
<i>Egernia multiscutata</i>				
<i>Egernia napoleonis</i>				
<i>Eremiascincus richardsonii</i>				
<i>Hemiergis initialis</i>			*	JF
<i>Lerista distinguenda</i>			*	JF
<i>Menetia greyii</i>	Dwarf Skink		*	JF
<i>Morethia lineocellata</i>				
<i>Morethia obscura</i>				JF
<i>Tiliqua rugosa</i>	Bobtail		*	JF
<b>VARANIDAE (Monitors or goannas)</b>				
<i>Varanus gouldii</i>	Gould's Goanna			JF
<i>Varanus rosenbergi</i>	Rosenberg's Goanna	CS3		
<i>Varanus tristis</i>	Black-headed Tree Goanna		*	

Table 2 (cont.)

Species	Common Name	Status	December 2006	Previous record
<b>TYPHLOPIDAE (Blind snakes)</b>				
<i>Ramphotyphlops australis</i>	Southern Blind Snake			JF
<i>Ramphotyphlops pinguis</i>		CS3	*	
<i>Ramphotyphlops waitii</i>	Beaked Blind Snake			
<b>BOIDAE (Pythons)</b>				
<i>Antaresia stimsoni</i>	Stimson's Python	CS3		
<i>Morelia spilota imbricata</i>	South-West Carpet Python	CS1	(+)	
<b>ELAPIDAE (Venomous land snakes)</b>				
<i>Acanthophis antarcticus</i>	Southern Death-adder	CS2		
<i>Brachyurophis semifasciata</i>	Shovel-nosed Snake			
<i>Demansia psammophis</i>	Yellow-faced Whip-Snake		*	
<i>Neelaps bimaculatus</i>	Black-naped Snake			
<i>Notechis scutatus</i>	Tiger Snake			
<i>Parasuta gouldii</i>	Black-headed Snake			
<i>Parasuta nigriceps</i>	Black-backed Snake			
<i>Pseudechis australis</i>	Mulga Snake			
<i>Pseudonaja affinis</i>	Dugite			JF
<i>Pseudonaja modesta</i>	Ringed Brown Snake	CS3		
<b>Number of Species</b>	<b>52</b>		<b>19</b>	<b>22</b>

**Table 3.** Birds that may occur in the proposed Hanson quarry development area, and those recorded during the 2006 field survey (\*). JF = recorded in the 1990/1991 survey of John Forrest National Park. Status as described in Methods.

Species	Common Name	Status	December 2006	Previous record
<b>CASUARIIDAE (Cassowaries and emus)</b>				
<i>Dromaius novaehollandiae</i>	Emu	CS3		
<b>ARDEIDAE (herons)</b>				
<i>Ardea novaehollandiae</i>	White – faced Heron			
<b>THRESKIORNITHIDAE (Ibis)</b>				
<i>Theskiornis spinicollis</i>	Straw – necked Ibis		*	
<b>ACCIPITRIDAE (hawks and eagles)</b>				
<i>Accipiter cirrocephalus</i>	Collared Sparrowhawk	CS3		JF
<i>Accipiter fasciatus</i>	Brown Goshawk	CS3	*	JF
<i>Aquila audax</i>	Wedge-tailed Eagle	CS3	*	
<i>Elanus caeruleus</i>	Black-shouldered Kite			
<i>Lophoictinia isura</i>	Square-tailed Kite	CS3		
<i>Haliastur sphenurus</i>	Whistling Kite	CS3		
<b>FALCONIDAE (Falcons)</b>				
<i>Falco berigora</i>	Brown Falcon	CS3	*	
<i>Falco cenchroides</i>	Nankeen Kestrel			
<i>Falco longipennis</i>	Australian Hobby			
<i>Falco peregrinus</i>	Peregrine Falcon	CS1		
<b>TURNICIDAE (Button-quails)</b>				
<i>Turnix varia</i>	Painted Button-quail	CS3		JF
<i>Turnix velox</i>	Little Button-quail			
<b>COLUMBIDAE (Pigeons and doves)</b>				
<i>Columba livia</i>	Feral Pigeon	Int		
<i>Phaps chalcoptera</i>	Common Bronzewing	CS3	*	JF
<i>Phaps elegans</i>	Brush Bronzewing	CS3		
<i>Streptopelia chinensis</i>	Spotted Turtle-Dove	Int		JF
<i>Streptopelia senegalensis</i>	Laughing Turtle-Dove	Int		
<b>CACATUIDAE (Cockatoos)</b>				
<i>Calyptorhynchus banksii naso</i>	Red-tailed Black Cockatoo	CS1	*	JF
<i>Calyptorhynchus latirostris</i>	Carnaby's Black Cockatoo	CS1		JF
<i>Calyptorhynchus baudini</i>	Baudin's Black-Cockatoo	CS1		
<i>Eolophus roseicapilla</i>	Galah		*	JF
<i>Cacatua pastinator</i>	Western Corella			
<b>PSITTACIDAE (Parrots)</b>				
<i>Glossopsitta porphyrocephala</i>	Purple-crowned Lorikeet			
<i>Neophema elegans</i>	Elegant Parrot			JF
<i>Platycercus icterotis</i>	Western Rosella			JF
<i>Purpureicephalus spurius</i>	Red-capped Parrot		*	JF
<i>Barnardius zonarius</i>	Australian Ringneck		*	JF
<i>Polytelis anthopeplus</i>	Regent Parrot			JF
<i>Trichoglossus haematodus</i>	Rainbow Lorikeet	Int		
<b>CUCULIDAE (Cuckoos)</b>				
<i>Cacomantis flabelliformis</i>	Fan-tailed Cuckoo			JF
<i>Chrysococcyx basalis</i>	Horsfield's Bronze-Cuckoo			JF
<i>Chrysococcyx lucidus</i>	Shining Bronze-Cuckoo		*	
<i>Cuculus pallidus</i>	Pallid Cuckoo			JF

Table 3 (cont.)

Species	Common Name	Status	December 2006	Previous record
<b>STRIGIDAE (Hawk owls)</b>				
<i>Ninox connivens</i>	Barking Owl	CS2		
<i>Ninox novaeseelandiae</i>	Southern Boobook			JF
<b>TYTONIDAE (Barn owls)</b>				
<i>Tyto alba</i>	Barn Owl			
<i>Tyto novaehollandiae</i>	Masked Owl	CS2		
<b>PODARGIDAE (Australian frogmouths)</b>				
<i>Podargus strigoides</i>	Tawny Frogmouth			JF
<b>CAPRIMULGIDAE (Nightjars and allies)</b>				
<i>Eurostopodus argus</i>	Spotted Nightjar			
<b>AEGOTHELIDAE (Owlet-nightjars)</b>				
<i>Aegotheles cristatus</i>	Australian Owlet-nightjar			
<b>HALCYONIDAE (Kingfishers)</b>				
<i>Dacelo novaeguineae</i>	Laughing Kookaburra	Int	*	JF
<i>Todiramphus sanctus</i>	Sacred Kingfisher			JF
<b>MEROPIIDAE (Bee-eaters)</b>				
<i>Merops ornatus</i>	Rainbow Bee-eater	CS1		JF
<b>CLIMACTERIDAE</b>				
<i>Climacteris rufa</i>	Rufous Treecreeper	CS3		JF
<b>MALURIDAE (Fairy-wrens and allies)</b>				
<i>Malurus elegans</i>	Red – winged Fairy - wren	CS3		
<i>Malurus splendens</i>	Splendid Fairy-wren	CS3	*	JF
<i>Stipiturus malachurus</i>	Southern Emu-wren	CS3		JF
<b>PARDALOTIDAE (Pardalotes and allies)</b>				
<i>Pardalotus punctatus</i>	Spotted Pardalote			JF
<i>Pardalotus striatus</i>	Striated Pardalote		*	JF
<i>Sericornis frontalis</i>	White – browed Scrubwren	CS3	*	
<i>Smicronis brevirostris</i>	Weebill		*	JF
<i>Gerygone fusca</i>	Western Gerygone		*	JF
<i>Acanthiza apicalis</i>	Inland Thornbill	CS3	*	JF
<i>Acanthiza chrysorrhoa</i>	Yellow-rumped Thornbill	CS3		JF
<i>Acanthiza inornata</i>	Western Thornbill	CS3	*	JF
<b>MELIPHAGIDAE (Honeyeaters)</b>				
<i>Acanthorhynchus superciliosus</i>	Western Spinebill		*	JF
<i>Anthochaera carunculata</i>	Red Wattlebird		*	JF
<i>Anthochaera lunulata</i>	Western Wattlebird			
<i>Manorina flavigula</i>	Yellow-throated Miner			
<i>Melithreptus brevirostris</i>	Brown-headed Honeyeater			
<i>Melithreptus lunatus</i>	White-naped Honeyeater			JF
<i>Lichmera indistincta</i>	Brown Honeyeater		*	JF
<i>Phylidonyris melanops</i>	Tawny-crowned Honeyeater	CS3		
<i>Phylidonyris nigra</i>	White-cheeked Honeyeater	CS3		
<i>Phylidonyris novaehollandiae</i>	New Holland Honeyeater	CS3	*	JF
<b>PETROICIDAE (Robins)</b>				
<i>Eopsaltria griseogularis</i>	Western Yellow Robin	CS3	*	
<i>Eopsaltria georgiana</i>	White – breasted Robin	CS3		
<i>Petroica goodenovii</i>	Red-capped Robin		*	JF
<i>Petroica multicolor</i>	Scarlet Robin	CS3		JF
<b>NEOSITTIDAE (Sitellas)</b>				
<i>Daphoenositta chrysoptera</i>	Varied Sittella		*	JF

Table 3 (cont.)

