Government of **Western Australia**
Department of **Environment and Conservation**

PROPOSED MANAGEMENT PLAN FOR

BAITING FERAL CATS ON THE FORTESCUE MARSH

Submitted by

Dr Stephen van Leeuwen
Science Division, Department of Environment and Conservation
Locked Bag 104, Bentley Delivery Centre WA 6983
stephen.vanleeuwen@dec.wa.gov.au

Prepared by

Dr. David Algar[1], Hamish Robertson[2] and Cath Rummery[3]

[1]Senior Research Scientist, Fauna Conservation
Science Division, Department of Environment and Conservation
PO Box 51, Wannerooo, WA 6946
dave.algar@dec.wa.gov.au

[2]Foretscue Marsh Conservation Officer,
Pilbara Region, Department of Environment and Conservation
PO Box 835 Karratha WA 6714

[3]Regional Leader Nature Conservation
Pilbara Region, Department of Environment and Conservation
PO Box 835 Karratha WA 6714

For

Fortescue Metals Group Ltd
Level 2, 87 Adelaide Terrace
East Perth WA 6004

October 2011

Department of
Environment and Conservation

Contents

List of Figures

List of Tables

Acknowledgments

This document has been compiled following discussion with a number of people about related research and their ideas regarding the proposed management plan. These people, their area of expertise and organization are listed below in alphabetical order.

Allan Burbidge:	Bird surveys - DEC, Woodvale
Mike Bamford:	Fauna surveys of the Marshes – MJ and AR Bamford Consulting Ecologists
Rob Brazell:	Bait manufacture and distribution – DEC, Collie
Sarah Comer:	Bird surveys, feral cat monitoring – DEC, Albany
Annette Cook:	Northern Quolls – DEC, Woodvale
Neil Hamilton:	Bird surveys, feral cat monitoring – DEC, Woodvale
Mike Johnston:	Feral cat monitoring – DSE Victoria
Ashley Millar:	Western Shield baiting – DEC, Kensington
Cam Tiller:	Bird surveys, feral cat monitoring – DEC, Albany
Stephen van Leeuwen:	Regional perspective – DEC, Kensington

Report Outline

The Department of Environment and Conservation (DEC) was requested to draft a management plan for the effective control of feral cats at the Fortescue Marsh, using baiting as the primary technique. This request comes from the Fortescue Metals Group Limited (FMG) who have had a condition (Condition 16) placed on their Christmas Creek Water Expansion Project by the Department of Sustainability, Environment, Water, Population and Communities (DSEWPC). Condition 16 requires FMG to undertake an offset feral cat baiting program at the Marsh.

This report presents a proposed adaptive management plan to develop an effective, landscape-scale and cost efficient baiting strategy for an on-going feral cat baiting campaign at the Fortescue Marsh. In the first year of the program the DEC's current standard feral cat baiting protocol should be implemented. Data collected from the baiting and monitoring programs can then be used to refine subsequent baiting campaigns to optimise baiting effectiveness. The plan addresses monitoring requirements for the baiting campaign to determine baiting efficacy, measurement of potential risk to non-target species and also population responses of a number of species likely to benefit from the implementation of a sustained cat control program. This plan aims to provide long-term, sustained and effective feral cat control at the Fortescue Marsh and is the first step to the reconstruction and conservation of biodiversity for the area.

1 Background

The Australian arid zone has experienced a high rate of native mammal decline following European settlement. Since the 1920s, approximately 33% of all mammals and about 90% of medium-sized mammals (35 - 5 500 g adult bodyweight range) have either suffered dramatic range contractions or are extinct (Burbidge and McKenzie 1989). Many of these species are now restricted to several offshore islands and others, due to small population sizes and restricted geographic ranges, are vulnerable to total extinction. A number of causes have been proposed to explain this decline. These causes include changed fire regimes, competition from introduced herbivores, disease, extreme variability in weather and site fertility and predation by introduced predators, specifically the feral cat (*Felis catus*) and fox (*Vulpes vulpes*) (see Abbott 2002; Burbidge and McKenzie 1989; Dickman 1996a, b; EA. 1999; Johnson *et al*. 1989; Morton 1990). Predation by feral cats has also been demonstrated to threaten the continued survival of many other native species persisting at low population densities (e.g. Risbey *et al*. 2000; Smith and Quin 1996) and has been identified as one of the major obstacles to the reconstruction of faunal communities as it has prevented the successful re-introduction of a number of species to parts of their former range (Christensen and Burrows 1995; Dickman 1996b; EA. 1999; Gibson *et al*. 1995). The suppression of introduced predators is therefore a critical component of successful reintroduction, recovery or maintenance of populations of small to medium-sized native fauna (Christensen and Burrows 1995; Fischer and Lindenmayer 2000; McKenzie *et al*. 2007).

Effective control of feral cats is recognised as one of the most important fauna conservation issues in Australia today and as a result, a national Threat Abatement Plan (TAP) for Predation by Feral Cats (EA 1999; DEWHA 2008a) has been developed. The objective of the TAP is to protect affected native species and ecological communities, and to prevent further species and ecological communities from becoming threatened. Baiting is recognized as the most effective method for controlling feral cats on mainland Australia (Algar and Burrows 2004; Algar *et al*. 2007; DEWHA 2008a; EA 1999; Short *et al*. 1997), when there is limited risk posed to non-target species. The feral cat bait (*Eradicat*®) (see detailed description in Algar and Burrows 2004; Algar *et al*. 2007) has proven to be an effective tool in reducing feral cat numbers and is now used as a control method for feral cat management at a number of sites across Western Australia (see Algar *et al*. in review a and b).

2 Methodology

2.1 Site Description

The Fortescue Marsh is an extensive intermittent wetland situated at 22^0 26’.44” S, 119^0 26’.38” E. It is to be proposed as a Ramsar site at the next opportunity and it is also designated as a Wetland of National Importance (see Directory of Important Wetlands in Australia). It is located in the Pilbara Craton (Hamersley Basin) and has the form of a broad valley or small plain that lies between the Chichester and Hamersley Ranges. The marsh occupies an area of 1,000 km^2 when in flood (DEWHA 2008b). (see Figure 1)

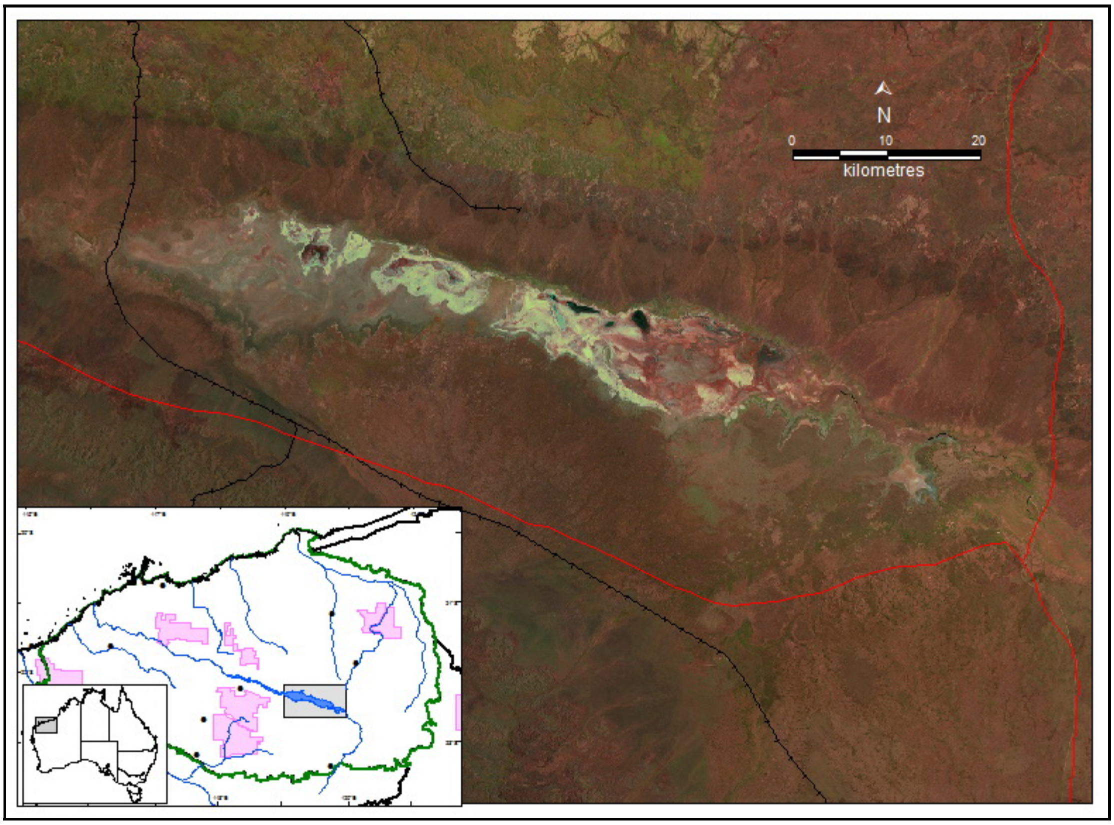

Figure 1 Location and regional setting of the Fortescue Marsh.

Climatic conditions in the Pilbara are influenced by tropical cyclone systems that predominately occur between January and March. The majority of rainfall received in the Pilbara is associated with these systems. The long term average annual rainfall is 312 mm at Newman (FMG 2009). Temperatures are high, with summer maxima typically between 35 - 40°C and winter maxima between 22 - 30°C.

Botanical surveys conducted for FMG's Cloud Break Iron Ore Project Public Environmental Review included fringing vegetation of the Marshes. Five distinct vegetation communities were identified (Mattiske Consulting Services 2005, cited in FMG 2009) and include:

- low woodland to low open forest of *Acacia aneura*, *A. citrinoviridis*, *A. pruinocarpa* over *A. tetragonophylla* and *Psydrax latifolia* over *Chrysopogon fallax*, *Stemodia viscosa*, *Blumea tenella*, *Themeda triandra* and species of *Triodia* and *Aristida*. This vegetation community occurs within the creek and drainage lines leading into the Marsh;
- hummock grassland of *Triodia angusta* with patches of *A. victoriae*, *A. aneura*, *A. xiphophylla* over *Atriplex codonocarpa*, *Eremophila cuneifolia* and mixed chenopods;
- low halophytic shrubland of *Tecticornia auriculata* and *T. indica* with associated chenopod species of *Maireana* species and *A. flabelliformis* with *Muehlenbeckia florulenta* with patches of *A. victoriae* and *A. sclerosperma*. This vegetation community adjoins the low woodland to low open forest of *A. aneura*;
- low halophytic shrubland of *T. auriculata*, *T. indica*, *T. halocnemoides* with patches of *Frankenia* species. This is the predominant vegetation community along the fringes of the Marsh and
- hummock grassland of *T. angusta* with patches of *A. victoriae* over *A. codonocarpa* and mixed chenopods and Poaceae species.

