



Report

McArthur River Mine Phase 3 Development Project Terrestrial and Aquatic Fauna

12 JANUARY 2012

Prepared for
MET Serve Pty Ltd
PO Box 306
Fortitude Valley Post Office
Fortitude Valley
QLD 4006

42626794

URS

Project Manager:



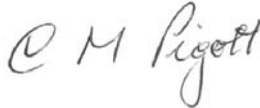
Angus McLeod
Associate Ecologist

URS Australia Pty Ltd

**Level 17, 240 Queen Street
Brisbane, QLD 4000
GPO Box 302, QLD 4001
Australia**

**T: 61 7 3243 2111
F: 61 7 3243 2199**

Principal-In-Charge:



Chris Pigott
Senior Principal

Authors:

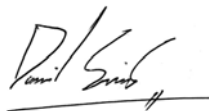


Keith Martin
Senior Environmental
Scientist

Paul Barden - EMS

Dr. Dean Thorburn – Indo-
Pacific Environmental

Reviewer:



Dan Simmons
Senior Associate
Environmental Scientist

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Abbreviations

Abbreviation	Description
AUSRIVAS	Australian River Assessment System
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CR	Critically Endangered
DIPE	Department of Infrastructure, Planning and Environment (NT)
DR-PIFR	Department of Resources – Primary Industry, Fisheries and Resources
DMSO	Dimethyl sulfoxide
DSEWPC	Commonwealth Department of the Sustainability, Environment, Water, Population and Communities
EIA	Environmental Impact Assessment
EIS	Environmental Impact Statement
EN	Endangered
EPBC Act	Commonwealth <i>Environment Protection and Biodiversity Conservation Act, 1999</i>
GFU	Gulf Fall and Uplands
LC	Least Concern
MNES	Matters of National Environmental Significance
MPC	Maximum Permitted Concentration
MRM	McArthur River Mine
NAF	Non Acid Forming
NRETAS	Department of Natural Resources, Environment, The Arts and Sport (NT)
NRM	Natural Resource Management
NT	Northern Territory
NT	Near Threatened
OEF	Overburden Emplacement Facility
TPWC Act	Territory Parks and Wildlife Conservation Act 2006
TSF	Tailings Storage Facility
PAF	Potential Acid Forming
PDS	Hallprint fish tag designation
PDX	Hallprint fish tag designation
PER	Public Environmental Report
TSF	Tailings Storage Facility
VU	Vulnerable

Executive Summary

Introduction

MET Serve Pty Ltd has contracted URS Australia to undertake terrestrial fauna and aquatic ecology investigations in support of the preparation of an Environmental Impact Statement (EIS) for the McArthur River Mine (MRM) Phase 3 Development Project (the Project). The aim of this terrestrial fauna and aquatic ecology investigation is to characterise the ecological values of the overall study area and determine biodiversity values for areas potentially impacted by the Project, with a focus on significant species and habitats identified under NT and Commonwealth legislation. This report also identifies potential impacts and provides mitigation strategies.

The study involved a staged approach to ensure an appropriate level of biodiversity assessment was undertaken and to allow for adequate impact assessment. This approach included database searches, literature review, review of ongoing monitoring programs and field verification surveys.

Terrestrial Fauna

Riparian Bird Monitoring Program

As a condition of approvals for the diversion of the McArthur River, a commitment was included in the 2006 Public Environmental Report (PER) and Mine Management Plan (MMP) to conduct a riparian bird monitoring program. The objective of the program was to monitor riparian birds in the vicinity of the project area and to assess the progress of rehabilitation works in the vicinity of the rechanneling works for Barney Creek and the McArthur River. The monitoring program focused on riparian birds, particularly two key riparian indicator species, the buff-sided robin (*Poecilodryas cerviniventris*) and the purple-crowned fairy-wren (*Malurus coronatus macgillivrayi*). These species were chosen as indicators due their known strong habitat association with riparian forest and woodland habitats. Apart from the two target species, the riparian bird monitoring program also provided baseline information on the bird communities of the area.

Since the commencement of the program in November 2006 ten seasonal surveys of riparian birds have been conducted, incorporating 1,656 20 minute / 2 ha searches across 56 sites, with 55,086 bird observations documented. A total of 141 bird species were recorded within the survey plots, and 172 bird species have been recorded from the wider McArthur River Station riparian habitat and adjacent floodplain habitats in the vicinity of the project area.