Species	Common Name	Status	December 2006	Previous record
<b>PACHYCEPHALIDAE (Whistlers and allies)</b>				
<i>Colluricincla harmonica</i>	Grey Shrike-thrush	CS3	*	JF
<i>Falcunculus frontatus</i>	Crested Shrike-tit	CS2		
<i>Pachycephala pectoralis</i>	Golden Whistler	CS3	*	JF
<i>Pachycephala rufiventris</i>	Rufous Whistler		*	JF
<b>DICRURIDAE (Fantails and allies)</b>				
<i>Grallina cyanoleuca</i>	Australian Magpie-lark			JF
<i>Rhipidura fuliginosa</i>	Grey Fantail		*	JF
<i>Rhipidura leucophrys</i>	Willie Wagtail			
<b>CAMPEPHAGIDAE (Cuckoo-shrikes and trillers)</b>				
<i>Coracina novaehollandiae</i>	Black-faced Cuckoo-shrike		*	JF
<i>Lalage sueurii</i>	White – winged Triller			
<b>ARTAMIDAE (Woodswallows and allies)</b>				
<i>Artamus cinereus</i>	Black-faced Woodswallow	CS3	*	
<i>Artamus cyanopterus</i>	Dusky Woodswallow	CS3		
<i>Gymnorhina tibicen</i>	Australian Magpie		*	JF
<i>Strepera versicolor</i>	Grey Currawong	CS3		JF
<b>CORVIDAE (Crows and allies)</b>				
<i>Corvus coronoides</i>	Australian Raven		*	JF
<b>MOTACILIDAE (Old World wagtails and pipits)</b>				
<i>Anthus australis (novaeseelandiae)</i>	Australian Pipit			
<b>PASSERIDAE (Finches and allies)</b>				
<i>Stagonopleura oculata</i>	Red – eared Firetail	CS3	*	
<b>DICAEIDAE (Flowerpeckers)</b>				
<i>Dicaeum hirundinaceum</i>	Mistletoebird		*	JF
<b>HIRUNDINIDAE (Swallows and martins)</b>				
<i>Cheramoeca leucosternus</i>	White-backed Swallow			
<i>Hirundo neoxena</i>	Welcome Swallow			
<i>Hirundo nigricans</i>	Tree Martin		*	
<b>SYLVIIDAE (Old World warblers)</b>				
<i>Cincloramphus mathewsi</i>	Rufous Songlark			
<b>ZOSTEROPIDAE (White-eyes)</b>				
<i>Zosterops lateralis</i>	Silvereve		*	JF
<b>Number of Species</b>	<b>95</b>		<b>37</b>	<b>50</b>

**Table 4.** Mammals that may occur in the proposed Hanson quarry development area, and those recorded during the 2006 field survey (\*). JF = recorded in the 1990/1991 survey of John Forrest National Park. (+) indicates species reported by nearby residents. Status as described in Methods.

Species	Common Name	Status	December 2006	Previous record
<b>TACHYGLOSSIDAE (Echidnas)</b>				
<i>Tachyglossus aculeatus</i>	Echidna		*	JF
<b>DASYURIDAE (Dasyurids)</b>				
<i>Antechinus flavipes</i>	Mardo	CS3	*	JF
<i>Dasyurus geoffroyi</i>	Chuditch	CS1		
<i>Phascogale tapoatafa</i>	Brush-tailed Phascogale	CS1		
<i>Sminthopsis gilberti</i>	dunnart	CS3	*	JF
<b>PERAMELIDAE (Bandicoots)</b>				
<i>Isoodon obesulus fusciventer</i>	Quenda	CS2	(+)	JF
<b>MACROPODIDAE (Kangaroos and wallabies)</b>				
<i>Macropus fuliginosus</i>	Western Grey Kangaroo		*	JF
<i>Macropus irma</i>	Western Brush Wallaby	CS2		JF
<i>Macropus robustus</i>	Euro	CS3		JF
<b>PHALANGERIDAE (brush-tailed possums)</b>				
<i>Trichosurus vulpecula</i>	Common Brush-tailed Possum		*	
<b>BURRAMYIDAE (Pygmy-possums)</b>				
<i>Cercartetus concinnus</i>	Western Pygmy-possum	CS3	*	
<b>TARSIPEDIDAE (Honey possum)</b>				
<i>Tarsipes rostratus</i>	Honey Possum	CS3	*	
<b>VESPERTILIONIDAE (Vespertilionid bats)</b>				
<i>Vespadelus regulus</i>	Southern Forest Bat			
<i>Chalinolobus gouldii</i>	Gould's Wattled Bat		*	
<i>Chalinolobus morio</i>	Chocolate Wattled Bat			
<i>Falsistrellus mackenziei</i>	False Pipistrelle	CS2		
<i>Nyctophilus geoffroyi</i>	Lesser Long-eared Bat			
<i>Nyctophilus gouldi</i>				
<i>Nyctophilus timoriensis</i>	Greater Long-eared Bat			
<b>MOLOSSIDAE (Freetail bats)</b>				
<i>Mormopterus planiceps</i>	Western Freetail Bat			
<i>Tadarida australis</i>	White-striped Freetail Bat		*	
<b>MURIDAE (Rats and mice)</b>				
<i>Hydromys chrysogaster</i>	Rakali or Water Rat	CS2		
<i>Mus musculus</i>	House Mouse	Int	*	JF
<i>Rattus rattus</i>	Black Rat	Int		JF
<b>LEPORIDAE (Rabbits and hares)</b>				
<i>Oryctolagus cuniculus</i>	European Rabbit	Int	*	JF
<b>CANIDAE (Dogs and foxes)</b>				
<i>Vulpes vulpes</i>	Fox	Int	*	JF
<b>FELIDAE (Cats)</b>				
<i>Felis catus</i>	Feral Cat	Int		JF
<b>SUIDAE (pigs)</b>				
<i>Sus scrofa</i>	Feral Pig	Int		JF
<b>BOVIDAE (horned ruminants)</b>				
<i>Capra hircus</i>	Feral Goat	Int	(+)	
Number of Species	29		12	13

**Table 5.** Species considered to be extinct (ie locally extinct) in the vicinity of the Hanson quarry project.

Species	Conservation Status
<b>BURHINIDAE</b>	
Bush Stone Curlew <i>Burhinus grallarius</i>	CS2 (Priority 4)
<b>MYRMECOBIIDAE (Numbat)</b>	
Numbat <i>Myrmecobius fasciatus</i>	CS1. (WA Act Schedule 1 (Vulnerable) and Vulnerable under the EPBC Act).
<b>POTOROIDAE (Bettongs and potoroos)</b>	
Woylie <i>Bettongia penicillata</i>	CS2 (Priority 5)
<b>MACROPODIDAE (Kangaroos and wallabies)</b>	
Tammar <i>Macropus eugenii</i>	CS2 (Priority 5)
Quokka <i>Setonix brachyurus</i>	CS1. (WA Act Schedule 1 (Vulnerable) and Vulnerable under the EPBC Act).
Black-flanked Rock-Wallaby <i>Petrogale lateralis</i>	CS1. (WA Act Schedule 1 (Vulnerable) and Vulnerable under the EPBC Act).
<b>PSEUDOCHEIRIDAE (ring-tailed possums)</b>	
Western Ring-tailed Possum <i>Pseudocheirus occidentalis</i>	CS1. (WA Act Schedule 1 (Vulnerable) and Vulnerable under the EPBC Act).

**Table 6.** The total number of each species captured by pitfall or funnel trapping during the December 2006 survey. The number of funnel captures is shown in parentheses.

Species	Site					Total
	A	B	C	D	E	
Agamidae (dragons)						
<i>Pogona minor</i> Western Bearded Dragon		1	1			2
Elapidae (front – fanged snakes)						
<i>Demansia psammophis</i>				1 <sub>(1)</sub>		1
Gekkonidae (geckoes)						
<i>Crenadactylus ocellatus</i> Clawless Gecko	1		4 <sub>(1)</sub>	1 <sub>(1)</sub>	6 <sub>(2)</sub>	12
<i>Diplodactylus granariensis</i> Wheatbelt Stone Gecko			2	1	1 <sub>(1)</sub>	4
<i>Strophurus spinigerus</i> Spiny-tailed Gecko				5 <sub>(1)</sub>	4 <sub>(1)</sub>	9
<i>Gehyra variegata</i> Tree Dtella			1		2 <sub>(2)</sub>	3
<i>Diplodactylus polyophthalmus</i>	2		1	2 <sub>(1)</sub>		5
<i>Diplodactylus aff Poloyophthalmus</i>	2					2
Pygopodidae (legless lizards)						
<i>Delma fraseri</i> Fraser's Legless-Lizard				1		1
<i>Pletholax gracilis</i>					1	1
Scincidae (skinks)						
<i>Cryptoblepharus plagioccephalus</i> Fence Skink	1			1	1	3
<i>Ctenotus fallens</i>			2 <sub>(1)</sub>	3 <sub>(2)</sub>	1 <sub>(1)</sub>	6
<i>Hemiergus initialis</i>	1	1				2
<i>Menetia greyii</i> Dwarf Skink	1 <sub>(1)</sub>	1	2			4
<i>Lerista distinguenda</i>	1	2	2 <sub>(1)</sub>			5
Typhlopidae (blind snakes)						
<i>Ramphotyphlops pinguis</i>			1		1	2
Dasyuridae (dasyurid marsupials)						
<i>Sminthopsis gilberti</i>	2		1	3		6
<i>Antechinus flavipes</i> Mardo	1	5		1		7
Muridae (rats and mice)						
<i>Mus musculus</i> House Mouse	1		1	1 <sub>(1)</sub>	5	8
Tarsipedidae						
<i>Tarsipes rostratus</i> Honey Possum	1	5	8	8 <sub>(1)</sub>	4	26
Burramyidae (Pygmy – possums)						
<i>Cercartetus concinnus</i> Western Pygmy – possum	2		1			3
Myobatrachidae (ground frogs)						
<i>Heleioporus barycragus</i> Hooting Frog	1			1		2
<b>Total captures</b>	<b>17</b>	<b>15</b>	<b>27</b>	<b>28</b>	<b>26</b>	<b>113</b>
<b>Species richness</b>	<b>13</b>	<b>6</b>	<b>13</b>	<b>13</b>	<b>10</b>	<b>21</b>

**Table 7.** The total number of each species captured by Elliott and Cage trapping during the December 2006 survey. The number of Elliot captures is shown in parentheses.