A list of mammal, reptile and bird list expected to occur at the Fortescue Marsh (taken from Davis *et al*. 2005, cited in FMG 2009 and compiled by H. Robertson DEC, Karratha) is appended (see Appendix 1).

2.2 Baits and Baiting Program

The feral cat baits (*Eradicat*®) proposed for use as part of the Fortescue Marsh baiting program are manufactured at DEC's Bait Manufacturing Facility at Harvey, Western Australia. The bait is similar to a chipolata sausage in appearance, approximately 25 g wet-weight, dried to 15 g, blanched and then frozen. This bait is composed of 70% kangaroo meat mince, 20% chicken fat and 10% digest and flavour enhancers (Patent No. AU 781829). Toxic feral cat baits are dosed at 4.5 mg of sodium monofluoroacetate (compound 1080) per bait. Prior to bait application, feral cat baits are thawed and placed in direct sunlight on-site. This process, termed 'sweating', causes the oils and lipid-soluble digest material to exude from the surface of the bait. All feral cat baits are sprayed, during the sweating process, with an ant deterrent compound (Coopex®) at a concentration of 12.5 g l^{-1} as per the manufacturer's instructions. This process is aimed at preventing bait degradation by ant attack and enhancing acceptance of baits by cats by limiting the physical presence of ants on and around the bait medium.

Baiting is currently conducted under an 'Experimental Permit' issued by the Australian Pesticides and Veterinary Medicines Authority (APVMA). A registration package was submitted to the APVMA for full registration of *Eradicat*® mid 2010. Baiting operations are governed by a 'Code of Practice on the Use and Management of 1080' (Health Department, Western Australia) and associated '1080 Baiting Risk Assessments'.

The plan will test whether effective and sustained feral cat control is achievable at Fortescue Marsh using an annual winter baiting program as the primary control technique. Earlier research in the arid and semi-arid zones has indicated that the effectiveness of baiting programs for feral cats is maximized by distributing baits during the cool, dry winter periods (Algar and Burrows 2004). At this time the abundance and activity of all prey types, in particular predator-vulnerable young mammals and reptiles, is at its lowest, and bait degradation due to rainfall, ants and hot, dry weather, is significantly reduced.

The baiting programs are to be conducted from a dedicated baiting aircraft which will deploy the baits at previously designated bait drop points. The baiting aircraft flies at a nominal speed of 130 knots at 500 feet AGL (Above Ground Level). A GPS point is recorded on the flight plan each time bait leaves the aircraft. A baiting intensity of 50 baits km^{-2} is recommended for effective and cost efficient control (Algar and Burrows 2004). The 'bombardier' releases a bag of 50 baits into each 1 km map grid, along flight transects 1 km apart, to achieve the application rate of 50 baits km^{-2}. The ground spread of 50 baits is approximately 250 x 150 m (D. Algar unpub. data). Accredited DEC staff will be responsible for transportation, on-site preparation and baiting operations. The DEC 'Protocol for Deployment of Cat Baits' is appended (see Appendix 2).

It is suggested that the Marsh and surrounds be divided into two sites. One site is to be the treatment (baited) site and the other the control (non-baited) site. To ensure independence between the treatment and control sites, a buffer zone should be used to separate the two sites. The buffer zone should be at least one average feral cat home range estimated to be approximately 5 km in all directions (D. Algar unpub. data). A reconnaissance of the area should be undertaken prior to mapping the location of the two sites, their shape and size. It is anticipated that each site will be in the vicinity of 750-1000 km^2 with the upper limit used for this plan.

2.3 Baiting Efficacy and Monitoring Programs

Survey programs should be conducted before and following baiting programs to assess their impact on the feral cat population. Surveys will also need to be conducted to assess the effect of baiting to non-target species potentially at risk from consuming baits. In addition, the population responses of a number of key species likely to benefit from the implementation of a sustained cat control program should be measured.

2.3.1 Feral Cats

Two independent methods are proposed for monitoring baiting efficacy: 1) the percentage of radio-collared cats found dead after each baiting program; 2) surveys of cat activity at camera-trap stations to derive indices of abundance/activity/occupancy. Differences in the indices obtained pre- and post-baiting can then be used as a measure of baiting efficacy.

2.3.1.1 Cat trapping and radio-collaring

Prior to each baiting program, twenty cats should be trapped in the treatment site and fitted with GPS data-logger radio-collars. Mortality of these animals will provide the first measure of baiting efficacy. These collars will also provide detailed information on cat activity patterns prior to and during the cat baiting program. Under the adaptive management framework of this program, these data can then be used to modify the spacing of flight transects so that feral cats have the greatest chance of encountering baits within the shortest possible time. The goal is to provide the most cost-effective baiting regime.

Feral cats should be trapped in padded leg-hold traps, Victor ‘Soft Catch’ traps No. 3 (Woodstream Corp., Lititz, Pa.; U.S.A.), using a mixture of cat faeces and urine as the attractant. Trapped cats will need to be sedated, and the sex and bodyweight recorded. The cats should be cats fitted with a GPS data-logger/radio-telemetry collar containing a mortality signal and pre-determined drop-off date (several weeks following each baiting program). Collars will need to be retrieved after individual cats have died (as indicated during daily monitoring using VHF telemetry), or collected following the collar drop-off date. Data downloaded from GPS-collars include: date, time, latitude and longitude, number of satellites and horizontal dilution of precision.

2.3.1.2 Surveys of cat activity

Surveys to monitor the abundance of feral cats, like most mammalian carnivores, is difficult because they occur at low densities, have large home ranges and tend to be secretive and cryptic (Long *et al*. 2007; Saunders and McLeod 2007; Witmer 2005). In most cases a density estimate of a population rather than its total size is usually enough to assess biological significance (Saunders and McLeod 2007). Capture-recapture studies for estimating abundance are usually unsuitable because of low capture rates and recapture probabilities. Consequently most monitoring techniques use indices of abundance derived from data such as track (foot print) counts and more recently photographs at camera-trap stations to provide information necessary to make management decisions or to evaluate the impact of a control program (Thompson *et al*. 1998). The number of encounters of a particular species recorded during such surveys is likely to be not only a function of population density but also activity levels of individuals in the population. Activity levels may be influenced by factors such as seasonal changes in behaviour (especially those related to breeding) and the availability of resources including food and shelter (Edwards *et al*. 2000; Engeman *et al*. 2002; Wilson and Delahay 2001). Despite these potentially confounding factors, the use of count indices in particular recorded at camera-trap stations suit the requirements of a feral cat monitoring program at the Fortescue Marsh. Here the use of camera-trap stations to monitor feral cats is relatively simple to implement and time efficient as extensive areas can be surveyed rapidly. The use of camera-trap stations, although more expensive than conducting track counts, have appreciable benefits and provide a more scientifically rigorous survey methodology. Benefits of using camera-trap stations include: -

1. less environmental disturbance as the area is only traversed at the beginning and completion of each survey period rather than daily during track surveys;
2. increased efficient use of time in the field because other activities can be undertaken while cats are being monitored remotely;
3. improved data collection as unlike track counts, camera-trap stations are not affected by weather conditions;
4. improved reliability of data because potential human error and/or bias that can occur in reading and/or recording track counts does not occur in data collected from camera-trap stations;
5. greater confidence in methodology with determination of detection probabilities from radio-collared cats and presence/absence at camera-trap stations. These detection probabilities cannot be generated from track counts.

In situations where individual animals can be identified from photographs (eg. through variations in natural pelage patterns or markings), use of remotely deployed automatic cameras in camera-trap studies have been used to provide the more robust estimates of abundance. However, individual feral cats cannot be easily distinguished, particularly when black and light ginger coat-coloured animals occur in the population; it is therefore unlikely that reliable estimates of abundance could be derived. As the intention of monitoring is to compare abundance/activity prior to and following baiting programs and to monitor broad trends over time, rather than estimate population size, identification of individual cats is not necessary

A minimum of 50 camera-trap stations, in both treatment and control sites, would be required to provide a sufficiently robust sample to accurately assess changes in the feral cat population following control operations. It is prudent to cap station numbers at a maximum of 100 for efficiency of monitoring (i.e. more would take up too many resources, especially time, without much benefit to power of sampling). Sites should be selected either on a grid system without preference to tracks, or randomly selected sites throughout the entire operational cell.

When using multiple stations to generate an activity index it is necessary to separate the stations by sufficient distance so that the probability of a single animal being recorded on more than one station in any single survey period is minimized and therefore the stations can be considered as independent sampling units (e.g. Beier and Cunningham 1996; Edwards *et al.* 2000; Kendall *et al*. 1992; Sargeant *et al*. 1998; Wilson and Delahay 2001; Zielinski and Stauffer 1996). If the stations are too close together, data relating to animal movements will not be spatially independent and data show serial correlation. The effects of serial correlations are important because non-independence invalidates the use of many parametric statistical analyses to test for significant treatment effects (Edwards *et al*. 2000). To ensure independence, camera-trap stations should be separated by at least one average home range (Harrison *et al*. 2002) estimated to be approximately 5 km in all directions for feral cats (D. Algar unpub. data). The placement of the camera-trap stations should also provide a broad coverage of the entire site and be an efficient and representative sampling of the population using the surrounding habitat. The proportion of operational area covered is more important than the distance between camera-trap stations. The effect of serial correlation and non-independence can be tested by selective camera sampling during analysis.

As multiple indexing assessments are to be made through time on the same area, then the same locations should be used (Engeman *et al*. 2002). To alleviate any potential neophobic reaction to camera-trap placement they should be installed well in advance of the first survey and camera-trap covers left in place throughout the time of this program. For the first trial, camera-trap stations should be operational for at least three weeks for each monitoring period (i.e. before and after baiting). Results from the first trial may prove that this time period can be reduced but it would be necessary to ensure that enough data are collected during the first monitoring period to make an informed decision for subsequent monitoring periods.

The ability of any survey technique to detect significant differences will depend on the sampling effort and proportion of positive results per survey. Small sample size, large variance and the magnitude of the real difference (effect size) will reduce the ability to detect change (Wilson and Delahay 2001). Two types of camera-trap stations could be used during monitoring; passive stations and active stations. Passive stations have no attracting lure and detect animals during the normal course of their movements. Active stations contain a lure to attract animals to the site and thereby increase the likelihood of detecting animals, particularly at low density. Passive stations often generate sample sizes that are too low to adequately monitor population changes (Fleming *et al*. 2001). Algar *et al*. (in review a) found visits to active stations by cats were usually more than ten times greater than visits to the passive stations. There are a number of audio and olfactory lures for cats that could be used at the active stations. Harrison (1997) suggested that free-ranging carnivores were less likely to become accustomed to scents that they encounter only a few times each year. Thus concerns of habituation should not deter the use of scent lures for long-term monitoring of carnivore populations. It is therefore recommended that active stations be used at each camera-trap to entice animals to the stations and thereby maximize the number of station incursions for each survey period. Lures should be removed outside the survey periods.