A notable finding of the riparian bird monitoring program was an increase in abundance of purple-crowned fairy-wren within the cattle exclusion fence between the diversion inlet and the southern bund, particularly in higher bank riparian woodland habitat. This increase has occurred concurrently with an expansion of cane grass distribution in this area and suggests that the fencing is reducing the overall impact of cattle grazing in the riparian woodland (although cattle persist in low numbers within the fenced area).

Fauna Survey of Phase 3 Expansion Areas 2011

Results from the database search and literature review were used in the design of a new field investigation specific to the Phase 3 Development Project expansion areas. Large amounts of existing data were available, much of the existing data were current and related directly to locations within or adjacent to the Project area and much of the area was already in a disturbed state. For these reasons,

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it was concluded that primary data collection was generally not required to the same level as a 'greenfield' site where no previous baseline data existed.

A fauna survey incorporating the main vertebrate fauna trapping program was undertaken between 30 May and 6 June 2011. Four systematic survey sites were sampled within the study area, including two sites in the proposed OEF expansion area and two sites in the eastern OEF (outer bund) expansion area. An additional site in the proposed Tailings Storage Facility (TSF) area was sampled opportunistically. Other survey components, including site inspections, incidental observations and remote bat echolocation detection, were undertaken between 30 May and 23 June 2011.

Standard biological survey techniques were used during field surveys, including a number of live capture/release trapping techniques, standard and general observational (birds and mammals), habitat searches (reptiles and amphibians), as well as methods to indirectly detect the presence of terrestrial fauna.

Overall results from the field surveys recorded ten frog, 15 reptile, 20 mammal and 77 bird species within the three main project component areas. These totals include data from both the systematic site surveys and from general observations through the area. The field surveys recorded one reptile and five mammal species not observed in the McArthur River area on any previous surveys. The field surveys recorded two species within the Project area that are listed as "Vulnerable" under the *Territory Parks and Wildlife Conservation Act 2006 (TPWC Act)*.

Species of Conservation Significance

A search of the *Environmental Protection and Biodiversity Conservation Act 1999 (EPBC Act)* Protected Matters database identified six threatened species of national conservation significance as being potentially present in the project area; including three bird species, one mammal species, one reptile species and one fish species. In addition to the Commonwealth listed threatened species, a further 15 migratory species have been identified as potentially occurring in the area. Lists of threatened species under the *TPWC Act* were obtained from the NRETAS website.

An assessment of the complete fauna list recorded in the area against *EPBC Act and TPWC Act* listings identified some additional threatened species. Threatened species in the three highest threat categories (Critically Endangered, Endangered and Vulnerable) known or expected in the McArthur River area include one fish, two reptile, seven bird and one mammal species.

Of the threatened terrestrial fauna species, the only species which are regularly sighted in the Project area are Australian bustard (*Ardeotis australis*), Mertens' water monitor (*Varanus mertensi*) and yellow-spotted monitor (*Varanus panoptes*). Australian bustard is a common species in the McArthur River area, and was observed in all project component areas during the 2011 field survey. This species has probably benefitted from improvements in habitat quality (e.g. native grasslands) in the mine area brought about by cattle exclusion fencing. The two monitor species were once common but are considered threatened due to the widespread colonisation of the introduced cane toad (*Rhinella marina*) in the area.

Eleven species listed as Migratory or Marine under the *EPBC Act* occur, or may potentially occur, within the Project area. There are no data to suggest that any of these species maintain important populations in the McArthur River area.

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Summary of Terrestrial Fauna Investigations

Overall results indicate that a total of approximately 24 frog, 62 reptile, 189 bird and 32 mammal species occur within the McArthur River Mine area. A breakdown of species recorded in each of the three major expansion area component sites during the field surveys indicates a total of 89 vertebrate species were observed in the northern Overburden Emplacement Facility (OEF) areas, 75 species in the eastern OEF area and 59 in the TSF area. These figures are however not directly comparable due to differences in search effort, especially in the TSF area where no systematic trapping was undertaken. The figures do however reflect fewer terrestrial vertebrates in the eastern OEF area compared to the northern OEF area. The eastern OEF area is subject to regular and significant flooding, and terrestrial mammals and reptiles are generally unable to establish permanent populations because of this. The eastern OEF had good populations of frogs due to moist conditions created by the dense shading and proximity of permanent water. However, terrestrial small mammals were absent, and reptiles were generally represented by semi-aquatic species or arboreal species such as lizards of the genera *Gehyra* and *Cryptoblepharus*.