Species	Site					Total
	A	B	C	D	E	
Dasyuridae (dasyurid marsupials)						
<i>Antechinus flavipes</i> Mardo		5 <sup>(5)</sup>				5
Phalangeridae						
<i>Trichosurus vulpecula</i> Brush tailed Possum		2				2
Scincidae (skinks)						
<i>Tiliqua rugosa</i> Bobtail		1				1
<b>Total</b>		<b>8</b>				<b>8</b>

**Table 8.** Bird species recorded at each trapping site, indicating the number of visits (out of a total of 5) during which each species was observed during the December 2006 survey.

Species	Site A	Site B	Site C	Site D	Site E
<b>Australian Magpie</b> <i>Gymnorhina tibicen</i>	3	-	-	1	1
<b>Australian Raven</b> <i>Corvus coronoides</i>	1	-	1	1	1
<b>Black-faced Cuckoo Shrike</b> <i>Coracina novaehollandiae</i>	2	-	-	1	-
<b>Bronzewing Pigeon</b> <i>Phaps chalcoptera</i>	1	1	2	-	-
<b>Brown Falcon</b> <i>Falco berigora</i>	-	-	-	-	1
<b>Brown Goshawk</b> <i>Accipiter fasciatus</i>	-	-	1	-	-
<b>Brown Honeyeater</b> <i>Lichmera indistincta</i>	-	-	1	1	-
<b>Galah</b> <i>Cacatua roseicapilla</i>	1	-	-	-	2
<b>Golden Whistler</b> <i>Pachycephala pectoralis</i>	1	4	-	-	1
<b>Grey Fantail</b> <i>Rhipidura fuliginosa</i>	1	3	1	2	-
<b>Grey Shrike-thrush</b> <i>Colluricincla harmonica</i>	-	1	-	-	-
<b>Inland Thornbill</b> <i>Acanthiza apicalis</i>	1	-	1	1	1
<b>Laughing Kookaburra</b> <i>Dacelo novaeguineae</i>	-	-	1	-	-
<b>Mistletoebird</b> <i>Dicaeum hirundinaceum</i>	-	1	-	-	-
<b>New Holland Honeyeater</b> <i>Phylidonyris novaehollandiae</i>	-	1	-	1	-
<b>Ringneck Parrot</b> <i>Barnardius zonarius</i>	2	-	-	1	1
<b>Red-capped Parrot</b> <i>Platycercus spurius</i>	-	1	1	1	-
<b>Red-tailed Black Cockatoo</b> <i>Calyptorhynchus banksii</i>	-	2	-	-	-
<b>Red Wattlebird</b> <i>Anthochaera carunculata</i>	-	-	-	1	-
<b>Rufous Whistler</b> <i>Pachycephala rufiventris</i>	-	-	1	1	-
<b>Scarlet Robin</b> <i>Petroica goodenovii</i>	-	-	-	-	1
<b>Shining Bronze-Cuckoo</b> <i>Chrysococcyx lucidus</i>	-	-	-	-	1
<b>Silvereye</b> <i>Zosterops lateralis</i>	-	3	1	1	1
<b>Splendid Fairy-wren</b> <i>Malurus splendens</i>	3	-	2	2	1
<b>Striated Pardalote</b> <i>Pardalotus striatus</i>	-	-	1	1	-
<b>Tree Martin</b> <i>Hirundo nigricans</i>	-	-	-	1	1
<b>Varied Sittella</b> <i>Daphoenositta chrysoptera</i>	-	-	1	1	-
<b>Wedge-tailed Eagle</b> <i>Aquila audax</i>	-	-	-	1	2
<b>Weebill</b> <i>Smicronis brevirostris</i>	3	3	3	5	3
<b>Western Gerygone</b> <i>Gerygone fusca</i>	1	2	2	3	2
<b>Western Spinebill</b> <i>Acanthorhynchus superciliosus</i>	-	2	-	1	-
<b>Western Thornbill</b> <i>Acanthiza inornata</i>	1	1	1	-	1
<b>Western Yellow Robin</b> <i>Eopsaltria griseogularis</i>	-	2	-	-	-
<b>White-browed Scrubwren</b> <i>Sericornis frontalis</i>	-	-	-	1	1
<b>Total sightings</b>	<b>21</b>	<b>27</b>	<b>21</b>	<b>29</b>	<b>22</b>
<b>Species richness</b>	<b>13</b>	<b>14</b>	<b>16</b>	<b>21</b>	<b>17</b>

**Table 9.** Additional information on species of conservation significance.

Species	Significance	Status on project area	Potential impact of proposal
millipede <i>Dinocambala ingens</i>	CS3. Short Range Endemic restricted to western Darling Scarp near Perth.	Present. Collected on edge of granite outcrop.	Loss of habitat and fragmentation of population.
scorpion-fly <i>Austromerope poultonii</i>	CS2. Priority 4 (DEC). Northern limit of range.	Status on site unknown. Occurs in forest leaf-litter.	Loss of habitat.
Hooting Frog <i>Heleioporus barycragus</i>	CS3. Local significance. Northern limit of range.	Present. Probably breeds in Susannah Brook, with adults dispersing into upland habitats for much of year.	Loss of upland habitat. Disruption of movement of adults across the landscape. Potential for degradation of breeding habitat.
Wheatbelt Stone Gecko <i>Diplodactylus granariensis</i>	CS3. Local significance. Probably outlying population.	Present. Mostly on gravelly sands near granites.	Loss of habitat. Fragmentation of population.
Beautiful Gecko <i>Diplodactylus pulcher</i>	CS3. Local significance. Probably outlying population.	Not recorded. Possibly not present.	May not be present but, if present, population would suffer loss of habitat.
legless lizard <i>Pletholax gracilis</i>	CS3. Local significance. Unusual on scarp.	Present in heath on gravelly sand around granites.	Loss of habitat. Population is probably small because likely to be restricted to gravelly sands, making it vulnerable to local extinction. Fragmentation of local population also likely.
Dell's Skink <i>Ctenotus delli</i>	CS2. Priority 4. (DEC).	Not recorded but very likely to be present. Most likely in heath on gravelly sand around granites.	Loss of habitat and fragmentation of population.
skink <i>Eremiascincus richardsonii</i>	CS3. Local significance. Southern limit of range.	Not recorded but may be present around granites.	Loss of habitat and fragmentation of population.

Table 9 (cont.)

Species	Significance	Status on project area	
blind snake <i>Ramphotyphlops pinguis</i>	CS3. Local significance. Restricted distribution and at northern limit of range.	Present. Caught at Sites C and E; both near granite areas.	Loss of habitat and fragmentation of population
Stimson's Python <i>Antaresia stimsoni</i>	CS3. Local significance. Southern limit of range.	Not recorded but may be present. Most likely in granite areas.	Loss of habitat and fragmentation of population. Population is likely to be small because this is a top order predator and therefore will be vulnerable to local extinction. May also be vulnerable to roadkill.
South-West Carpet Python <i>Morelia spilota imbricata</i>	CS1. Schedule 4 (WA Wildlife Act).	Reported by Hanson staff in granite areas.	Loss of habitat and fragmentation of population. Population is likely to be small because this is a top order predator and therefore will be vulnerable to local extinction. May also be vulnerable to roadkill.
Southern Death-adder <i>Acanthophis antarcticus</i>	CS2. Priority 4. (DEC).	Not recorded. Project area may be just outside range of species, which is to the south. If present, could be in any terrestrial habitat.	Loss of habitat and fragmentation of population. Population is likely to be small because this is a top order predator and therefore will be vulnerable to local extinction. May also be vulnerable to roadkill.
Ringed Brown Snake <i>Pseudonaja modesta</i>	CS3. Local significance. Possible extinct in Perth area.	Not recorded and may be locally extinct. Habitat in Perth area unknown.	Nil impact as probably locally extinct.
30 birds of CS3.	CS3. Local significance. Declined in Perth area.	14 species confirmed. Most are sedentary species of heathland and understorey.	Loss of habitat and fragmentation of populations.

Table 9 (cont.)