As cats photographed at the camera-trap stations may not be individually identified, it is customary to ignore the number of detections and simply record whether an animal was present or absent at the station (Ray and Zielinski 2008). These presence/absence data are more robust to statistical analysis than the total number of detections recorded at a station or multiple-station sample units. Thus in this case, camera-trap station counts have an index of usage expressed as the mean number of positive cat photographs per night. The index is formed by calculating an overall mean from the daily means (Engeman 2005; Engeman *et al*. 1998). The VARCOMP procedure within the SAS statistical software package produces the variance component estimates. Before and after impact (baiting) can be compared separately for the baited and non-baited sites respectively. Comparison of indices prior to and following individual baiting programs are analysed using a ‘z’-test (Elzinga *et al*. 2001). Analysis for a reinvasion effect can be undertaken by comparing indices post-baiting with those pre-baiting the following year.

The data collected can also be used in occupancy analysis and associated estimates of detectability to estimate population abundance, an alternative approach to activity indices (MacKenzie et al. 2006; Long and Zielinski 2008). Occupancy, when adjusted for probability of detection, is a more defensible population metric than classical measures of relative abundance. Both population measures should be pursued and their utility assessed during the course of the program.

It is suggested that the program be reviewed annually following each baiting campaign. Baiting efficacy results will indicate the effectiveness of this strategy over time or the need for change. Data collected annually, following each baiting campaign, from the GPS data-logger radio-collars on activity and patterns of home range use will provide valuable information on where changes could be made to improve efficacy and cost-efficiency of the baiting strategy.

2.3.2 Non-target Species

2.3.2.1 Non-target baiting risk

A species risk to 1080 baiting programs is based on several factors: - its degree of tolerance to the toxin and known food preferences that suggest the species is likely to consume a bait. Bird and reptile species have a higher tolerance to 1080 than mammals (McIlroy 1984; McIlroy *et al*. 1985; Calver *et al*. 1989a). The method of bait distribution (a) and timing of baiting campaigns (b) are also likely to significantly reduce bird and reptile consumption of baits.

a) Bait deployment in most baiting campaigns is conducted from an aircraft over broad-scale areas reducing the detectability and thus accessibility of baits to birds.

b) Baiting campaigns are generally conducted at times when reptiles are less active and therefore less likely to find and consume baits.

Research into baiting campaigns targeting feral cats has indicated a temporal variability in bait consumption (Algar and Angus 2000; Algar *et al*. 2007). This variability is correlated with the availability of prey, which is a function of season/rainfall. The optimum time to conduct baiting programs to maximize their effectiveness at the Fortescue Marsh will most likely be in mid-winter (dry season) when conditions are coolest and the likelihood of rainfall, which causes degradation of baits, is relatively low (see Bureau of Meteorology records). Also, the abundance and activity of all prey types, in particular predator-vulnerable young mammalian prey and reptiles, is at its lowest during winter months and bait degradation due to ants and to hot, dry weather is significantly reduced.

The combination of factors associated with degree of tolerance to 1080 and baiting methodologies would indicate that bird and reptile species are unlikely to be at risk from feral cat baiting programs proposed for the Fortescue Marsh. This is not the case for mammals, as the sensitivity to 1080 for many species tends to be much higher than for birds and reptiles. The degree to which 1080 tolerance has developed within native mammal populations is in the order of herbivorous > omnivorous > carnivorous species (Twigg and King 1991). The level of tolerance of different populations within a species may also vary depending on the degree of exposure to the toxin during the course of their evolution and the extent of their current and previous exposure (op cit.).

Native mammal species from this area whose known food preferences suggest that they may consume a bait are presented in Table 1. Weight ranges are taken from Strahan (1983) and Menkhorst and Knight (2001). Approximate Lethal Dose$_{50}$ data (LD_{50}) where LD_{50} is the amount of toxin theoretically required to kill 50% of test animals are standardized to mg pure 1080 kg^{-1} bodyweight, have been taken from Calver *et al.* (1989b)[A]; Anon. (2002)[B] and Twigg *et al*. (2003)[C]. Approximate Lethal Dose (ALD) the dose which causes 10% of deaths are provided, in parenthesis, where known from the above references. LD_{50} data are greater than the ALD by a factor of less than or equal to 1.5 in approximately 80% of species (McIlroy 1981; 1984; Calver *et al*. 1989b). LD_{50} and ALD data are taken from the most recent source and referenced to the above authors by superscript, rather than from the original work. Where data for different populations differ, they are presented as a range, if unknown; they are left blank in the Table. Only data from Western Australian populations have been cited.

Table 1 Species potentially at risk from feral cat baits.

Family Dasyuridae		**Body Weight (g)**	**Approximate LD_{50} & ALD values (mg/kg)**
Northern Quoll	*Dasyurus hallucatus*	300-1,000	7.1 [C]
Mulgara	*Dasycercus cristicauda*	60-170	4.9 [C], (3.27) [C]
Kaluta	*Dasykaluta rosamonda*	20-40	
Pilbara Ningaui	*Ningaui timealeyi*	2-10	(12) [A]
Long-tailed Planigale*	*Planigale ingrami*	4-6	
Common Planigale*	*P. maculata*	6-12	(4) [A]
Woolley's Pseudantechinus	*Pseudantechinus woolleyae*	18-43	
Lesser Hairy-footed Dunnart	*Sminthopsis youngsoni*	9-14	
Stripe-faced Dunnart	*S. macroura*	15-25	
Long-tailed Dunnart	*S. longicaudata*	15-20	
Family Thylacomyidae			
Bilby	*Macrotis lagotis*	800-2,500	14.1 [B]
Family Muridae			
Short-tailed Mouse	*Leggadina lakedownensis*	15-25	(4) [A]
Common Rock Rat	*Zyzomys argurus*	30-75	14.9 [C], (9.96) [C]
Spinifex Hopping Mouse	*Notomys alexis*	27-45	
Sandy Inland Mouse	*Pseudomys hermannsbergensis*	9-17	38.5 [B]
Pebble Mound Mouse	*P. chapmanii*	8-17	
Desert Mouse	*P. desertor*	13-30	

* the *Planigale* recorded for the Marsh is listed as *Planigale* sp. (Appendix 1), as such data for both the Long-tailed and Common Planigale have been included in Table 1.

An investigation of hazard, focused on mammal species, has broadly defined a range of species theoretically at risk from operational feral cat baiting campaigns (Algar 2006). The theoretical risk is determined by the amount of toxin ingested in laboratory trials compared to the range of toxin values required for an ALD for adult animals. The field risk potentially faced by individuals of any non-target species will depend on their weight relative to adult size and the rate and extent that baits are encountered. The location and/or uniformity of distribution of toxin within the bait medium are also of significance where baits are only partially consumed. A number of laboratory and field trials has been conducted to assess bait consumption by a range of species (op cit.). These trials, of necessity, have been conducted at the individual level for the various species and have shown that there is considerable variation in individual bait consumption on a daily basis and also between individuals of the same species, and hence in the amount of 1080 potentially ingested. However, the risk posed to a species and the benefits accruing from reduced cat predation following feral cat baiting campaigns should be assessed finally at the population level.

The theoretical 1080 baiting risks to non-target mammal species expected to be present at the Fortescue Marsh that have been evaluated thus far (Algar 2006), are presented below.

- The Spinifex Hopping Mouse was the only rodent to consume bait material. Field trials indicated that some Spinifex Hopping Mice consume baits however; laboratory trials suggest that this species is unlikely to consume enough bait material to pose a risk. Although no ALD values are available for this species, the amount of toxin ingested compared to the range of toxin values required for an ALD (0.92-1.53 mg) in the closely related Mitchell's Hopping Mouse (*Notomys mitchelli*), (taken from Twigg *et al*. (2003)), suggests the Spinifex Hopping Mouse is not at risk from feral cat baiting programs.
- The other mice species are too small to consume baits. The larger Desert Mouse is predominately herbivorous and unlikely to consume bait material (Algar 2006).
- The Common Rock-rat did not consume or attempt to consume any bait material during laboratory trials. Thus, it is highly unlikely that this species would face any direct risk from feral cat baiting programs.
- The high range of 1080 values required for an ALD for the Bilby suggests that this species is unlikely to be at risk from feral cat baiting programs unless individuals consume at least four baits. The laboratory trials suggest that multiple bait consumption is only likely to occur when alternative food is absent. Operational feral cat baiting programs conducted at Lorna Glen where radio-collared Bilby are present and monitored have had no impact on their population.
- Field and laboratory trials with the smaller dasyurids (< 30 g) have indicated either no or negligible bait consumption. Taking into account small sample sizes, this group of species is unlikely to be at risk from feral cat baiting programs.

- Laboratory trials have suggested that the Mulgara is at risk from feral cat poisoning campaigns. In the absence of alternative food, these trials indicated that bait consumption increased and therefore so does the potential risk from baiting. Although Mulgara were observed to consume bait material in the laboratory trials, field trials of bait consumption, conducted with a larger sample size, showed that Mulgara did not consume baits. These field trials were also conducted in late autumn when prey resources were likely to be scarce. The abundance of Mulgaras at Lorna Glen has increased significantly in the presence of annual feral cat baiting campaigns, suggesting that this species may have benefited from cat control (Hamilton *et al*. 2010). It is suggested that further trials be conducted at the Fortescue Marsh to confirm that there is no or minimal baiting risk to Mulgaras. It is suggested that a number of individuals be radio-collared and the impact caused by a feral cat baiting program be evaluated. Assessing the impact on Mulgaras is discussed further (see Section 2.4.1.2).
- Bait consumption by the Northern Quoll has not been assessed. Data for a closely related species, the Chuditch (*Dasyurus geoffroii*), on probable toxin ingested and the range of 1080 values required for an ALD, suggested Chuditch were potentially at risk from feral cat baiting programs. It was also likely that individual animals would consume more than one bait thus increasing the risk. The Northern Quoll has the same ALD value as the Chuditch, but has half the bodyweight and therefore the theoretical risk to the Northern Quoll is greater. However, recent baiting trials at Fitzgerald River National Park did not cause any mortality in a radio-collared population of Chuditch (Comer and Tiller unpub. data). If the Northern Quoll is found to be present at the Fortescue Marsh, it is suggested that a number of individuals be radio-collared and the impact caused by a feral cat baiting program be evaluated. Assessing the impact on the Northern Quoll is discussed further (see Section 2.4.1.2).