A number of feral animals and domestic stock species are present in the area. These include the cane toad (*Rhinella marina*), and mammal species such as donkey, pig and cattle. The latter species is present due to the area being an active cattle station.

Aquatic Ecology

Xstrata undertakes field monitoring investigations on aquatic ecology for the Project in response to recommendations by the NT Government in its approval of the 2006 PER for the Phase 2 Expansion, and to commitments made by Xstrata through that process. These studies are ongoing and data collected are current. As such, no additional studies specific to the Phase 3 Development Project were required.

Fishes

Sampling for fishes occurs annually in the early dry (as soon as sites become accessible after the wet season) and late dry seasons. Fish community structure in the McArthur River is examined using a variety of methods, which includes fyke, seine and gill nets and electrofishing equipment. Visual survey and line fishing techniques are also utilised.

A total of 47 species of fish have been recorded from freshwaters of the McArthur River. Thirty two species of fish have been recorded from non-tidal waters, with the additional 15 species known from tidally influenced freshwaters in the vicinity of Burketown Crossing. Twenty seven species of fish are considered to be freshwater species, i.e. capable of breeding in freshwater. Three elasmobranch species have been also been recorded, with *Himantura dalyensis* (formerly known as *H. chaophraya*) and *Carcharhinus leucas* being recorded from tidal and freshwaters, and *Pristis microdon* which has been captured as far upstream as Eight Mile Waterhole.

Approximately 1200 fish have been tagged with a PDS or PDX dart tag since 2007. Thirty two recaptures have been recorded with a vast majority (29) being of *Neoarius paucus*. Baseline sampling conducted between 2006 and 2008 (i.e. prior to the opening of the river diversion) indicated *Melanotaenia splendida inornata* to be the most abundant species occurring in the McArthur River during both the early and late dry seasons. *Leiopotherapon unicolor*, *Ambassis macclaeayi*, *Ambassis mulleri*, *Amniataba percoides* and *Glossogobius giurus* were also captured in high abundances

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between 2006 and 2008. These species were also well represented in the original McArthur River channel designated for realignment, with a total 29 species (21 freshwater) of fish known from that section and waterholes immediately upstream.

Metals in Aquatic Fauna Monitoring Program

Twelve sample sites throughout the McArthur River catchment were selected for metals analysis. Sites are located as far downstream as the Burketown Crossing, within the mine lease (including within the diversion, and Surprise and Barney Creeks) and as far upstream Top Crossing. Sites that are not in the immediate vicinity of the mine include those which are considered to be outside of the area that the MRM ore body is likely to directly influence. Reference samples are collected from two adjacent systems, the Limmen Bight (~150 km NW of MRM) and Wearyan Rivers (~80 km NE of MRM) to provide background levels from the region.

Muscle and liver tissue are collected from *N. erebi* and *L. unicolour*, while *M. splendida inornata* is analysed whole (head, tail, fin and gut removed). The muscle tissue is only analysed from *M. rosenbergii*. Of the ~450 individual fish and crustaceans analysed between 2005 and 2008, very few Maximum Permitted Concentration (MPC) exceedances have been recorded with only five and 13 individuals exceeding values for lead and copper, respectively. These exceedances were observed in fishes collected in the vicinity of the mine however a number of individuals captured upstream also exceeded MPC. In all years, lead isotope values have been shown to approach that of the MRM ore body with increased proximity to the mine.

Macroinvertebrate Monitoring Program

Twenty-four sites were initially selected for sampling, however a number of these sites have been removed from the program or have not been sampled during some years due to an absence of surface water, unsuitable habitats or absence of safe sampling. Sampling for the program is limited to one seasonal sample per year based with the NT AUSRIVAS protocol.