Species	Significance	Status on project area	
Barking Owl <i>Ninox connivens</i>	CS2. Priority 2. (DEC).	Not recorded. May be visitor but unlikely to be nesting habitat. Will forage widely.	Minor loss of habitat.
Masked Owl <i>Tyto novaehollandiae</i>	CS2. Priority 3. (DEC).	Not recorded. May be visitor but unlikely to be nesting habitat. Will forage widely.	Minor loss of habitat.
Crested Shrike-tit <i>Falcunculus frontatus</i>	CS2. Priority 4. (DEC).	Not recorded. May be occasional visitor. Forages in eucalypts, particularly Wandoo.	Loss of habitat.
Peregrine Falcon <i>Falco peregrinus</i>	CS1. Schedule 4 (WA Wildlife Act).	Not recorded but project area is very likely to be within feeding range of a pair. The birds forage widely over all habitats. Nesting unlikely but potential on abandoned quarry face.	Minimal impact as birds have a very large home range.
Forest Red-tailed Black-Cockatoo <i>Calyptorhynchus banksii naso</i>	CS1. Schedule 1 (WA Wildlife Act).	Small flock seen in Site B on two occasions. Breeding unlikely. Foraging mainly in eucalypts, especially Marri <i>Corymbia calophylla</i> .	Loss of foraging habitat.
Carnaby's Black-Cockatoo <i>Calyptorhynchus latirostris</i>	CS1. Schedule 1 (WA Wildlife Act) and Endangered (EPBC Act).	Not recorded but likely to visit regularly. Breeding unlikely. Foraging in range of habitats, including eucalypts and heaths.	Loss of foraging habitat.

Table 9 (cont.)

Species	Significance	Status on project area	
Baudin's Black-Cockatoo <i>Calyptrorhynchus baudinii</i>	CS1. Schedule 1 (WA Wildlife Act) and Vulnerable (EPBC Act).	Not recorded but likely to visit regularly. Breeding unlikely. Foraging mainly in eucalypts, especially Marri <i>Corymbia calophylla</i> .	Loss of foraging habitat.
Rainbow Bee-eater <i>Merops ornatus</i>	CS1. Migratory (EPBC Act).	Not recorded but likely to be a breeding visitor. This is a widespread species most likely to occur within the project area along tracks and clearings.	Loss of habitat.
Chuditch <i>Dasyurus geoffroii</i>	CS1. Schedule 1 (WA Wildlife Act) and Vulnerable (EPBC Act).	Not recorded but likely to be present. May occur anywhere within project area. Individuals have home ranges of several hundred hectares.	Fragmentation of population.
Brush-tailed Phascogale <i>Phascogale tapoatafa</i>	CS1. Schedule 1 (WA Wildlife Act).	Not recorded but likely to be present. May occur anywhere within project area.	Fragmentation of population.
Quenda <i>Isoodon obesulus fusciventer</i>	CS2. Priority 5 (DEC).	Not recorded but reported elsewhere along Susannah Brook. May be limited suitable habitat, but animals may move through project area.	Fragmentation of population.
Brush Wallaby <i>Macropus irma</i>	CS2. Priority 4 (DEC).	Not recorded but very likely to be present. Could occur in all habitats.	Loss of habitat. Fragmentation of population.
Western False Pipistrelle <i>Falsistrellus mackenziei</i>	CS2. Priority 4 (DEC).	Not recorded but very likely to be present. Most likely in forested areas.	Loss of habitat. Fragmentation of population.

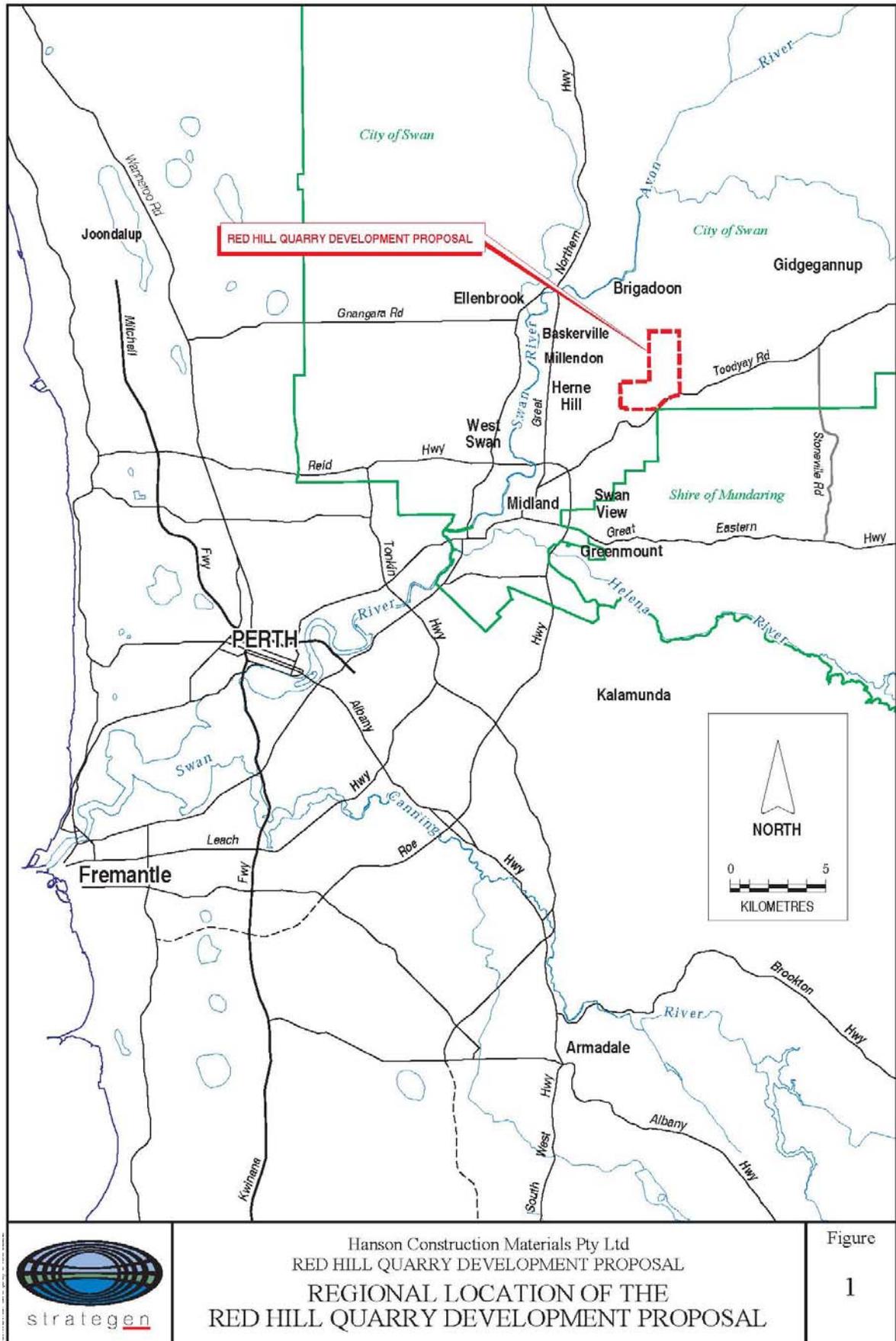
Table 9 (cont.)

Species	Significance	Status on project area	
Rakali or Water-Rat <i>Hydromys chrysogaster</i>	CS2. Priority 4 (DEC).	Not recorded but likely to be seasonal visitor along Susannah Brook.	Minimal impact assuming no degradation of Susannah Brook.
Mardo <i>Antechinus flavipes</i>	CS3. Local significance. Declined in Perth region.	Present. Especially abundant at Site B in Jarrah forest with gravelly soil.	Loss of habitat. Fragmentation of population.
dunnart <i>Sminthopsis gilberti</i>	CS3. Local significance. Declined in Perth region.	Present. No clear habitat preference.	Loss of habitat. Fragmentation of population.
Western Pygmy-possum <i>Cercartetus concinnus</i>	CS3. Local significance. Declined in Perth region.	Present. Most in woodland areas with Wandoo.	Loss of habitat. Fragmentation of population.
Honey Possum <i>Tarsipes rostratus</i>	CS3. Local significance. Declined in Perth region.	Present. Especially abundant in heath near granites.	Loss of habitat. Fragmentation of population.

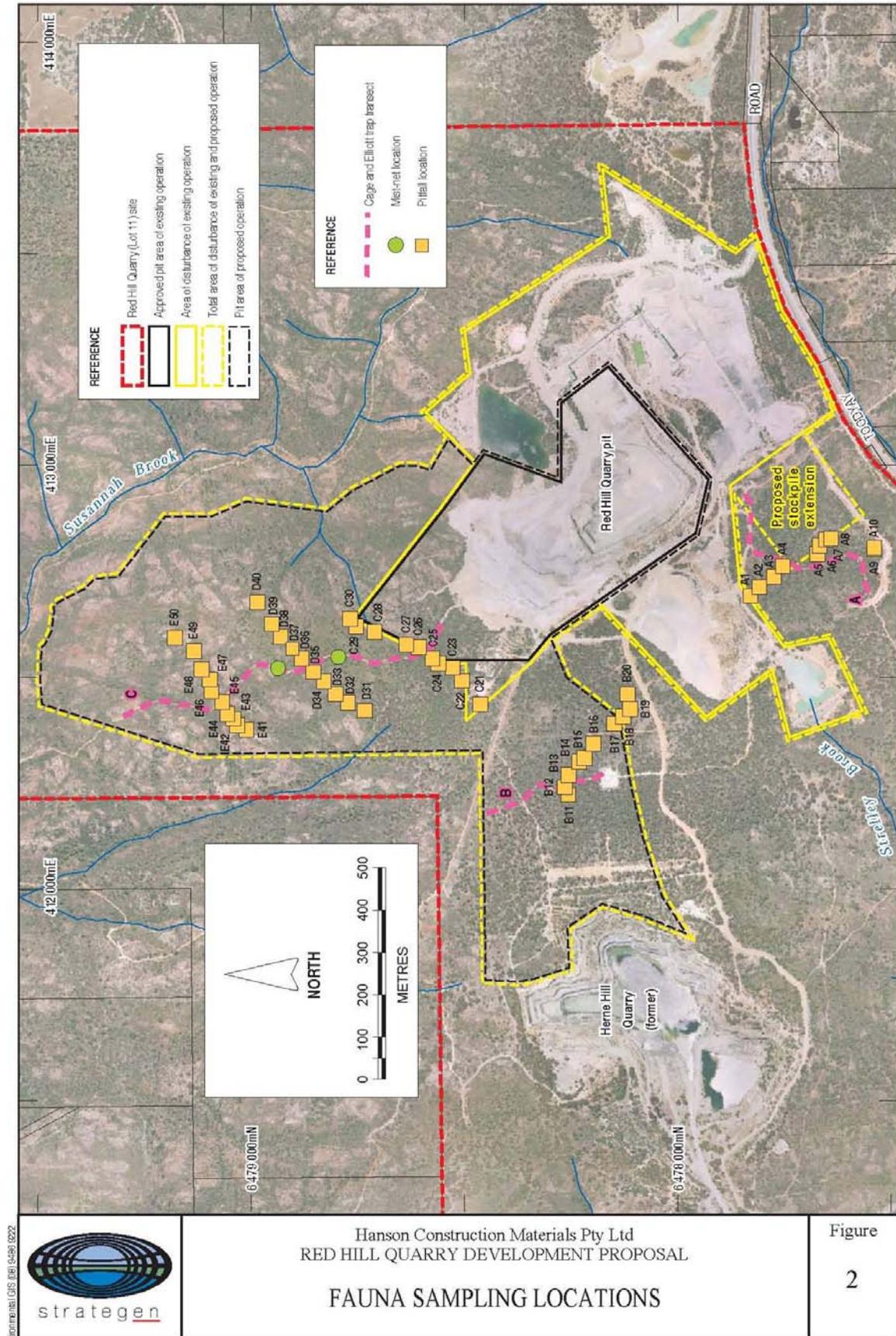
**Table 10.** The potential impacts to fauna of the proposal as assessed following the guidance of the EPA's Guidance Statement No. 56. (Terrestrial fauna surveys for environmental impact assessment in Western Australia, EPA 2004).