A “1080 Baiting Application and Risk Assessment” as per the *Code of Practice for the Safe Use and Management of 1080 in Western Australia (August 2010)* will need to be completed prior to undertaking a baiting program at Fortescue Marsh. The information provided above and that of Buckmaster (2009) should be used to assess the potential for non-target bait consumption and also risk assessment and mitigation.

2.3.2.2 Mammal surveys

Documenting changes in mammal abundance at the Fortescue Marsh, in order to detect potential impacts of cat control will be a significant challenge due to:

a) numbers of individuals per unit area are likely to be low for a given species; and
b) seasonal effects, such as presence/absence of cyclonic or thunderstorm associated rainfall events, will have a big impact on numbers. In some cases, it may even impact on species presence. The other problem is the high mobility of species such as the Bilby which through their normal foraging and dispersal activities may only be present in the Fortescue Marsh area intermittently. Therefore the focus for the survey of mammals in this project should be on those species that are relatively sedentary.

The species probably of most interest is the Northern Quoll. The Northern Quoll is listed nationally as Endangered under the *Environment Protection and Biodiversity Conservation Act* 1999 (EPBC Act). In Western Australia, the species is listed under Schedule 1 of the *Wildlife Conservation Act 1950* as fauna that is rare or likely to become extinct. Predation by the feral cat is a key threatening process listed under the EPBC Act (EA 1999) and this introduced predator may be having an impact on Northern Quoll populations either through competition for food or direct predation (DSEWPC 2011).

The status of the Northern Quoll at the Fortescue Marsh and surrounds is unknown. Northern Quolls have been recorded in the northern Chichester Ranges (Bonney Downs Station) and on Roy Hill Station south of the Marsh, but the species seems to be rarely present in the eastern Hamersley Range despite the presence of apparently suitable habitat. No Quolls were recorded at the Fortescue Marsh during the Pilbara survey (Gibson and McKenzie 2009) however during this survey, trapping methods targeted ‘small ground-dwelling mammals’, no baited cage traps or Elliott traps were used and few or no spotlighting runs were performed.

A targeted survey should be undertaken during the months of May/June prior to the first baiting program to determine whether the quoll is present at the Marsh. The survey should adopt the national guidelines for undertaking a survey for the species (DSEWPC 2011) and use wire cages in a trapping program. If present, a number of individuals should be fitted with VHF radio-collars containing a mortality sensor. Monitoring these individuals following the first baiting program will provide information on the impact of the baiting on this species and the possible need for modifying the baiting strategy to mitigate future risk.

If present, it is likely that the Northern Quoll could be one of the species that benefit from cat control, either directly through reduced predation and/or mesopredator release. It will therefore be essential to survey Northern Quoll numbers at both the treatment and non-baited sites to assess any beneficial impact of cat control. An annual trapping program should be instigated and conducted prior to each baiting campaign. This plan will enable data to be collected on Northern Quoll abundance and distribution. In addition to cage trapping, valuable information on Northern Quoll distribution and indices of activity and estimates of occupancy can also be collected from the camera-traps used in the concurrent surveys of cat activity. Chuditch are attracted to the olfactory lures used in cat trapping and it is likely that Northern Quolls will be similarly affected.

Mulgara are relatively common at the Fortescue Marsh (M. Bamford pers. comm.), despite this it would be prudent to monitor this species as it is listed nationally as Vulnerable under the EPBC Act. A targeted survey should be undertaken concurrently with that for the Northern Quoll prior to the first baiting program. The survey should adopt the national guidelines for undertaking a survey for the species (DSEWPaC 2011). A number of trapped individuals should also be fitted with VHF radio-collars containing a mortality sensor. Monitoring these individuals following the initial baiting program will provide information on the impact of the baiting on this species. The trapping grid network established in both treatment and control sites to survey the Northern Quoll could be modified to accommodate an annual survey program for the Mulgara. Thus, the impact of baiting at both the individual and population level for the Mulgara could be assessed.

2.3.2.3 Bird surveys

Similar to mammals, birds in the Fortescue Marsh area present a challenge for long-term monitoring of changes in abundance due to the high number of nomadic species, significant influence of seasonal conditions, such as presence or absence of cyclones, and low numbers of individuals per unit area. Detecting the impacts on the avifauna by removing predation pressure from feral cats will be challenged by these constraints.

Burbidge *et al*. (2010) sampled seven sites in the Fortescue management area, with frequency of recording summarized in Table 2. Many of these taxa are unlikely to benefit directly from removal of feral cats, however density of those that are ground foraging and relatively sedentary may increase as a result of removing the predation threat. Species that may be more likely to respond positively to a decrease in predation pressure are indicated in Table 2.

There is still some debate regarding the most appropriate surveying methodology for birds. The consensus of opinion is that fixed distance sampling (Barraclough 2000; Bibby *et al*. 1998; Buckland *et al*. 2001) should be used to monitor changes in density of species in established permanent, randomly selected, monitoring points in baited and non-baited cells. The number of points surveyed is questionable without conducting a pilot study however, there would need to be an absolute minimum of 10 points but more likely between 20-30 monitoring points in each site (A. Burbidge pers. comm.). Observations should be conducted for 10 minutes at each site, and observers rotated between sites to counter observer bias. The optimum time to conduct bird observations is usually early morning, but obviously not all points can be sampled at the same time. As such, it is best to restrict observations to relatively early in the day, but make sure that all sampling units are sampled at least once very early in the morning - i.e. rotate the sequence in which units are sampled (A. Burbidge pers. comm.). Bird surveys should be conducted annually at the same time each year.

There is potential for the use of Automated Recording Units (ARUs) set up on a grid system to monitor birds. This has limitations by only recording vocal species and may be affected by weather conditions but over a period of 3-4 weeks could limit observer bias and provide an index for long-term changes in calling rates. At this stage, opinion suggests the best option would be to use distance sampling, but have a small number of ARUs. The ARUs could be placed at monitoring points and the files analyzed to determine the degree of correlation with human observers, calibrate against the distance sampling, and to allow the establishment of a call reference library.

Table 2 Birds recorded during the DEC Pilbara Biological Survey from quadrats in and near the Fortescue Marsh (see Burbidge et al. 2010), foraging habits and potential for use as a monitoring target. The 'frequency of records' is the number of quadrats (total n = 7) where the species was recorded in the FMG area.

Common Name	Frequency of records from Burbidge *et al.* 2010	Ground foraging	Potential monitoring target
Emu	1	Y	
Stubble Quail	1	Y	
Black-shouldered Kite	1		
Whistling Kite	2		
Australian Hobby	2		
Nankeen Kestrel	1		
Australian Bustard	2	Y	
Little Button-quail	1	Y	
Crested Pigeon	6	Y	Y
Diamond Dove	2	Y	Y
Galah	2		
Little Corella	2		
Australian Ringneck	3		
Spotted Nightjar	1	Y	
Australian Owlet-nightjar	1	Y	
Rainbow Bee-eater	2	Y	
Variegated Fairy-wren	5	Y	Y
White-winged Fairy-wren	1	Y	Y
Red-browed Pardalote	1	Y	
Weebill	2		
Chestnut-rumped Thornbill	2		
Slaty-backed Thornbill	2		
Spiny-cheeked Honeyeater	2		
Yellow-throated Miner	2		
Singing Honeyeater	6		
White-plumed Honeyeater	2		
Brown Honeyeater	1		
Red-capped Robin	1	Y	Y
Hooded Robin	1	Y	Y
White-browed Babbler	2		
Crested Bellbird	2	Y	Y
Rufous Whistler	4		
Grey Shrike-thrush	1		
Magpie-lark	3		
Willie Wagtail	7		
Black-faced Cuckoo-shrike	4		
White-winged Triller	1		
Black-faced Woodswallow	7		
Grey Butcherbird	3		
Pied Butcherbird	6		
Little Crow	3		
Torresian Crow	3		
Western Bowerbird	1		Y
Singing Bushlark	1		
Richard's Pipit	2	Y	Y
Zebra Finch	7	Y	
Painted Finch	1	Y	
Mistletoebird	1		
Spinifexbird	1	Y	Y

These surveys may also provide further evidence of the presence of the Night Parrot (*Pezoporus occidentalis*) in the Fortescue Marsh, a species listed as critically endangered.

2.3.2.4 Reptile surveys

Although reptile species' abundances will potentially benefit from reduced predation pressure following cat control, reptile activity is likely to be at its lowest when the majority of field work is being undertaken. Increasing field work commitments to conduct reptile surveys at a more suitable time is probably not warranted.

2.4 Indicative Works Program

An indicative works program to ensure the successful delivery of the feral cat baiting program is provided in Table 3. This indicative program captures the key activities that will be undertaken throughout the year and provides some indication of the duration of each activity and the personnel who will be responsible for the delivery of that activity.

It is recommended that the program be reviewed annually after each baiting program when the various data analyses have been completed. Baiting efficacy results will indicate the effectiveness of this strategy over time or the need for change. Data collected annually, following each baiting campaign, from the cat GPS data-logger radio-collars on activity and patterns of home range use will provide valuable information on where changes could be made to improve efficacy and cost-efficiency of the baiting strategy. Monitoring radio-collared Northern Quolls and Mulgara through the first baiting campaign will provide information on the impact of the baiting on these species and the possible need for modifying the baiting strategy to mitigate future risk. Long-term monitoring of changes in key non-target mammal and bird species populations should provide direct evidence of the benefit of cat control at the Marsh.

Table 3 Indicate works program for Fortescue Marsh feral cat baiting program. (Resources position in bold are responsible for coordinating activity.)

Activity	Action	Resources	Timing/Duration
Planning	• Baiting approvals and Risk assessment.	**Senior Research Scientist** Regional Leader Nature Conservation	February, March & April Wk 5 - 18
Stakeholder liaison	• Consent and indemnity letters	**Fortescue Marsh Conservation Officer**	May Wk 19 & 20
Monitoring and survey program	• Select and establish treatment and control sites. • Set up camera trap monitoring stations. • Complete cat trapping and radio-collaring. • Establish surveyed trapping grids for Northern Quoll and Mulgara. • Complete Northern Quoll radio-collar monitoring. • Service monitoring trap stations	**Project Research Scientist**, Project Technical Officer, Fortescue Marsh Conservation Officer	June & July 2012 Wk 23 - 27
Monitoring flights	• Conduct monitoring flights/ground traverses to locate and ensure all radio-collard animals are alive prior to bait delivery.	**Senior Research Scientist** Project Research Scientist, Project Technical Office	July Wk 28
Bait delivery	• Bait preparation	**Senior Research Scientist**, Project Research Scientist, Project Technical Officer	July Wk 29

Activity	Action	Resources	Timing/Duration
Bird surveys	• Set up program and conduct surveys. • Service monitoring trap stations.	**Project Research Scientist**, Project Technical Officer, Fortescue Marsh Conservation Officer	July & August Wk 30 -32
Monitoring flights	• Conduct monitoring flights/ground traverses to ensure the status of collard animal • Radio collar retrieval • Bird surveys	**Senior Research Scientist** Project Research Scientist, Project Technical Office	August Wk 33
Complete Program	• Complete bird surveys • Retrieve cameras	**Project Research Scientist**, Project Technical Officer, Fortescue Marsh Conservation Officer	August Wk 34
Program Evaluation	• Baiting efficacy results review • Activity and patterns of home range use • Review of monitoring data for radio-collared Northern Quolls and Mulgara	**Senior Research Scientist** Project Research Scientist, Project Technical Officer, Fortescue Marsh Conservation Officer	September Wk 35 - 37

3 Risks and Recommendations

It is important to document the risks associated with this project which are listed below.