Results indicate that aquatic macroinvertebrate taxa numbers from edge habitats were lowest at exposed sites on Surprise Creek and Barney Creek downstream of mine processing areas and the TSF, and at reconstructed sites on the diversions. There was a general increase in taxa numbers indicating recovery at downstream reference sites.

Sampling conducted in 2008 and 2009 demonstrated that there are impacts on aquatic biota (macroinvertebrates) associated with elevated levels of metals, sulphate and other water chemistry parameters associated with the Surprise – Barney Creek system. The results also demonstrate that macroinvertebrate communities within the diversion sites are significantly different to reference sites when comparing edge habitats and that this is in part related to the absence of riparian vegetation and stream morphology factors.

Riffle sites within the McArthur River have been rapidly colonised by macroinvertebrates and are not significantly different to reference sites on the basis of macroinvertebrate abundance data. Riffle sites on exposed sections of Surprise Creek and the Barney Creek diversion display macroinvertebrate communities that were significantly different (impaired) when compared with reference sites or McArthur River diversion sites.

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Species of Conservation Significance

A total of 28 records (including 19 captures) of freshwater sawfish (*Pristis microdon*) (TPWC Act and EPBC Act – Vulnerable) have been collected during the biannual sampling of fishes for MRM between March 2006 and June 2011. With the exception of a 2050 mm individual captured in June 2011, most have been small and between one and two years of age. A single recapture has been recorded during the study, with an individual captured in waters above the Burketown Crossing in September 2009 recaptured one year later in the same area, and which had grown ~550mm in that year.

Captures during the current study suggest that the recruitment of juveniles appears correlated to the magnitude and duration of the wet season, i.e. greater numbers are encountered after large wet seasons. Sustained waters of a long wet season facilitate upstream recruitment by a) providing increased depth and thus reduced obstruction by barriers including rock bars, sand bars and barrages, and b) the extended time available for upstream migration.

The Gulf snapping turtle (*Elseya lavarackorum*) (TPWC Act – Least Concern; EPBC Act – Endangered) is a large short necked turtle reported to occur in several large river systems of the southern gulf, from the Roper River NT across to the Nicholson River, Queensland. During the course of regular fish monitoring surveys at McArthur River in 2007, eight individuals of a large *Elseya*, possibly *E. lavarackorum*, were captured incidentally by gill netting at a location in the lower Glyde River. Despite a significant effort of netting for fish at various locations in the main channel of the McArthur River and in other areas since 2006, no other records of this turtle have been made.

Ecological Impact Assessment

Terrestrial Fauna

The main Project components that will require expansion into areas of fauna habitat are: the northern OEF expansion; the pit, bund and eastern OEF expansion; and the TSF expansion. The primary impacts from these developments on terrestrial fauna may be direct habitat loss, and a threat to future habitat restoration along the McArthur River channel if appropriate rehabilitation of the McArthur River diversion is not effectively implemented.

In the northern OEF area, the fauna species occurring are generally common and wide-ranging forms, with no species specialised in this woodland habitat. Australian bustard (TPWC Act – Vulnerable) occur in this area and it is likely that emu (TPWC Act – Vulnerable) may occasionally be present. The Project will remove some of the habitat for these species, but the amount is very minor considering the large areas of similar habitat available in the region.

The pit expansion and eastern OEF areas include a diversity of habitats including riparian corridor, riparian woodland, low open woodland and hill woodland on rocky outcrops. These habitats provide refuge, feeding and roosting sites for a range of species, especially birds. Two bird species, purple-crowned fairy-wren and buff-sided robin are specialised to the riparian habitats. Riparian areas are also likely to act as important refuge sites from which terrestrial riparian fauna species would be able to recolonise restoration areas on the McArthur and Barney Creek diversions. If the rehabilitation of the McArthur River diversion is not effectively implemented, there may be some loss of current riparian habitat connectivity when the outer bund area is converted to an OEF as the back channels of the old river bed in these areas are still currently functioning as terrestrial ecological systems.

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Xstrata made commitments in the 2005 EIS and subsequent 2006 PER to rehabilitate the McArthur River diversion channel and restore it to a functioning riparian ecosystem. This involves rehabilitating not only the in-stream and bankside habitats, but extends into the adjacent natural vegetation. The eastern OEF will leave a minimum of 75 m from the crest of the river but has some potential to threaten this habitat rehabilitation effort (and therefore threaten the return of riparian fauna into these areas) if appropriate rehabilitation of the McArthur River diversion is not effectively implemented.