<b>Factor</b>	<b>Impact and explanation</b>
Degree of habitat degradation or clearing within the local area or region.	Moderate to high (Project area is in region where clearing has been extensive, but the vegetation and landforms of the project area are represented in nearby conservation estate).
Size/scale of proposal/impact.	High (>10ha of remnant native vegetation may be disturbed over the life of the project - Bioregion Group 1).
Rarity of vegetation and landforms.	Moderate (impacted vegetation and landforms include some that are moderately limited in local distribution, particularly Wandoo woodland and heaths on gravelly sands around granites).
Refugia.	Moderate (Granite outcrops and associated vegetation may act as refugia).
Significant habitats	Moderate (Wandoo woodland and heaths of gravelly sands around granites are significant but are represented nearby).
Fauna protected under international agreements or treaties, Specially Protected or Priority Fauna.	High (faunal assemblage includes species of high conservation significance).
Other significant fauna	High (many species that have locally declined because project area is close to Perth and is transitional between the coastal plain and the scarp).
Size of remnant and condition/intactness of habitat and faunal assemblage.	Moderate (project area supports landforms and habitats typical of area).
Ecological linkage.	High (the project area is strategically placed between John Forrest National Park and the Darling Range Regional Park).
Heterogeneity or complexity of the habitat and faunal assemblage.	High (project area has high habitat heterogeneity and a complex faunal assemblage).

**Figure 1.** Location map for the Red Hill site.



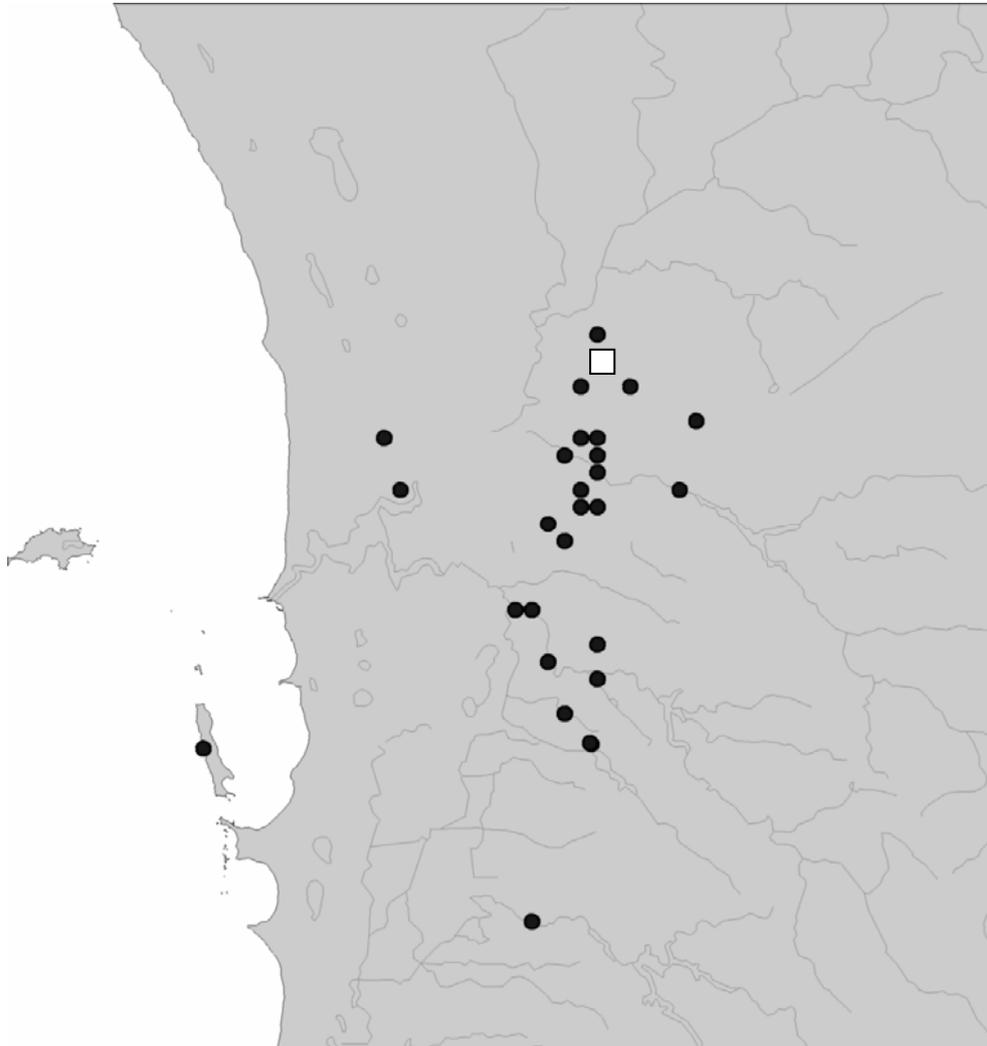
**Figure 2.** Fauna sampling locations at Hanson quarry. Locations of pitfall traps, transects of Elliott and cage traps, and mist-netting sites are indicated.



Hanson Construction Materials Pty Ltd  
 RED HILL QUARRY DEVELOPMENT PROPOSAL  
 FAUNA SAMPLING LOCATIONS

Figure  
 2

**Figure 3.** Locations of museum specimens of the millipede *Dinocambala ingens* (source: WA Museum). Locations on the coastal plain and Garden Island are considered to be erroneous (M. Harvey pers. comm.). The white square indicates the approximate location of the Red Hill quarry.



## APPENDICES

**Appendix 1.** The number of each trap type and the number of nights that they were operated during the December 2006 survey.

Trap Type	Site	December 2006		
		Traps	Nights	Trap Nights
Pitfall traps	A	10	5	50
	B	10	5	50
	C	10	5	50
	D	10	5	50
	E	10	5	50
	<b>Total</b>			<b>250</b>
Funnel traps	A	10	5	50
	B	10	5	50
	C	10	5	50
	D	10	5	50
	E	10	5	50
	<b>Total</b>			<b>250</b>
Elliott traps	A	14	4	56
	B	15	4	60
	C	21	4	84
	<b>Total</b>			<b>200</b>
Cage traps	A	14	4	56
	B	15	4	60
	C	21	4	84
	<b>Total</b>			<b>200</b>
			<b>Total</b>	<b>900</b>

**Appendix 2a.** Pitfall trapping locations for the Red Hill transects. Datum is WGS84 (Zone 50).

<b>Pitfall</b>	<b>Location</b>	<b>Pitfall</b>	<b>Location</b>
A1	0412692E, 6477830N	C26	0412571E, 6478607N
A2	0412713E, 6477809N	C27	0412577E, 6478636N
A3	0412737E, 6477775N	C28	0412606E, 6478711N
A4	0412762E, 6477754N	C29	0412620E, 6478754N
A5	0412791E, 6477673N	C30	0412638E, 6478768N
A6	0412810E, 6477668N	D31	0412421E, 6478734N
A7	0412825E, 6477652N	D32	0412440E, 6478773N
A8	0412827E, 6477641N	D33	0412460E, 6478802N
A9	0412802E, 6477540N	D34	0412490E, 6478830N
A10	0412806E, 8477540N	D35	0412512E, 6478854N
B11	0412222E, 6478257N	D36	0412544E, 6478882N
B12	0412240E, 6478265N	D37	0412567E, 64778903N
B13	0412269E, 6478256N	D38	0412596E, 6478931N
B14	0412300E, 6478232N	D39	0412625E, 6478952N
B15	0412309E, 6478219N	D40	0412677E, 6478985N
B16	0412343E, 6478198N	E41	0412376E, 6479011N
B17	0412390E, 6478149N	E42	0412386E, 6479033N
B18	0412407E, 6478128N	E43	0412402E, 6479042N
B19	0412425E, 6478112N	E44	0412413E, 6479056N
B20	0412460E, 6478118N	E45	0412441E, 6479068N
C21	0412436E, 6478463N	E46	0412466E, 6479093N
C22	0412491E, 6478506N	E47	0412494E, 6479097N
C23	0412522E, 6478528N	E48	0412519E, 6479116N
C24	0412532E, 6478561N	E49	0412562E, 6479134N
C25	0412544E, 6478575N	E50	0412593E, 6479179N

**Appendix 2b.** Vegetation Communities and Trap Placement. Information on vegetation communities from Mattiske Consulting.