1. Baiting is currently conducted under an 'Experimental Permit' issued by the Australian Pesticides and Veterinary Medicines Authority (APVMA). A registration package was submitted to the APVMA for full registration of *Eradicat*® mid 2010 but has not yet been approved. As such, it is imperative that approval is sought to add the Fortescue Marsh site to the existing permit as soon as possible. Approvals from the APVMA can take a considerable time and there is no guarantee that it will be granted.

2. Agreement needs to be sought as to whether baiting at the Marsh is undertaken under the current aerial baiting service contract (DEC1430982010) utilised for 'Western Shield' baiting. If so, Thunderbird/Jetfield Nominees Pty Ltd could undertake the baiting at the current rate. This contract rate is based on the current 'Western Shield' cells where costing of ferry to, from and within a cell have been calculated by the contractor and therefore may not be considered applicable in this instance. The appropriate rate will need to be clarified with the contractor directly. In addition, the current aerial baiting services contract expires 14 June 2012; however it may be extended to 14 June 2013 through use of extension options (subject to guidance from the Director of Nature Conservation, DEC) (A. Millar pers. comm.). Pricing beyond this period would need to be at the market rate of the time.

3. Equipment malfunction either during bait manufacture, transport or deployment can cause delay and additional costs.

4. Baiting programs can be adversely affected by inclement weather which may result in a reduction in baiting efficacy and additional costs. Cloudy conditions and rainfall can hinder bait preparation in the field and aerial deployment. Baiting outcomes can be improved if long-term weather forecasts are used to ensure that baiting programs are only conducted when prolonged periods of fine weather are

assured. An operational protocol has now been established within DEC (see Appendix 2) to minimize the possibility of poor baiting outcomes due to adverse weather conditions (Algar and Richards 2010; Algar *et al*. in review a and b). Preparation of the baits prior to aerial delivery is also of critical importance to the success of the baiting program. In the field, baits must be permitted to sweat on racks under sunny conditions to allow the oils and lipid-soluble digest material to exude from the surface of the bait. If this process is prevented or interrupted due to adverse weather conditions, the baits may rapidly deteriorate and become either rancid or mouldy and as a consequence unpalatable to cats.

5. There are potential risks to the success of a baiting program targeting feral cats. There are three main factors that are critical to the outcome of baiting campaigns, these are: 1) baiting intensity and bait encounter, 2) the abundance of prey items and 3) weather conditions at the time of baiting. Cats, despite being opportunistic predators, will only consume a food item if they are hungry (Bradshaw 1992). Thus for cats to consume baits they must encounter them when they are hungry. If a cat encounters a bait when not hungry it may not be consumed regardless of the acceptability of the bait. The relationship between bait consumption and hunger can be extended to prey abundance, which is also a function of long-term weather conditions (season/rainfall). The likelihood of cats encountering baits when hungry is potentially diminished in the presence of an abundant prey population. Therefore bait uptake is invariably low when prey availability is high. The impact of baiting can also be substantially reduced if significant rainfall occurs immediately following the baiting program. Rain renders the baits less palatable to cats by washing away the oils and flavour enhancers that sweat to the surface of the bait. Bait longevity in the field is a critical component in developing successful baiting campaigns to target feral cats.

6. There is also a potential risk to non-target species from baiting programs. At the Fortescue Marsh, the Northern Quoll, if present, is possibly at risk from baiting. If the species is located, it is recommended that radio-collared individuals are monitored following the baiting program. This will provide information on the impact of the baiting on this species and the possible need for modifying the baiting strategy to mitigate future risk.

7. There is also the risk of not being able to amass a suitable data set that lends itself to analysis, particularly for mammal and bird surveys. That is insufficient data to provide enough statistical power to allow sensible conclusions to be drawn.

*   *   *   *   *

4 REFERENCES

Abbott I (2002) Origin and spread of the cat, *Felis catus*, on mainland Australia, with a discussion of the magnitude of its early impact on native fauna. *Wildlife Research.* **29**, 51-74.

Algar D (2006) A summary of research undertaken to identify non-target risks in the use of the feral cat bait *Eradicat*® and encapsulation of the toxin. Unpublished Report, Department of Environment and Conservation.

Algar D, Angus GJ (2000) Recommendations on a control strategy for feral cats at Peron Peninsula, Western Australia. Report to Project Eden Management Committee. Department of Conservation and Land Management, Western Australia.

Algar D, Burrows ND (2004) A review of Western Shield: feral cat control research. *Conservation Science Western Australia* **5(2)**, 131-163.

Algar D, Angus GJ, Williams MR, et al. (2007) Influence of bait type, weather and prey abundance on bait uptake by feral cats (*Felis catus*) on Peron Peninsula, Western Australia. *Conservation Science Western Australia* **6(1)**, 109–149.

Algar D, Richards J (2010) Controlling introduced predators in the rangelands – the conclusion. *Landscope* **25(4)**, 17-23.

Algar D, Onus M, Hamilton N (in review b) Feral cat control as part of 'Rangeland Restoration' at Lorna Glen (Matuwa), Western Australia – the first seven years. Conservation Science Western Australia*.*

Algar D, Richards J, Hamilton N, et al. (in review a) Controlling introduced predators in the rangelands. *Wildlife Research*.

Anon. (2002) 1080 Summary Information. Miscellaneous Publication No. 011/2002, ISSN1326-4168. Government of Western Australia.

Barraclough RK (2000) Distance sampling: A discussion document produced for the Department of Conservation. DOC Science and Research Internal Report 175.

Beier P, Cunningham SC (1996) Power of track surveys to detect changes in cougar populations. *Wildlife Society Bulletin* **24(3)**, 540-546.

Bibby C, Jones M, Marsden S (1998) Bird Surveys: Expedition field techniques. *Royal Geographical Society with IBG, London*.

Biota (2005) Fauna habitats and fauna assemblage of the proposed FMG Stage B rail corridor and mine areas. Unpublished report to Fortescue Metals Group.

Bradshaw JWS (1992) *The Behaviour of the Domestic Cat*. CAB International, Wallingford.

Buckland ST, Anderson DR, Burnham KP, Laake JL (2001) *Introduction to Distance Sampling; Estimating Abundance of Biological Populations*. Oxford University Press.

Buckmaster AJ (2009) Risk assessment of the likelihood of consumption of the Curiosity® cat bait and the encapsulated toxicant by all Australian terrestrial vertebrate animals: A desktop analysis. Report to the Victorian Government, Department of Sustainability and Environment, Arthur Rylah Institute for Environmental Research.

Burbidge AA, McKenzie NL (1989) Patterns in the modern decline of Western Australia's vertebrate fauna: causes and conservation implications. *Biological Conservation* **50**, 143-198.

Burbidge AH, Johnstone RE, Pearson.DJ (2010) Birds in vast arid upland: avian biogeographical patterns in the Pilbara region of Western Australia. *Records of the Western Australian Museum* Supplement **78,** 247-270.

Calver MC, King DR, Bradley JS, Gardner JL, Martin GR (1989a) Assessment of the potential target specificity of 1080 predator baiting in Western Australia. *Australian Wildlife Research* **16**, 625-638.

Calver MC, McIlroy JC, King DR, Bradley JS, Gardner JL (1989b) Assessment of an approximate lethal dose technique for determining the relative susceptibility of non-target species to 1080 toxin. *Australian Wildlife Research* **16**, 33-40.

Christensen PES, Burrows ND (1995) Project Desert Dreaming: the reintroduction of mammals to the Gibson Desert. In *Reintroduction Biology of Australian and New Zealand Fauna* (ed M. Serena), pp. 199-208. Surrey Beatty and Sons, Chipping Norton.

Davis RA, Wilcox JA, Metcalf BM, Bamford M.J. (2005) Fauna survey of proposed Iron Ore Mine, Cloudbreak. Prepared for Fortescue Metals Group by M.J. & A.R. Bamford.

DEWHA (Department of the Environment, Heritage, Water and the Arts) (2008a) Threat Abatement Plan for Predation by Feral Cats, DEWHA, Canberra.

DEWHA (Department of Environment, Heritage, Water and Arts) (2008b) Australian Heritage Database. *Fortescue Marshes, Roy Hill, WA, Australia.* Department of Environment, Heritage, Water and the Arts. Australian Federal Government.

DSEWPaC (2011) *Environment Protection and Biodiversity Conservation Act 1999* referral guidelines for the endangered northern quoll, *Dasyurus hallucatus.* EPBC Act policy statement 3.21. Department of Sustainability, Environment, Water, Population and Communities.

Dickman CR (1996a) Impact of exotic generalist predators on the native fauna of Australia. *Wildlife Biology* **2**, 185-195.

Dickman CR (1996b). *Overview of the Impact of Feral Cats on Australian Native Fauna*. Report to Australian Nature Conservation Agency.

EA (Environment Australia) (1999) Threat Abatement Plan for predation by feral cats*.* Environment Australia, Biodiversity Group, Canberra, Australia.

Edwards GP, de Prue ND, Shakeshaft BJ, et al. (2000) An evaluation of two methods of assessing feral cat and dingo abundance in central Australia. *Wildlife Research* **27**, 143-149.

Elzinga CL, Salzer DW, Willougby JW, et al. (2001) *Monitoring Plant and Animal Populations*. Blackwell Science Inc. USA.

Engeman RM (2005) Indexing principles and a widely applicable paradigm for indexing animal populations. *Wildlife Research* **32,** 203-210.

Engeman RM, Allen L, Zerbe GO (1998) Variance estimate for the Allen activity index. *Wildlife Research* **25**, 643-648.

Engeman RM, Pipas MJ, Gruver KS, et al. (2002) Plot placement when using a passive tracking index to simultaneously monitor multiple species of animals. *Wildlife Research* **29**, 85-90.

Fischer J, Lindenmayer DB (2000) An assessment of the published results of animal relocations. *Biological Conservation* **96(1)**, 1-11.

Fleming PJS, Corbett L, Harden B, et al. (2001) *Managing the Impacts of Dingoes and Other Wild Dogs*. Bureau of Rural Sciences, Australian Government Publishing Service, Canberra.