Aquatic Ecology

The majority of the potential impacts on aquatic ecology from the proposed Phase 3 Expansion Project arise from the development of the eastern OEF and expansion of the pit bund. They potentially include the loss of staging habitat, loss of floodplain function, potential increases in flow velocities and potential chemical effects if appropriate environmental management strategies are not effectively implemented.

Management and Monitoring

The following measures are recommended to manage, mitigate, offset and monitor potential impacts of The Project on terrestrial and aquatic fauna:

- The old McArthur River channel both upstream and downstream of the current bund wall is still functioning. It is recommended that development of these two areas be avoided if appropriate rehabilitation of the McArthur River diversion is not effectively implemented;
- Encroachment of the eastern OEF area within close proximity of Barney Creek and the McArthur diversion is likely to have negative impacts on terrestrial and aquatic ecology. It is recommended that safe setbacks from these landscape features be maintained;
- Increased planting of the diversion batters and planting of established trees to stabilise banks should be undertaken in the event the eastern OEF is established;
- Additional baffling may be required on the western diversion wall to reduce erosion which may potentially occur as a result of increased flow rates;
- Appropriate water management infrastructure should be incorporated into the expanded northern OEF to prevent flow of contaminants into the McArthur River via drainage lines entering below the diversion channel;
- A program to relocate populations of purple-crowned fairy-wrens and buff-sided robins from within the pit area and the two old McArthur River channel sites should be investigated; and
- The planned cattle exclusion zone (as per the proposed Phase 2 offset program yet to be implemented) should be implemented as a component of the Project, and should be expanded away from the river to include woodland plains habitats similar to those found in the northern OEF area. Consideration should also be given to expanding the cattle exclusion zone along the river upstream of the mine site.

If development of the eastern OEF results in loss of the two old channel McArthur River areas then it is recommended that surveys of aquatic fauna of these areas should be undertaken to identify their importance as dry season refugia and wet season resting area, and to aid in the management of the consequences of this project component.

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Continuation of the current riparian bird and aquatic ecology monitoring programs is recommended and may require some modifications to ensure that additional impacts from the Project are adequately addressed. In particular, it is desirable to increase the frequency of monitoring for metal and metalloid accumulation in aquatic fauna when the eastern OEF is established.

Introduction

1.1 Study Aims and Objectives

MET Serve Pty Ltd has contracted URS Australia to undertake terrestrial fauna and aquatic ecology investigations in support of the preparation of an Environmental Impact Statement (EIS) for the McArthur River Mine (MRM) Phase 3 Development Project (the Project). This work is being undertaken in accordance with the Scope of Works documentation provided by MET Serve Pty Ltd and dated 17 March 2011, and in accordance with URS' proposal dated 1 April 2011.

The aim of the fauna and aquatic ecology investigation is to characterise the ecological values of the overall study area and determine biodiversity values for areas potentially impacted by the Project, with a focus on significant species and habitats. The study also aims to identify potential impacts and provided mitigation strategies. In meeting these aims the specific objectives for the terrestrial and aquatic fauna studies are to:

- determine the species composition and habitats of terrestrial and aquatic fauna of the McArthur River area through a combination of literature review, review of current monitoring programs and limited field assessment;
- identify the known or potential presence of conservation significant fauna species or sensitive ecological communities in the area, and their possible occurrence in the Project area;
- provide assessment of the impacts of the Project on terrestrial and aquatic fauna, particular on species of recognised conservation significance; and
- develop strategies to minimise and manage potentially adverse ecological impacts.

1.2 Study Approach

The McArthur River area has been the focus of numerous previous environmental studies, as well as current and ongoing monitoring surveys, so the existing dataset on fauna and aquatic ecology (especially for fishes and riparian birds) for the area is particularly robust in terms of species inventory and likely presence of threatened species. In light of this background, an extensive new field study of The Project area was considered unlikely to produce any significant new results.