Code	Vegetation Description	Trap Numbers
1	Mosaic of lithic complex on exposed granites to patches of open to closed heath of Proteaceae and Myrtaceae species, including <i>Hakea incrassata</i> , <i>Hakea undulata</i> , <i>Allocasuarina humilis</i> , <i>Dryandra armata</i> var. <i>armata</i> and <i>Hypocalymma angustifolium</i> on exposed granites	D40, D41, D43, D44, D45,
2	Open to closed heaths of Proteaceae – Myrtaceae species, including <i>Hakea incrassata</i> , <i>Allocasuarina humilis</i> , <i>Dryandra armata</i> var. <i>armata</i> and <i>Hypocalymma angustifolium</i> on exposed granites.	C28, D42, D46, D47, D48, D49,
3	Open woodland of <i>Eucalyptus rudis</i> - <i>Eucalyptus wandoo</i> , <i>Corymbia calophylla</i> over <i>Trymalium ficundum</i> subsp. <i>floribundum</i> , <i>Darwinia citrodora</i> over sedges on creeklines	No traps along creekline
4	Open woodland of <i>Eucalyptus wandoo</i> and <i>Eucalyptus accedens</i> - <i>Corymbia calophylla</i> over low understorey, including <i>Hibbertia hypericoides</i> , <i>Bossiaea eriocarpa</i> , <i>Phyllanthus caius</i> on clay loams.	D31, D32
5	Open woodland of <i>Eucalyptus wandoo</i> and <i>Eucalyptus accedens</i> with dense understorey, including <i>Hakea incrassata</i> , <i>Hakea undulata</i> , and <i>Hakea trifurcata</i> on clay over shallow granite	A1, A2, A3, A4, A5, A6 A7, C21, C22, C23, C24, C25, C26, C27, , D33, D50
6	Open woodland of <i>Eucalyptus marginate</i> and <i>Corymbia calophylla</i> over a dense understorey of <i>Hakea incrassata</i> , <i>Allocasuarina humilis</i> , <i>Hakea undulata</i> on sandy soils over granite.	A8, A9, A10, C29, C30, D34, D35, D36, D37, D38, D39,
7	Open forest of <i>Allocasuarina fraseriana</i> - <i>Eucalyptus marginata</i> – <i>Corymbia calophylla</i> over low understorey including <i>Grevillea wilsoni</i> , <i>Hibbertia hypericoides</i> and <i>Hakea spp</i> on sandy gravel.	B11, B12, B13, B14, B17, B18, B19, B20,
8	Open woodland of <i>Allocasuarina huegeliana</i> over patches of <i>Lithic Complex</i> and open heath of Proteaceae – Myrtaceae species on exposed granites.	B16, B16,

### **Appendix 3.** Categories used in the assessment of conservation status.

#### **IUCN categories (based on review by Mace and Stuart 1994) as used for the Environmental Protection and Biodiversity Conservation (EPBC) Act and the WA Wildlife Conservation Act.**

**Extinct.** Taxa not definitely located in the wild during the past 50 years.

**Extinct in the Wild.** Taxa known to survive only in captivity.

**Critically Endangered.** Taxa facing an extremely high risk of extinction in the wild in the immediate future.

**Endangered.** Taxa facing a very high risk of extinction in the wild in the near future.

**Vulnerable.** Taxa facing a high risk of extinction in the wild in the medium-term future.

**Near Threatened.** Taxa that risk becoming Vulnerable in the wild.

**Conservation Dependent.** Taxa whose survival depends upon ongoing conservation measures. Without these measures, a conservation dependent taxon would be classed as Vulnerable or more severely threatened.

**Data Deficient (Insufficiently Known).** Taxa suspected of being Rare, Vulnerable or Endangered, but whose true status cannot be determined without more information.

**Least Concern.** Taxa that are not Threatened.

#### **Schedules used in the WA Wildlife Conservation Act.**

**Schedule 1.** Rare and Likely to become Extinct.

**Schedule 2.** Extinct.

**Schedule 3.** Migratory species listed under international treaties.

**Schedule 4.** Other Specially Protected Fauna.

#### **WA Department of Environment and Conservation Priority species** (species not listed under the Conservation Act, but for which there is some concern).

**Priority 1.** Taxa with few, poorly known populations on threatened lands.

**Priority 2.** Taxa with few, poorly known populations on conservation lands; or taxa with several, poorly known populations not on conservation lands.

**Priority 3.** Taxa with several, poorly known populations, some on conservation lands.

**Priority 4.** 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 be if present circumstances change.

**Priority 5.** Taxa in need of monitoring. Taxa which are not considered threatened but are subject to a specific conservation program, the cessation of which would result in the species becoming threatened within five years (IUCN Conservation Dependent).

**Appendix 4.** Results of the DEC Threatened Species Database search. The number of records of each species within the search area (see Methods) is shown. DEC categories are explained in Appendix 3.

Schedule 1	Species	Number of Records
Carnaby's Cockatoo	<i>Calyptorhynchus latirostris</i>	3
Forest Red-tailed Black-Cockatoo	<i>Calyptorhynchus banksii naso</i>	5
Baudin's Black-Cockatoo	<i>Calyptorhynchus baudinii</i>	1
Chuditch	<i>Dasyurus geoffroii</i>	37
Numbat	<i>Myrmecobius fasciatus</i>	1
Brush-tailed Phascogale	<i>Phascogale tapoatafa</i>	1
Western Ring-tailed Possum	<i>Pseudocheirus occidentalis</i>	1
<b>Schedule 4</b>		
Peregrine Falcon	<i>Falco peregrinus</i>	3
South-West Carpet Python	<i>Morelia spilota imbricata</i>	1
<b>Priority 1</b>		
scorpion-fly	<i>Austromerope poultoni</i>	1
<b>Priority 4</b>		
Peregrine Falcon	<i>Falco peregrinus</i>	
Brush Wallaby	<i>Macropus irma</i>	6
Rakali (Water-Rat)	<i>Hydromys chrysogaster</i>	10
Dell's Skink	<i>Ctenotus delli</i>	1
<b>Priority 5</b>		
Quenda	<i>Isodon obesulus fusciventer</i>	29

**Appendix 5.** Results of the EPBC Threatened Species Database search. EPBC categories are explained in Appendix 3.

Category	Species
<b>Birds</b>	
<b>Endangered</b>	
Carnaby's Cockatoo	<i>Calyptorhynchus latirostris</i>
<b>Vulnerable</b>	
Baudin's Black-Cockatoo	<i>Calyptorhynchus baudinii</i>
<b>Migratory</b>	
White-bellied Sea-Eagle	<i>Haliaeetus leucogaster</i>
Rainbow Bee-eater	<i>Merops ornatus</i>
<b>Mammals</b>	
Chuditch	<i>Dasyurus geoffroii</i>

**Appendix 6.** Raw pitfall (P) and funnel (F) trapping data.

Date	Transect	Trap	Species
19/12/06	A	P2	<i>Sminthopsis gilberti</i>
19/12/06	A	P1	<i>Crenadactylus ocellatus</i>
19/12/06	A	P9	<i>Diplodactylus aff polyophthalmus</i>
19/12/06	B	P15	<i>Tarsipies rostratus</i>
19/12/06	B	F25	<i>Menetia greyii</i>
19/12/06	C	P25	<i>Tarsipies rostratus</i>
19/12/06	C	P21	<i>Diplodactylus polyophthalmus</i>
19/12/06	C	F26	<i>Crenadactylus ocellatus</i>
19/12/06	C	P30	<i>Crenadactylus ocellatus</i>
19/12/06	D	P31	<i>Cryptoblepharus plagiocephalus</i>
19/12/06	D	F32	<i>Strophurus spinigerus</i>
19/12/06	D	F32	<i>Diplodactylus polyophthalmus</i>
19/12/06	D	F32	<i>Demansia psammophis</i>
19/12/06	D	P33	<i>Strophurus spinigerus</i>
19/12/06	E	F42	<i>Gehyra variegata</i>
19/12/06	E	P43	<i>Tarsipies rostratus</i>
19/12/06	E	P47	<i>Mus musculus</i>
19/12/06	E	P48	<i>Tarsipies rostratus</i>
19/12/06	E	F48	<i>Diplodactylus granariensis</i>
19/12/06	E	P49	<i>Tarsipies rostratus</i>
19/12/06	E	F49	<i>Crenadactylus ocellatus</i>
19/12/06	E	F49	<i>Crenadactylus ocellatus</i>
19/12/06	E	P40	<i>Mus musculus</i>
19/12/06	E	F50	<i>Strophurus spinigerus</i>
20/12/06	A	P4	<i>Sminthopsis gilberti</i>
20/12/06	B	P15	<i>Antechinus flavipes</i>
20/12/06	B	P15	<i>Antechinus flavipes</i>
20/12/06	B	P19	<i>Antechinus flavipes</i>
20/12/06	C	P21	<i>Tarsipies rostratus</i>
20/12/06	C	P23	<i>Menetia greyii</i>
20/12/06	C	P25	<i>Tarsipies rostratus</i>
20/12/06	C	P25	<i>Tarsipies rostratus</i>
20/12/06	C	P26	<i>Mus musculus</i>
20/12/06	C	P26	<i>Ramphotyphlops pinguis</i>
20/12/06	C	P26	<i>Crenadactylus ocellatus</i>
20/12/06	C	P30	<i>Pogona minor</i>
20/12/06	C	P30	<i>Gehyra variegata</i>
20/12/06	D	P33	<i>Tarsipies rostratus</i>
20/12/06	D	P34	<i>Tarsipies rostratus</i>
20/12/06	D	P36	<i>Tarsipies rostratus</i>
20/12/06	D	P37	<i>Tarsipies rostratus</i>
20/12/06	D	P40	<i>Heleioporus barycragus</i>
20/12/06	E	P41	<i>Ramphotyphlops pinguis</i>
20/12/06	E	P43	<i>Tarsipies rostratus</i>
20/12/06	E	P46	<i>Crenadactylus ocellatus</i>
20/12/06	E	F48	<i>Ctenotus fallens</i>