FMG (Fortescue Metals Group Pty Ltd) (2009) *Fortescue Marshes Management Plan.* Fortescue Metals Group Limited.

Gibson DF, Johnson KA, Langford DG, et al. (1995) The Rufous Hare-wallaby *Lagorchestes hirsutus*: a history of experimental reintroduction in the Tanami Desert, Northern Territory. In *Reintroduction Biology of Australian and New Zealand Fauna* (ed M Serena), pp 171-176. Surrey Beatty and Sons, Chipping Norton.

Gibson LA, McKenzie NL (2009) Environmental associations of small ground-dwelling mammals in the Pilbara region, Western Australia. *Records of the Western Australian Museum* Supplement **78,** 91–122.

Hamilton N, Onus M, Forrest K (2010) Fighting back: mulgaras return. *Landscope* **26(2),** 7-8.

Harrison RL, Barr DJ, Dragoo JW (2002) A comparison of population techniques for swift foxes (*Vulpes velox*) in New Mexico. *American Midland Naturalist* **148**, 320-337.

Johnson KA, Burbidge AA, McKenzie NL (1989) Australian Macropodoidea: status, causes of decline and future research and management. In *Kangaroos, Wallabies and Rat Kangaroos* (eds G Grigg, P Jarman, I Hume) Surrey Beatty.

Kendall KC, Metzgar LH, Patterson DA, et al. (1992) Power of sign surveys to monitor population trends. *Ecological Applications* **2(4)**, 422-430.

Long RA, Donovan TM, Mackay P, Zielinski WJ, Buzas JF (2007) Comparing scat detection dogs, cameras, and hair snares for surveying carnivores. *Journal of Wildlife Management* **71(6),** 2018-2025.

Long RA, Zielinski WJ (2008) Designing effective non-invasive carnivore studies. In '*Noninvasive Survey Methods for Carnivores*' (eds. RA Long P MacKay WJ Zielinski, JC Ray) pp 8-44. Island Press, Washington.

MacKenzie DI, Nichols JD, Royle JA, Pollock KH, Bailey LL, Hines JE (2006) *Occupancy Estimation and Modeling: Inferring Patterns and Dynamics of Species Occurrence.* Academic Press, Burlington MA.

Mattiske Consulting Services (2005) Flora and vegetation on the Cloud Break and White Knight Leases. Report for the Fortescue Metals Group.

McIlroy JC (1981) The sensitivity of Australian animals to 1080 poison. II. Marsupial and eutherian carnivores. *Australian Wildlife Research* **8**, 385-399.

McIlroy JC (1984) The sensitivity of Australian animals to 1080 poison. VII. Native and introduced birds. *Australian Wildlife Research* **11**, 373-385.

McIlroy JC, King DR, Oliver AJ (1985) The sensitivity of Australian animals to 1080 poison. VIII. Amphibians and reptiles. *Australian Wildlife Research* **12**, 113-118.

McKenzie NL, Burbidge AA, Baynes A, et al. (2007) Analysis of factors implicated in the recent decline of Australia's mammal fauna. *Journal of Biogeography* **34**, 597–611.

Menkhorst PW, Knight F (2001) *A Field Guide to the Mammals of Australia*. (Oxford University Press.).

Morton SR (1990) The impact of European settlement on the vertebrate animals of arid Australia: a conceptual model. *Proceedings of the Ecological Society of Australia* **16**, 201-213.

Ray JC, Zeilinski WJ (2008) Track stations. In *Noninvasive Survey Methods for Carnivores* (eds RA Long, P MacKay, WJ Zielinski, J C Ray) pp 75-109. Island Press, Washington.

Risbey DA, Calver M, Short J, et al. (2000) The impact of cats and foxes on the small vertebrate fauna of Heirisson Prong, Western Australia. II. A field experiment. *Wildlife Research* **27**, 223-235.

Sargeant GA, Johnson DH, Berg WE (1998) Interpreting carnivore scent-station surveys. *Journal of Wildlife Management* **62(4)**, 1235-1245.

Saunders G, McLeod L (2007) Improving fox management strategies in Australia. Bureau of Rural Sciences, Canberra.

Short J, Turner B, Risbey DA, et al. (1997) Control of feral cats for nature conservation. II. Population reduction by poisoning. *Wildlife Research* **24**, 703-714.

Smith AP, Quin DG (1996) Patterns and causes of extinction and decline in Australian conilurine rodents. *Biological Conservation* **77**, 243-267.

Strahan R (1983) *Complete Book of Australian Mammals*. (Angus and Robertson, Sydney.)

Thompson WL, White GC, Gowan C (1998) *Monitoring Vertebrate Populations*. Academic Press, San Diego, California USA.

Twigg LE, King DR (1991) The impact of fluoroacetate-bearing vegetation on native Australian fauna: A review. *Oikos* **61,** 412-30.

Twigg LE, Martin GR, Eastman AF, King DR Kirkpatrick WE (2003) Sensitivity of some Australian animals to sodium fluoroacetate (1080): additional species and populations, and some ecological considerations. *Australian Journal of Zoology* **51**, 515-31.

Wilson GJ, Delahay RJ (2001) A review of methods to estimate the abundance of terrestrial carnivores using field signs and observation. *Wildlife Research* **28**, 151-164.

Witmer GW (2005) Wildlife population monitoring: some practical considerations. *Wildlife Research* **32**, 259–263.

Zieilinski WJ, Stauffer HB (1996) Monitoring *Martes* populations in California: survey design and power analysis. *Ecological Applications* **6**, 1254-1267.

5 Appendices

5.1 Appendix 1

A reptile, bird and mammal list for species expected to occur at the Fortescue Marsh (taken from Davis *et al*. 2005, cited in FMG 2009 and compiled by H. Robertson DEC, Karratha).

Reptiles

Reptiles expected to occur within and around the Fortescue Marsh. A (+) indicates species recorded by Bamford Consulting in April 2005 for the Cloud Break fauna survey (Davis *et al.* 2005), species recorded in the area by the WA Museum are indicated by WAM and BIO indicates species of conservation significance recorded by Biota in 2005 (Biota 2005).

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.

Species	Status	Recorded
Cheluidae		
Plate-shelled Tortoise (*Chelodina steindachneri*)		+
Agamidae (dragon lizards)		
Ring-tailed dragon (*Ctenophorus caudicinctus*)		+
Military dragon (*Ctenophorus isolepis*)		
Central netted dragon (*Ctenophorus nuchalis*)		+
Western netted dragon (*Ctenophorus reticulatus*)		+
Diporiphora winneckei		
Lophognathus (Amphibolurus) gilberti		
Lophognathus (Amphibolurus) longirostris		+
Bearded dragon (*Pogona minor)*		
Tympanocryptis cephala		

Species	Status	Recorded
Gekkonidae (geckoes)		
Clawless gecko (*Crenadactylus ocellatus*)		
Fat-tailed gecko (*Diplodactylus conspicillatus*)		+ WAM
Western saddled ground gecko (*Diplodactylus pulcher*)		
Diplodactylus savagei		WAM
Sand-plain gecko (*Diplodactylus stenodactylus*)		WAM
Pilbara Dtella (*Gehyra Pilbara*)		
Spotted Dtella (*Gehyra punctata*)		
Variegated Dtella (*Gehyra variegata*)		+ WAM
Bynoe's gecko (*Heteronotia binoei*)		+ WAM
Desert cave gecko (*Heteronotia spelea*)		+
Nephrurus levis		
Nephrurus wheeleri		
Marbled velvet gecko (*Oedura marmorata*)		WAM
Beaked gecko (*Rhynchoedura ornate*)		
Jewelled gecko (*Strophurus elderi*)		
Strophurus jeanae		WAM
Strophurus strophurus		
Strophurus wellingtonae		WAM
Pygopodidae (legless lizards)		
Delma borea		
Delma butleri		
Delma elegans		WAM
Delma haroldi		
Delma nasuta		WAM
Delma pax		WAM
Delma tincta		WAM
Burton's leglass lizard (*Lialis burtonis*)		+ WAM
Hooded scaly-foot (*Pygopus nigriceps*)		WAM
Scincidae (skink lizards)		
Carlia munda		+
Carlia triacantha		WAM

Species	Status	Recorded
Fence skink (*Cryptoblepharus plagiocephalus*)		+
Ctenotus duricola		WAM
Ctenotus grandis		
Ctenotus hanloni		
Ctenotus helenae		
Ctenotus leonhardii		
Ctenotus nigrilineatus	CS2	
Ctenotus pantherinus		+ WAM
Ctenotus piankai		
Ctenotus rubicundus		+ WAM
Ctenotus saxatilis		+ WAM
Ctenotus schomburgkii		
Ctenotus serventyi		
Ctenotus uber johnstonei	CS2	BIO
Cyclodomorphus melanops		+
Pygmy spiny-tailed skink (*Egernia depressa*)		
Egernia Formosa		
Egernia pilbarensis		
Egernia striata		
Broad-banded sand swimmer (*Eremiascincus richardsonii*)		
Glaphyromorphus isolepis		
Lerista bipes		
Lerista labialis		
Lerista macropisthopus remota	CS2	
Lerista muelleri		+ WAM
Lerista zietzi		
Dwarf skink (*Menetia greyii*)		+ WAM
Menetia surda		
Morethia ruficauda		+
Notoscincus ornatus		WAM
Proablepharus reginae		WAM
Central blue-tongue (*Tiliqua multifasciata*)		+

Species	Status	Recorded
Varanidae (goanna or monitor lizards)		
Ridge-tailed monitor (*Varanus acanthurus*)		+
Varanus brevicauda		+ WAM
Varanus caudolineatus		+
Varanus eremius		WAM
Perentie (*Varanus giganteus*)		
Pygmy mulga monitor (*Varanus gilleni*)		
Gould's goanna (*Varanus gouldii*)		
Varanus panoptes		+
Black tailed monitor (*Varanus tristis*)		+
Typhlopidae (blind snakes)		
Ramphotyphlops ammodytes		+ WAM
Ramphotyphlops ganei	CS2	BIO
Beaked blind snake (*Ramphotyphlops grypus*)		+
Pilbara blind snakes (*Ramphotyphlops pilbarensis*)		
Boidae (pythons)		
Pygmy python (*Antaresia perthensis*)		
Stimson's python (*Antaresia stimsoni*)		
Black-headed python (*Aspidites melanocephalus*)		+
Pilbara olive python (*Liasis olivaceus barroni*)	CS1	
Elapidae (front-fanged snakes)		
Pilbara death adder (*Acanthophis wellsi*)		
Northwestern shovel-nosed snake (*Brachyurophis approximans*)		
Yellow-faced whipsnake (*Demansia psammophis cupreiceps*)		WAM
Moon snake (*Furina ornate*)		WAM
Monk snake (*Parasuta monachus*)		
Mulga snake (*Pseudechis australis*)		
Ringed brown snake (*Pseudonaja modesta*)		
Gwardar (*Pseudonaja nuchalis*)		WAM
Desert banded snake (*Simoselaps anomalus*)		
Rosen's snake (*Suta fasciata*)		

Species	Status	Recorded
Spotted snake (*Suta punctata*)		
Pilbara bandy-bandy (*Vermicella snelli*)		
Number of reptiles expected (recorded)	**100 (48)**	

Birds

Birds that are expected to occur in the study area. A (+) indicates species recorded by Bamford Consulting in April and May (*) 2005 for the Cloud Break fauna survey (Davis *et al.* 2005), species recorded in the area by Birds Australia Atlas database are indicated by BA. Birds recorded in the area by the WA Museum are not yet included in the WAM's digital database.