The McArthur River terrestrial and aquatic fauna study involved a staged approach to ensure an appropriate level of biodiversity assessment is undertaken and to allow for adequate impact assessment. This approach included:

- database searches to determine lists of species known or potentially occurring in the area, particularly in reference to species of conservation significance;
- literature review to obtain background or historical information on the biodiversity of the area;
- a summary review of several ongoing fauna and aquatic ecology monitoring programs currently in place at the McArthur River mine; and
- a field verification survey that included quantitative and opportunistic survey sampling in the proposed expansion areas, and an assessment of fauna habitats and current conditions.

Impact assessment of the effects on fauna and aquatic ecology was then determined based on the findings of the above studies in light of a review of planned project components and new data from other studies.

1 Introduction

1.3 Study Area

MRM is located in the Northern Territory (NT), approximately half way between Darwin and Mount Isa. MRM is located approximately 60 kilometres south-west of the township of Borroloola, 120 kilometres south of the Bing Bong loading facility on the Gulf of Carpentaria and 900 kilometres south-east of Darwin in the Gulf Region of NT in Australia.

The Project is located within the Gulf Fall and Uplands (GFU) bioregion of the Northern Territory (Baker *et al.* 2005). This bioregion covers an area of 111,783 km² within the NT, and a small portion within Queensland. 8.4% of this bioregion is currently reserved or protected in the NT.

The Gulf Fall and Uplands bioregion comprises undulating terrain with scattered low, steep hills on Proterozoic and Palaeozoic sedimentary rocks, often overlain by lateritised Tertiary material. Soils are mostly skeletal or shallow sands. The most extensive vegetation is woodland dominated by Darwin stringybark (*Eucalyptus tetradonta*) and variable-barked bloodwood (*Corymbia dichromophloia*) with spinifex understorey, and woodland dominated by northern box (*Eucalyptus tectifica*) with tussock grass understorey (Baker *et al.* 2005).

The Project area is located on McArthur River station, and is covered by mineral leases ML1123, ML1121, ML1122, ML1124 and ML1125, all of which are owned by Xstrata. These leases occupy a total area of about 11,000 ha although the total footprint of the mine site and expansion area is a fraction of this total.

The Project has three major components with potential to affect the terrestrial fauna and aquatic ecology of the site:

- Expansion of the northern Overburden Emplacement Facility (OEF) including several small water retention dams. This area is mainly dominated by low open woodland to shrubland;
- Expansion of the existing pit inside the existing bund area, and placement of non-acid forming overburden in the area between the existing bund wall, the McArthur River diversion channel and Barney Creek (eastern OEF). This area includes some upland woodland communities, lowland woodland, and areas of riparian woodland and riparian corridor along the old channel of the McArthur River and Barney Creek and
- Expansion of the existing Tailings Storage Facility (TSF) in an area of inland bloodwood community.

Other Project components such as expansion of the existing accommodation camp, expansion of the power station, and upgrading of the processing plant are considered unlikely to have significant additional impacts on terrestrial and aquatic fauna.

1 Introduction

1.4 Study Team

The roles and responsibilities of the study team for the terrestrial and aquatic fauna study are detailed below.

- Angus McLeod (Associate Ecologist, URS Australia) – Project Manager.
- Keith Martin (Senior Environmental Scientist, URS Australia) – Team leader and senior report author.
- Paul Barden (Director, Environmental Management Services) – Terrestrial fauna specialist; summary reporting for riparians birds and macroinvertebrate monitoring program; terrestrial fauna impacts assessment and management.
- Dr. Dean Thorburn (Director, Indo-Pacific Environmental) – Aquatic ecology specialist; summary reporting for aquatic ecology monitoring program; aquatic impacts assessment and management.

Legislative Context

2.1 Environment Protection and Biodiversity Conservation Act

The Commonwealth *Environment Protection and Biodiversity Conservation Act, 1999* (EPBC Act) provides for the protection of the environment, especially matters of National Environmental Significance (MNES), and is administered by the Commonwealth Department of the Sustainability, Environment, Water, Population and Communities (DSEWPC). It is designed to provide for the conservation of biodiversity through the protection of threatened species and ecological communities, migratory, marine and other protected species listed under the Act. In general, the *EPBC Act* streamlines national environmental assessment and approvals process, protects Australian biodiversity and integrates management of important natural and cultural places.