## Appendix 6 (cont.)

Date	Transect	Trap	Species
21/12/06	A	P9	<i>Heleioporus barycragus</i>
21/12/06	A	P9	<i>Diplodactylus</i> aff. <i>polyophthalmus</i>
21/12/06	B	P13	<i>Hemiergus initialis</i>
21/12/06	B	P16	<i>Lerista distinguenda</i>
21/12/06	B	P16	<i>Lerista distinguenda</i>
21/12/06	B	P17	<i>Antechinus flavipes</i>
21/12/06	C	P28	<i>Sminthopsis gilberti</i>
21/12/06	C	F29	<i>Lerista distinguenda</i>
21/12/06	C	F30	<i>Ctenotus fallens</i>
21/12/06	D	F35	<i>Tarsipies rostratus</i>
21/12/06	D	P36	<i>Sminthopsis gilberti</i>
21/12/06	D	P36	<i>Diplodactylus polyophthalmus</i>
21/12/06	D	P37	<i>Ctenotus fallens</i>
21/12/06	D	P38	<i>Tarsipies rostratus</i>
21/12/06	E	F34	<i>Strophurus spinigerus</i>
21/12/06	E	P37	<i>Mus musculus</i>
21/12/06	E	P40	<i>Strophurus spinigerus</i>
22/12/06	A	P2	<i>Cercartetus concinnus</i>
22/12/06	A	P5	<i>Cryptoblepharus plagiocephalus</i>
22/12/06	A	P10	<i>Mus musculus</i>
22/12/06	A	P10	<i>Hemiergus initialis</i>
22/12/06	B	P11	<i>Tarsipies rostratus</i>
22/12/06	B	P15	<i>Antechinus flavipes</i>
22/12/06	B	P16	<i>Tarsipies rostratus</i>
22/12/06	B	P16	<i>Tarsipies rostratus</i>
22/12/06	B	P17	<i>Tarsipies rostratus</i>
22/12/06	B	P20	<i>Pogona minor</i>
22/12/06	C	P21	<i>Tarsipies rostratus</i>
22/12/06	C	P22	<i>Cercartetus concinnus</i>
22/12/06	C	P25	<i>Tarsipies rostratus</i>
22/12/06	C	P28	<i>Tarsipies rostratus</i>
22/12/06	C	P29	<i>Menetia greyii</i>
22/12/06	C	P29	<i>Lerista distinguenda</i>
22/12/06	C	P30	<i>Tarsipies rostratus</i>
22/12/06	D	F32	<i>Ctenotus fallens</i>
22/12/06	D	F37	<i>Ctenotus fallens</i>
22/12/06	D	P37	<i>Antechinus flavipes</i>
22/12/06	D	P39	<i>Delma fraseri fraseri</i>
22/12/06	D	P40	<i>Sminthopsis gilberti</i>
22/12/06	D	P40	<i>Tarsipies rostratus</i>
22/12/06	D	F40	<i>Mus musculus</i>
23/12/06	A	P3	<i>Tarsipies rostratus</i>
23/12/06	A	P5	<i>Cercartetus concinnus</i>
23/12/06	A	P7	<i>Lerista distinguenda</i>
23/12/06	A	P9	<i>Antechinus flavipes</i>
23/12/06	B	P13	<i>Tarsipies rostratus</i>
23/12/06	B	P19	<i>Menetia greyii</i>
23/12/06	C	P21	<i>Ctenotus fallens</i>
23/12/06	C	P21	<i>Diplodactylus granariensis</i>
23/12/06	C	P28	<i>Crenadactylus ocellatus</i>
23/12/06	C	F29	<i>Lerista distinguenda</i>
23/12/06	C	P30	<i>Diplodactylus granariensis</i>
23/12/06	C	P30	<i>Menetia greyii</i>
23/12/06	D	P33	<i>Tarsipies rostratus</i>
23/12/06	D	P33	<i>Strophurus spinigerus</i>
23/12/06	D	P34	<i>Strophurus spinigerus</i>

## Appendix 6 (cont.)

<b>Date</b>	<b>Transect</b>	<b>Trap</b>	<b>Species</b>
23/12/06	D	P35	<i>Strophurus spinigerus</i>
23/12/06	D	P35	<i>Diplodactylus granariensis</i>
23/12/06	D	F37	<i>Crenadactylus ocellatus</i>
23/12/06	D	P40	<i>Sminthopsis gilberti</i>
23/12/06	E	P43	<i>Pletholax gracilis</i>
23/12/06	E	F45	<i>Gehyra variegata</i>
23/12/06	E	F46	<i>Crenadactylus ocellatus</i>
23/12/06	E	P47	<i>Mus musculus</i>
23/12/06	E	P48	<i>Mus musculus</i>
23/12/06	E	P48	<i>Mus musculus</i>
23/12/06	E	F48	<i>Crenadactylus ocellatus</i>
23/12/06	E	F48	<i>Crenadactylus ocellatus</i>
23/12/06	E	P49	<i>Mus musculus</i>
23/12/06	E	P49	<i>Cryptoblepharus plagiocephalus</i>

**Appendix 7.** Annotated bird species lists from the December 2006 field surveys.

The following list, presented in family order, includes thirty-seven species of birds recorded from five sites at the Red Hill quarry during one week of fauna surveys.

**NON-PASSERINES**

**THRESKIORNITHIDAE**

**Sacred Ibis** *Theskiornis molucca*

Flock of 12 circling high above ground on one occasion.

**Straw-necked Ibis** *Threskiornis spinicollis*

Flock of 7 observed circling high above ground on one occasion.

**ACCIPITRIDAE**

**Brown Goshawk** *Accipiter fasciatus*

One chasing Wedge-tailed Eagles above Site C.

**Wedge-tailed Eagle** *Aquila audax*

Seen on 3 occasions, mostly in pairs, riding thermals high above open granite areas. Nest on opposite side of valley (to north).

**FALCONIDAE**

**Brown Falcon** *Falco berigora*

One circling above Site E.

**COLUMBIDAE**

**Bronzewing Pigeon** *Phaps chalcoptera*

Seen and heard at 3 sites, often in pairs.

**CACATUIDAE**

**Galah** *Cacatua roseicapilla*

Two flying over Site A and two flying across valley north of Site E.

**Forest Red-tailed Black-Cockatoo** *Calyptorhynchus banksii*

Small flock (<10 birds?) heard calling (probably while feeding in jarrah) from Site B on two occasions.

**PSITTACIDAE**

**Australian Ringneck** *Barnardius zonarius*

Seen and heard at most sites.

**Red-capped Parrot** *Platycercus spurius*

Heard calling at 3 sites, observed perching in marri at Site C.

**CUCULIDAE**

**Shining Bronze-Cuckoo** *Chrysococcyx lucidus*

Heard calling along creekline north of proposed quarry on one occasion.

### **ALCEDINIDAE**

**Laughing Kookaburra** *Dacelo novaeguineae*  
One calling at Site C.

### **PASSERINES**

#### **MALURIDAE**

**Splendid Fairy-wren** *Malurus splendens*  
Recorded at most sites, usually calling from dense heathland shrubs.

#### **PARDALOTIDAE**

**Inland Thornbill** *Acanthiza apicalis*  
Heard at most sites, occasionally seen in canopy of wandoo trees.

**Striated Pardalote** *Pardalotus striatus*  
Heard calling from wandoo trees at 2 sites.

**Weebill** *Smicrornis brevirostris*  
Commonly heard at all sites, and occasionally seen gleaning from canopy of wandoos.

**Western Gerygone** *Gerygone fusca*  
Commonly heard at all sites.

**Western Thornbill** *Acanthiza inornata*  
Recorded at most sites calling from jarrah trees.

**White-browed Scrubwren** *Sericornis frontalis*  
Heard calling from dense heathland vegetation at 2 sites.

#### **MELIPHAGIDAE**

**Brown Honeyeater** *Lichmera indistincta*  
Heard calling near stockpile area and recorded at 2 sites.

**New Holland Honeyeater** *Phylidonyris novaehollandiae*  
Heard calling at 2 sites, more common in northern section where *Calothamnus* grows in dense areas.

**Red Wattlebird** *Anthochaera carunculata*  
2 observed in wandoo at Site D.

**Western Spinebill** *Acanthorhynchus superciliosus*  
Heard at 2 sites, usually calling from *Dryandra* thickets.

#### **PETROICIDAE**

**Scarlet Robin** *Petroica goodenovii*  
Heard calling from creekline north of proposed quarry on one occasion.

**Western Yellow Robin** *Eosaltria griseogularis*  
Recorded at Site B in dense *Dryandra* thicket, also an old nest found at this site.