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.

Species	Status	Recorded
Casuariidae (emu)		
Emu (*Dromaius novaehollandiae*)		+ BA
Phasianidae (quails)		
Stubble quail (*Coturnix pectoralis*)		
Brown quail (*Coturnix ypsilophora*)		* BA
Anatidae (ducks and geese)		
Black swan (*Cygnus atratus*)		*
Australian shelduck (*Tadorna tadornoides*)		*
Pacific black duck (*Anas superciliosa*)		+ BA
Grey teal (*Anas gracilis*)		* BA
Pink-eared duck (*Malacorhynchus membranaceus*)		*
Ardeidae (herons and egrets)		
White-faced heron (*Egretta novaehollandiae*)		+ BA
White-necked heron (*Ardea pacifica*)		+* BA

Species	Status	Recorded
Threskiornithidae (ibis)		
Straw-necked ibis (*Threskiornis spinicollis*)		+* BA
Accipitridae (osprey, hawks, eagles and harriers)		
Black-shouldered kite (*Elanus caeruleus (axillaris))*		BA
Square-tailed kite (*Hamirostra (Lophoictinia) isura)*		BA
Black-breasted buzzard (*Hamirostra melanosternon*)		
Black kite (*Milvus migrans*)		* BA
Whistling kite (*Haliastur sphenurus*)		+* BA
Brown goshawk (*Accipiter fasciatus*)		BA
Collared sparrowhawk (*Accipiter cirrocephalus*)		* BA
Little eagle (*Aquila (Hieraaetus) morphnoides*)		+ BA
Wedge-tailed eagle (*Aquila audax*)		+* BA
Spotted harrier (*Circus assimilis*)		* BA
Swamp harrier (*Circus approximans*)		
Falconidae (falcons)		
Brown falcon (*Falco berigora*)		+* BA
Nankeen kestrel (*Falco cenchroides*)		+* BA
Australian hobby (*Falco longipennis*)		* BA
Grey falcon (*Falco hypoleucos*)	CS2	*
Peregrine falcon (*Falco peregrinus*)	CS1	* BA
Black falcon (*Falco subniger*)		
Rallidae (crakes and rails)		
Black-tailed native hen (*Gallinula ventralis*)		+*
Otididae (bustard)		
Australian bustard (*Ardeotis australis*)	CS2	+* BA
Turnicidae (button-quails)		
Little button-quail (*Turnix velox*)		+* BA
Burhinidae (stone-curlews)		
Bush stone-curlew (*Burhinus grallarius*)	CS2	BA
Charadriidae (plovers, dotterels and lapwings)		
Black-fronted dotterel (*Charadrius (Elseyornis) melanops)*		+* BA
Red-kneed dotterel (*Erythrogonys cinctus*)		+* BA

Species	Status	Recorded
Glareolidae (pratincoles)		
Australian pratincole (*Stiltia isabella)*		
Columbidae (pigeons and doves)		
Common bronzewing (*Phaps chalcoptera*)		+* BA
Crested pigeon (*Ocyphaps lophotes*)		+* BA
Spinifex pigeon (*Geophaps plumifera*)		BA
Diamond dove (*Geopelia cuneata*)		+* BA
Peaceful dove (*Geopelia striata*)		BA
Cacatuidae (cockatoos and corellas)		
Galah (*Cacatua roseicapilla*)		+* BA
Little corella (*Cacatua sanguinea*)		+* BA
Cockatiel (*Nymphicus hollandicus*)		+* BA
Psittacidae (parrots, lorikeets and rosellas)		
Australian ringneck (*Barnardius zonarius*)		+* BA
Bourke's parrot (*Neophema bourkii*)		+* BA
Budgerigar (*Melopsittacus undulatus*)		* BA
Night parrot (*Pezoporus occidentalis*)	CS1	+
Cuculidae (cuckoos)		
Pallid cuckoo (*Cuculus pallidus*)		* BA
Black-eared cuckoo (*Chrysococcyx osculans*)		BA
Horsfield's bronze-cuckoo (*Chrysococcyx basalis*)		* BA
Centropodidae (pheasant coucals)		
Pheasant coucal (*Centropus phasianinus*)		
Strigidae (hawk owls)		
Southern boobook (*Ninox novaeseelandiae*)		+ BA
Tytonidae (barn owls)		
Barn owl (*Tyto alba*)		* BA
Podargidae (frogmouths)		
Tawny frogmouth (*Podargus strigoides*)		* BA

Species	Status	Recorded
Caprimulgidae (nightjars)		
Spotted nightjar (*Eurostopodus argus*)		+ * BA
Aegothelidae (owlet-nightjars)		
Australian owlet-nightjar (*Aegotheles cristatus*)		+ * BA
Apodidae (swifts)		
Fork-tailed swift (*Apus pacificus*)	CS1	
Halcyonidae (kingfishers)		
Blue-winged kookaburra (*Dacelo leachii*)		+ * BA
Red-backed kingfisher (*Todiramphus pyrrhopygia*)		+ * BA
Sacred kingfisher (*Todiramphus sanctus*)		BA
Meropidae (bee-eaters)		
Rainbow bee-eater (*Merops ornatus*)	CS1	+ * BA
Climacteridae (treecreepers)		
Black-tailed treecreeper (*Climacteris melanura*)		
Maluridae (fairy-wrens, grasswrens and emu-wrens)		
Variegated fairy-wren (*Malurus lamberti*)		+ * BA
White-winged fairy-wren (*Malurus leucopterus*)		+ * BA
Rufous-crowned emu-wren (*Stipiturus ruficeps*)		* BA
Striated grasswren (*Amytornis striatus*)		BA
Pardalotidae (pardalotes, thornbills, gerygones and allies)		
Red-browed pardalote (*Pardalotus rubricatus*)		BA
Striated pardalote (*Pardalotus striatus*)		+ BA
Redthroat (*Pyrrholaemus brunneus*)		BA
Weebill (*Smicrornis brevirostris*)		+ * BA
Western gerygone (*Gerygone fusca*)		+ * BA
Slaty-backed thornbill (*Acanthiza robustirostris*)		+ * BA
Chestnut-rumped thornbill (*Acanthiza uropygialis*)		* BA
Southern whiteface (*Aphelocephala leucopsis*)		*
Meliphagidae (honeyeaters and chats)		
Brown honeyeater (*Lichmera indistincta*)		+ BA
Black honeyeater (*Certhionyx niger*)		

Species	Status	Recorded
Pied honeyeater (*Certhionyx variegatus*)		
Singing honeyeater (*Lichenostomus virescens*)		+ * BA
Grey-headed honeyeater (*Lichenostomus keartlandi*)		+ * BA
White-plumed honeyeater (*Lichenostomus penicillatus*)		+ * BA
Black-chinned honeyeater (*Melithreptus gularis*)		+ BA
Grey honeyeater (*Lacustroica (Conopophila) whitei*		BA
Yellow-throated miner (*Manorina flavigula*)		+ * BA
Spiny-cheeked honeyeater (*Acanthagenys rufogularis*)		+ * BA
Orange chat (*Epthianura aurifrons*)		+
Crimson chat (*Epthianura tricolor*)		BA
Petroicidae (robins)		
Red-capped robin (*Petroica goodenovii*)		+ * BA
Hooded robin (*Petroica (Melanodryas*) *cucullata*)		+ * BA
Pomatostomidae (babblers)		
Grey-crowned babbler (*Pomatostomus temporalis*)		+ * BA
White-browed babbler (*Pomatostomus superciliosus*)		+ * BA
Cinclosomatidae (quail-thrush, wedgebills and whipbirds)		
Chiming wedgebill (*Psophodes occidentalis*)		BA
Chestnut-breasted quail-thrush (*Cinclosoma castaneothorax*)		
Neosittidae (sittellas)		
Varied sittella (*Daphoenositta chrysoptera*)		* BA
Pachycephalidae (shrike-tits, whistlers and allies)		
Crested bellbird (*Oreoica gutturalis*)		+ * BA
Rufous whistler (*Pachycephala rufiventris*)		+ * BA
Grey shrike-thrush (*Colluricincla harmonica*)		+ * BA
Dicruridae (flycatchers, magpie-larks and fantails)		
Grey fantail (*Rhipidura fuliginosa*)		* BA
Willie wagtail (*Rhipidura leucophrys*)		+ * BA
Magpie-lark (*Grallina cyanoleuca*)		+ * BA

Species	Status	Recorded
Campephagidae (cuckoo-shrikes and trillers)		
Black-faced cuckoo-shrike (*Coracina novaehollandiae*)		+ * BA
Ground cuckoo-shrike (*Coracina maxima*)		+ *
White-winged triller (*Lalage tricolor (sueurii))*		* BA
Artamidae (woodswallows, butcherbirds, magpies)		
Masked woodswallow (*Artamus personatus*)		
Black-faced woodswallow (*Artamus cinereus*)		+ * BA
Little woodswallow (*Artamus minor*)		BA
Grey butcherbird (*Cracticus torquatus*)		+ * BA
Pied butcherbird (*Cracticus nigrogularis*)		+ * BA
Australian magpie (*Cracticus (Gymnorhina) tibicen*)		+ * BA
Corvidae (ravens and crows)		
Torresian crow (*Corvus orru*)		+ * BA
Little crow (*Corvus bennetti*)		+ BA
Ptilonorhynchidae (bowerbirds)		
Western bowerbird		BA
Ptilonorhynchus maculatus (Chlamydera guttata)		
Alaudidae (larks)		
Singing bushlark (*Mirafra javanica*)		* BA
Motacillidae (pipits and wagtails)		
Richard's pipit (*Anthus australis (novaeseelandiae))*		+ * BA
Passeridae (grassfinches, sparrows and allies)		
Zebra finch (*Taeniopygia guttata*)		+ * BA
Star finch (western) (*Neochmia ruficauda subclarescens*)	CS2	+ BA
Painted finch (*Emblema pictum*)		* BA
Dicaeidae (flowerpeckers)		
Mistletoebird (*Dicaeum hirundinaceum*)		* BA
Hirundinidae (swallows and martins)		
Welcome swallow (*Hirundo neoxena*)		BA
Tree martin (*Hirundo nigricans*)		BA
Fairy martin (*Hirundo ariel*)		+ * BA

Species	Status	Recorded
Sylviidae (old world warblers)		
Little grassbird (*Megalurus gramineus*)		
Spinifexbird (*Eremiornis carteri*)		* BA
Rufous songlark (*Cincloramphus mathewsi*)		BA
Brown songlark (*Cincloramphus cruralis*)		+ * BA
Number of birds expected (recorded)	**127 (113)**	

Mammals

Mammals that are expected to occur in the area. A (+) indicates species recorded by Bamford Consulting in April and May (*) 2005 for the Cloud Break fauna survey (Davis *et al.* 2005), WAM indicates species recorded from the region by the Western Australian Museum and BIO indicates conservation significance species recorded from nearby areas by Biota in 2005.