A referral under the *EPBC Act* for the Project has been submitted to the Commonwealth. Based on that referral, the Commonwealth has determined that the Project is not considered a “controlled action” under the *EPBC Act* (Determination 2011/5904). This means that the Project does not require further assessment and approval under the EPBC Act before it can proceed.

2.2 Environmental Assessment Act 1982

The *NT Environmental Assessment Act 1982* provides for the impact assessment process under which major development projects are controlled and is administered by the NT Department of Natural Resources, Environment, The Arts and Sport (NRETAS). The primary purpose of the assessment process is to provide for appropriate examination of proposed new projects which may cause significant environmental impact. The legislation defines ‘environment’ to mean all aspects of the surroundings of man including the physical, biological, economic, cultural and social aspects.

2.3 Territory Parks and Wildlife Conservation Act

The *Territory Parks and Wildlife Conservation Act 2006* (TPWC Act) provides for the creation of parks and reserves and their management, and the conservation and sustainable utilisation of wildlife. It is administered by the NT Department of NRETAS.

Species that are considered to be threatened are listed under the *TPWC Act*. Species listed as threatened are managed so as to promote an increase or maintenance in population numbers. This is achieved through a number of measures including the protection of threatened species habitat and scientific programs such as captive breeding and propagation.

Under the *TPWC Act*, threatened species can be listed as:

- Vulnerable species;
- Endangered species;
- Critically endangered species;
- Extinct in the wild species; or
- Extinct species.

2.4 Fisheries Act (NT)

The *Fisheries Act* (NT) has been created to manage NT aquatic resources in a sustainable manner. The Act looks both at the management of single species and ecosystems as a whole. The Act is administered by the Department of Resources – Fisheries.

Terrestrial Fauna

The terrestrial fauna potentially affected by the Project is described in this section. Data from database searches, literature review, current monitoring programs and general field surveys have been used to describe the species composition and habitats of terrestrial vertebrate fauna in the wider McArthur River area, and in the Project expansion areas. Threatened species known or potentially occurring in the area are identified and their status in the area is assessed.

3.1 Database Searches

Data on the fauna of the McArthur River region were gathered from a number of recent and historical datasets.

Searches were conducted on two NT Government and one Commonwealth Government databases to obtain information on species lists, conservation values and threatened species potentially occurring in the Project area. The following searches were conducted;

- NT Fauna Atlas search for a species list and conservation attributes for the rectangular area surrounding McArthur River Mine was conducted with a top left coordinate of 53 K 610000 8188000 and a bottom right coordinate of 53 K 620000 8176000. This database was accessed on 19/4/11 (NRETAS 2011);
- A search of the NT National Resource Management (NRM) Infonet site for environmental data, including species lists, was conducted for the McArthur River area using the coordinates 16⁰22' to 16⁰28' and 136⁰01' to 136⁰09' which represents an area of about 178 sq km surrounding the mine. This database was accessed on 14/6/11 (NRM 2011); and
- A search using the Commonwealth Government's EPBC Protected Matters Search Tool for the block surrounding McArthur River Mine (coordinates 136.03008 -16.38679, 136.12371 - 16.38631, 136.12433 -16.49477, 136.03065 -16.49526, 136.03008 -16.38679) was conducted for the potential presence of EPBC-listed threatened species (DSEWPC 2011a).

The NT Fauna Atlas search returned fauna records for 19 amphibian, 39 reptile, 139 bird and 18 mammal species (Appendix A). These records are for a wide area around the mine site and it is likely that many of these species do not occur on habitats within the Project area. These records come from NT Museum specimens, as well as Atlas records from private and Government surveys in the area. It is likely that many of these records are duplicated from surveys previously conducted as part of EIS investigations at the mine. The search results include detailed location coordinates for each species record, and the conservation status (NT and Commonwealth) for each species. From these data, locations of listed threatened or migratory species sightings within or near the Project area were extracted.

The NT NRM Infonet database includes data from nearby blocks so the search results actually cover a greater area than that specified in the coordinates. The search results indicated a total of one fish, 24 frogs, 80 reptiles, 245 birds and 33 mammals in the region, although many of these species would not be expected in the McArthur River area due to habitat limitations. The report also identified 16 species regarded as threatened under NT or Commonwealth legislation as potentially occurring in the region.