### **NEOSITTIDAE**

#### **Varied Sittella** *Daphoenositta chrysoptera*

Two records, probably of the same small group of 5-7, flying and perching in canopy near Sites C and D.

### **PACHYCEPHALIDAE**

#### **Golden Whistler** *Pachycephala pectoralis*

Heard calling at most sites and one observation of female in *Dryandra* thicket.

#### **Rufous Whistler** *Pachycephala rufiventris*

Heard calling occasionally, mostly from dense *Dryandra* thickets at Site B.

#### **Grey Shrike-thrush** *Colluricincla harmonica*

One calling in jarrah woodland at Site B.

### **DICRURIDAE**

#### **Grey Fantail** *Rhipidura fuliginosa*

Seen and heard at most sites.

### **CAMPEPHAGIDAE**

#### **Black-faced Cuckoo-shrike** *Coracina novaehollandiae*

Seen twice flying above quarry entrance and heard at 2 sites.

### **ARTAMIDAE**

#### **Australian Magpie** *Gymnorhina tibicen*

Heard calling several mornings, seen occasionally flying through jarrah/wandoo upland.

### **CORVIDAE**

#### **Australian Raven** *Corvus coronoides*

Heard calling most mornings, 3 flew above existing quarry.

### **PASSERIDAE**

#### **Red-eared Firetail** *Stagonopleura oculata*

3 individuals observed along creekline north of proposed quarry site.

### **DICAEDAE**

#### **Mistletoebird** *Dicaeum hirundinaceum*

One calling as it flew over Site B.

### **HIRUNDINIDAE**

#### **Tree Martin** *Hirundo nigricans*

Observed on 2 occasions circling high above open granite outcrops.

### **ZOSTEROPIDAE**

#### **Silvereye** *Zosterops lateralis*

Seen and heard at most sites, mostly in small flocks flying through canopy.

## **Hanson's Quarry (Search for Gecko)**

**Harris I. and Bamford M. (Bamford Consulting Ecologists)**

**June 2007**

### **Introduction**

Bamford Consulting was commissioned by Hanson Construction Materials Pty Ltd (Hanson) to carry out a fauna survey at Hanson's Red Hill Quarry, located on Toodyay Road Red Hill. Results of the December 2006 field survey are presented in Harris and Bamford (2007). During the 2006 survey Bamford Consulting recorded a species of gecko thought to be similar to *Diplodactylus polyophthalmus*. Because this species was unusual and not typically representative of *D. polyophthalmus*, one specimen (of two caught) was presented to the Western Australian Museum (WAM) for formal identification. In order to determine if there were multiple individuals of this species at the survey site, it was proposed that intensive hand-searching be undertaken at a cool time of the year, as many reptiles can readily be found in that way. In addition, hand-searching during cool, moist conditions is an effective way of locating some significant invertebrates that may have been inadequately sampled during the December survey. As part of this programme, Bamford Consulting conducted a one day intensive search on May 15 2007 and the results of this work are presented and discussed below.

### **Methods**

In an effort to locate specimens of the gecko, hand searching techniques were employed both in the area that the individual was found and at selected sites throughout the general survey area. Hand searching techniques included:

- turning over granite and lateritic rocks;
- searching under fallen timber;
- searching under bark on dead trees;
- raking leaf litter;
- lifting rubbish deposits and
- searching through dead grass trees.

Rocks and logs were placed back into their original position to avoid excessive disturbance. Short range invertebrate species were also collected opportunistically and

samples submitted to WAM for identification. Weather conditions were fine and mild with a maximum temperature of approximately 25 degrees Celsius.

## Results

Results of the searching for reptile species are listed in Table 1 below. While six species of reptile were observed, including two species not previously recorded at this site, the Southern Shovel-nosed Snake and Gould's Hooded Snake, no individuals of the target species were observed. Three species of invertebrates were collected, two millipedes and one snail, and submitted to WAM for formal identification.

Table 1: Reptile species recorded during the site visit on 15 May 2007.

Species	Common Name	Number Found
<i>Ctenophorus ornatus</i>	Ornate Dragon	1
<i>Gehyra variegata</i>	Tree Delta	8
<i>Crenadactylus ocellatus</i>	Clawless Gecko	5
<i>Cryptoblepharus plagiocephalus</i>	Fence Skink	3
<i>Brachyurophis semifasciata</i>	Southern Shovel – nosed Snake*	2
<i>Parasuta gouldii</i>	Gould's Hooded Snake*	1

\* Not recorded in December 2006 but listed as expected to be present by Harris and Bamford (2007).

## Discussion

Although it was expected that hand-searching would locate further specimens of the gecko, this was not the case. Furthermore, while searching located two reptile species not found in December, it did not record three other species of gecko that were common during the December 2006 survey: *Diplodactylus granariensis*, *Strophurus spinigerus* and *Diplodactylus polyophthalmus*. This suggests that these common species were well hidden, possibly under large granite outcrops or fallen trees, implying that the target

species may also have been well hidden for the duration of winter. Recommendations based on this observation are discussed below.

The three invertebrate species collected were the millipede *Dinocambala ingens*, a land snail *Bothriembryon* sp. and a scorpion *Urodacus novaehollandiae*. The millipede and scorpion had been found previously (Harris and Bamford 2007), but the millipede was noted as being extremely abundant in the granite areas in May, whereas only one specimen had been found in December. The millipede has a restricted range along the Darling Escarpment from Serpentine to just north of Red Hill, but the scorpion is widespread in the South-West. The land snail is also widespread in the South-West. Despite searching, no other potentially significant invertebrates were collected.

### **Recommendations**

Following the December 2006 survey, proposed studies consisted of a winter survey to search for more specimens of the gecko and to collect potentially significant invertebrates. The following further studies are proposed:

1. Conduct a late winter/early spring survey for the gecko and for potentially significant invertebrates.
2. If no further gecko specimens are collected, consider an intense, summer trapping survey of the area where the original specimen was captured.

### **Reference**

Harris I. and Bamford M. 2007, *Hanson's Quarry Red Hill: Assessment of Fauna Values*, report prepared for Hanson Construction Materials Pty Ltd.

## **Hanson's Quarry (Search for Gecko)**

**Bancroft W., Harris I. and Bamford M. (Bamford Consulting Ecologists)  
October 2007**

### **Introduction**

During the 2006 survey of the Hanson Construction Materials Pty Ltd (Hanson) Red Hill Quarry (Harris and Bamford 2007a), Bamford Consulting recorded two specimens of a species of gecko thought to be similar to *Diplodactylus polyophthalmus*. Because this specimen was unusual and not typical of *D. polyophthalmus*, one specimen was presented to the Western Australian Museum (WAM) for formal identification. Despite this, the identification remains uncertain, with the possibility that the specimens represent an undescribed taxon, or simply aberrant individuals of *D. polyophthalmus*. In order to resolve this question by locating further specimens, Bamford Consulting conducted a one day intensive search on May 15, 2007, however no individuals were observed (Harris and Bamford 2007b). Further to the investigation of May 2007, Bamford Consulting conducted a half day search on September 28, 2007, the results of which are summarised below. In addition to searching for the gecko, the opportunity was taken to search for invertebrates potentially of conservation significance.

### **Methods**

The half day site visit was conducted by Dr Wes Bancroft and Mr. Ian Harris on September 28, 2007. Hand search techniques were employed both in the area that the individual was found and at selected sites adjoining the initial survey area. Hand searching techniques included:

- turning over granite and lateritic rocks;
- searching under fallen timber;
- searching under bark on dead trees;
- raking leaf litter;
- lifting rubbish deposits and
- searching through dead grass trees.

Rocks and logs were placed back into their original position to avoid excessive disturbance. Invertebrates potentially of conservation significance because of having a

restricted distribution (short range endemics) were also collected opportunistically and samples submitted to WAM for identification.

Weather conditions were cloudy with intermittent showers, with a maximum temperature of approximately 20 degrees Celsius.

## Results

Results of the searching for reptile species are listed in Table 1 below. While three species of reptile were observed, all had been recorded previously and no individual of the target species was recorded.

Table 1: Reptile species recorded during the site visit on 28 September 2007.

Species	Common Name	Number Found
<i>Gehyra variegata</i>	Tree Delta	6
<i>Crenadactylus ocellatus</i>	Clawless Gecko	3
<i>Hemiergus initialis</i>		2

Invertebrate species recorded were those that had been found previously: the millipede *Dinocambala ingens* and the scorpion *Urodacus novaehollandiae*. Particular attention focussed on trapdoor spiders but no burrows were located.

## Discussion

While the target species was not observed on this occasion, consideration must be given to the weather conditions at the time of the initial survey. During the December 2006 field survey thunderstorms and some rain were experienced, and these conditions combined with high temperatures were ideal for maximum reptile movement. Of interest is the fact that hand searching did not record three species of gecko that were common during the December 2006 survey: *Diplodactylus granariensis*, *Strophurus spinigerus* and *Diplodactylus polyophthalmus*. This suggests that these common species were well hidden, possible under large granite out crops or fallen trees, implying that the target

species may also be well hidden for the duration of winter and into spring. With this in mind it would not be unreasonable to suggest that intense searching and/or trapping during the warmer summer months may yield better results.

### **Recommendations**

1. Conduct limited intense trapping of the area during the summer period where the original specimen was captured.

### **Reference**

Harris I. and Bamford M. 2007a, *Hanson's Quarry Red Hill: Assessment of Fauna Values*, report prepared for Hanson Construction Materials Pty Ltd.

Harris I. and Bamford M. 2007b, *Hanson's Quarry (Search for Gecko)*, report prepared for Hanson Construction Materials Pty Ltd.