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.

Species	Status	Recorded
Tachyglossidae (echidnas)		
Echidna (*Tachyglossus aculeatus*)		*
Dasyuridae (dasyurid marsupials)		
Mulgara (*Dasycercus cristicauda*)	CS1	BIO
Little red kaluta (*Dasykaluta rosamondae*)		+ WAM
Northern quoll (*Dasyurus hallucatus*)		WAM
Pilbara ningaui (*Ningaui timealeyi*)		+ WAM
Planigale (*Planigale sp*)		+ WAM
Woolley's pseudantechinus (*Pseudantechinus woolleyae*)		
Long-tailed dunnart (*Sminthopsis longicaudata*)	CS2	BIO
Striped-faced dunnart (*Sminthopsis macroura*)		+ WAM
Lesser hairy-footed dunnart (*Sminthopsis youngsoni*)		WAM

Thylacomyidae (bilbies)		
Bilby (*Macrotis lagotis*)	CS1	* WAM
Macropodidae (kangaroos and wallabies)		
Spectacled hare-wallaby (*Lagorchestes conspicillatus*)	CS2	
Euro (*Macropus robustus*)		+
Red kangaroo (*Macropus rufus*)		+ *
Rothschild's rock-wallaby (*Petrogale rothschildi*)		
Pteropodidae (flying foxes)		
Black flying-fox (*Pteropus alecto*)		
Emballonuridae (sheathtail bats)		
Yellow-bellied sheathtail bat (*Saccolaimus flaviventris*)		+
Common sheathtail bat (*Taphozous georgianus*)		+
Hill's sheathtail bat (*Taphozous hilli*)		
Megadermatidae (ghost bat)		
Ghost bat (*Macroderma gigas*)	CS2	
Hipposideridae (leaf-nosed bats)		
Orange leaf-nosed bat (*Rhinonicteris aurantius*)	CS1	
Vespertilionidae (ordinary bats)		
Gould's wattled bat (*Chalinolobus gouldii*)		+
Chocolate wattled bat (*Chalinolobus morio*)		
North-western long-eared bat (*Nyctophilus bifax*)		
Lesser long-eared bat (*Nyctophilus geoffroyi*)		+
Greater long-eared bat (*Nyctophilus timoriensis*)		
Inland broad-nosed bat (*Scotorepens balstoni*)		
Little broad-nosed bat (*Scotorepens greyii*)		+ * WAM
Findlayson's cave bat (*Vespadelus findlaysoni*)		+
Molossidae (freetail bats)		
Northern freetail bat (*Chaerephon jobensis*)		+
Beccari's freetail bat (*Mormopterus beccarii*)		
Inland freetail bat (*Mormopterus* sp.3)		
White-striped freetail bat (*Tadarida australis*)		+

Muridae (rats and mice)		
Short-tailed mouse (*Leggadina lakedownensis*)	CS2	WAM
House mouse (*Mus musculus*)	Introduced	+ WAM
Spinifex hopping-mouse (*Notomys alexis*)		WAM
Western pebble-mound mouse (*Pseudomys chapmani*)	CS2	+
Desert mouse (*Pseudomys desertor*)		+ WAM
Sandy inland mouse (*Pseudomys hermannsburgensis*)		WAM
Common rock-rat (*Zyzomys argurus*)		+ WAM
Leporidae (rabbits and hares)		
Rabbit (*Oryctolagus cuniculus*)	Introduced	
Canidae (dogs and foxes)		
Dingo/dingo-dog hybrids (*Canis lupus dingo*)		+
Fox (*Vulpes vulpes*)	Introduced	
Felidae (cats)		
Feral/house cat (*Felis catus*)	Introduced	+ *
Equidae (horses)		
Donkey (*Equus asinus*)	Introduced	+
Horse (*Equus caballus*)	Introduced	*
Camelidae (camels)		
Camel (*Camelus dromedarius*)	Introduced	*
Bovidae (horned ruminants)		
Goat (*Capra hircus*)	Introduced	
Number of mammals expected (recorded)	**48(32)**	

5.2 Appendix 2

DEC Protocol for Deployment of Cat Baits (14/06/2011)

Background

Due to the specific conditional requirements associated with aerial cat baiting the following protocol has been developed to provide operational guidance in order to achieve the most effective baiting outcome. This document also aims to define roles and responsibilities of the various DEC staff involved in the coordination and support of an aerial cat baiting campaign. This document also outlines what should occur in the event of postponement of a cat baiting and how standby costs are to be administered.

The Operations Officer (Invasive Species) of Environmental Management Branch is to remain the lead point of contact between DEC and the aerial baiting contractor for all matters of a contractual and program planning nature. Any issues regarding the aerial baiting service or this protocol should be directed to this Officer in the first instance.

1. Stage 1 – Up to 3-4 weeks prior to baiting

At this stage the Operations Officer (Invasive Species) should review the longest-term (i.e. 28 day) weather forecast that is available for each of the cells and liaising with the aerial baiting contractor, the key proponent for each cell, Bait Manufacturing Facility (BMF) staff as well as Dr Dave Algar (DEC cat expert) regarding any potential problems. If poor weather is predicted, the Operations Officer (Invasive Species) should request the aerial baiting contractor to develop alternative flying schedules. The Operations Officer (Invasive Species) needs to consider any alternative flying schedules to ensure that:

- The baiting of other Western Shield cells is not compromised;
- BMF staff can assist regarding bait delivery and supervision; and
- The key cell proponent is aware of and endorses all proposed changes.

2. Stage 2 – Within 2 days prior to baiting

A final decision must be made about whether baiting will be attempted at each site based on weather forecasts and local staff input about conditions. This decision should be made by the Operations Officer (Invasive Species) in consultation with the key proponent, local staff, Dr Algar and Western Shield Coordinator. If the BMF staff have already left for the site, they can also provide input regarding the actual conditions on route. The Operations Officer (Invasive Species) will request the aerial baiting contractor to implement an alternative flying schedule if necessary (in line with section 5 below). If an amendment to the flying program is implemented, the Operations Officer (Invasive Species) should then notify all Aerial Baiting Coordinators as well as other relevant staff of the new flying schedule.

3. Stage 3 – On-site

Once BMF staff, the aerial baiting contractor and key proponent are on-site, the final decision on whether to proceed with baiting rests with the ‘on-site baiting coordinator’. The ‘on-site baiting coordinator’ will be a nominee appointed by the Operations Officer (Invasive Species) prior to the commencement of the baiting program. The decision to bait by the ‘on-site baiting coordinator’ will need to be made on a daily basis and based on an assessment of predicted and actual weather conditions, knowledge as per section 5 below, and in liaison with other appropriate staff as necessary i.e. Operations Officer (Invasive Species), key proponent and BMF staff. It may be worthwhile for the ‘on-site baiting coordinator’ to arrive on site one day early (or arrange for local staff to assess local conditions) so that they can provide last minute advice on whether the aerial baiting contractor should proceed to the location from the previous baiting cell.

4. Stage 4 – If the decision is made on-site to postpone baiting

The ‘on-site baiting coordinator’ should notify the key proponent and Operations Officer (Invasive Species) as soon as possible once a decision to postpone baiting has been made. If the aerial baiting contractor is requested to not bait for more than one day, the Operations Officer (Invasive Species) should discuss with the key proponent, Western Shield Coordinator, BMF staff and the aerial baiting contractor whether to request that the aerial baiting contractor continue with other aerial baiting operations or to request that the aerial baiting contractor remain on-site at the standby rate. If possible, whenever the aerial baiting contractor is requested to postpone baiting, alternate paid work should be found for BMF staff by the key proponent.

5. Guidelines for determining whether baiting should be postponed

At each of Stages 1 to 3 outlined above, the criteria to be used for making a decision on whether baiting should proceed should include:

- Is any rainfall predicted during baiting or within 5 days of the baiting event?
- If yes, what is the likelihood of rainfall in the relevant baiting areas?
- If yes, how much rainfall is predicted? If ≥ 5mm within 24-hour period then consideration should be to postpone baiting. If < 5mm within 24-hour period baiting could proceed depending on local conditions and knowledge.
- Following a rainfall event of ≥ 5mm rainfall within a 24-hour period, baiting can commence once there is no free-standing water, the soil is no longer saturated and weather forecasts and local conditions suggest that no subsequent rainfall of > 5mm within a 24-hour period will be experienced in the next 5 days. It is critical that all decisions and materials/evidence (i.e. weather forecasts, soil moisture readings) used to support the decision made to amend the baiting program or to postpone baiting is documented and forwarded to the Operations Officer (Invasive Species) to be placed on file.

6. Aerial Baiting Contractor Standby Costs

In terms of standby costs for the aerial baiting contractor under the current contract, if the aerial baiting contractor is prevented from flying due to adverse weather conditions or poor visibility caused by smoke or haze, standby conditions will not be invoked. However, if DEC decides that the aerial baiting should not proceed due to poor baiting outcomes, standby conditions may be invoked, as per the aerial baiting contract. In this scenario, baits will not be made available to the aerial baiting contractor. While all attempts will be made by the Operations Officer (Invasive Species) to amend the flying schedule if poor weather conditions are predicted at cat baiting sites, the key proponent for each cat baiting cell will be responsible for any standby costs.

7. Aerial Baiting Prescription

Dr Algar remains the key DEC contact for any cat baiting issues relating to the baiting prescription including baiting density, height at which baits are dropped from the aircraft and all other technical queries.

The current aerial cat baiting prescription is as follows:

- Baits: as freshly and as thoroughly sweated as possible at the time of aerial dropping
- Flight lines: parallel flight lines at 1 km intervals
- Altitude: 500ft AGL
- Bait density: 50 baits/km^2
- Bait dropping: baits to be dropped in a “tightish” scatter to achieve approximately 250m x 150m on the ground
- Speed: recommended no faster than 160kt/hr

The method by which the “tightish” scatter is achieved is at the discretion of the aerial baiting contractor.