The EPBC Protected Matters Search Tool results indicated six threatened and 14 migratory species listed under the *EPBC Act* as having potential to occur within the area. Threatened and migratory species known or potentially occurring in the area are discussed in Sections 3.5 and 4.5.

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3.2 Previous Studies

Existing reports and publications on the fauna of the McArthur River were acquired and reviewed. The combined dataset from these records was compiled into an overall species list for the site. Where records were directly applicable to the proposed project, these were highlighted for high relevance. These included records from areas within or in close proximity to areas affected by the proposed project, and also records from areas with identical habitat to those in the proposed expansion project area. All sites previously sampled for fauna or aquatic ecology on or near the proposed expansion area were identified and mapped, and the level of search effort recorded. Due to limitations in some reporting, it was not always possible to identify species recorded from some sites.

Fauna surveys have been conducted in and around the MRM area on numerous occasions since the 1970's. These surveys broadly fall into two categories:

- surveys conducted specifically to support environmental management of the mining operations, such as for EIA investigations; and
- surveys conducted by Government or private groups for purposes other than mining related assessment.

A series of wide-ranging surveys for terrestrial fauna in the Lower McArthur River Region were conducted by CSIRO during the 1970s (CSIRO 1976). These studies were financed by Mount Isa Mines, but were not limited to the mining lease area, ranging across many areas of the Borroloola region. The study contains historical data but site-specific records are not identified in the final report.

General surveys of terrestrial fauna were conducted in the mine project area for the original Draft Environmental Impact Statement during 1992 (Hollingsworth Dames & Moore 1992a); and again for the Phase 2 expansion project EIS in 2005 (URS/MRM 2005). Terrestrial fauna surveys were undertaken in December 2002 and April 2003 as part of the 2005 EIS. These surveys focussed on assessing areas not well covered by the previous fauna studies, especially the McArthur River proposed realignment, the open pit area and the overburden emplacement facility area. Some additional surveys were also conducted as part of the subsequent PER required after the 2005 EIS failed initial approval. These surveys covered all areas of the Project, including parts of the Project area subject to the MRM Phase 3 Development Project.

Surveys were also conducted in the Glyde River area to provide data for a previously proposed weir. Although the weir is no longer proposed, the data are still presented as they provide information on the broader project region

Following NT Government recommendations arising from the 1992 EIS, an additional fauna study of the project area and surrounds was conducted (Ecostudy 1992). This was originally meant to be an ongoing project, but actually only a single survey was undertaken. A frog survey of the mine site area was also conducted in 1992 (Tyler 1992).

Following on from commitments made in the 2005 Phase 2 EIS, Xstrata initiated studies into setting up a biodiversity offset program to compensate for the irreversible environmental effects of the mining operation. The program involved identification of several candidate sites on McArthur River Station, with a preferred option (the Glyde/Lower McArthur) eventually being settled upon (Xstrata Zinc 2011). The proposal for this project has been submitted to the NT Government and is currently under review. As part of this work, field surveys were conducted in the Glyde River area for threatened species (freshwater sawfish and Carpentarian grasswren) with additional observations also being recorded.

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Non mining-related surveys of the area have mainly targeted threatened species, particularly the Carpentarian grasswren (*Amytornis dorotheae*), which is classified under the *TPWC Act* as Endangered. The type locality for this species is the Glyde River, near the mine, and for many years up to the late 1980's, it was regularly visited by birdwatchers. This area was surveyed for the grasswren in 1986 through an NT Government consultancy (Martin & McKean 1986), and is believed to be the last time the species has been recorded in that area. Sites in the MRM region have been surveyed for grasswrens in 2005 as part of a Masters study (Perry 2005; Perry *et al.* 2011), in 2007 as part of the biodiversity offsets program (URS 2007a) and in 2008-2009 by Birds Australia (Harrington *et al.* 2009), but the species was not detected in the area during these surveys.

Many of the previous studies report observations made at sites impacted by the proposed Phase 3 expansion, or in nearby areas of identical habitat. These include the following studies:

- Hollingsworth Dames & Moore (1992) – two sites sampled along McArthur River upstream of pit in expansion area;
- Dames & Moore (2003) – two sites (F6 and F7) in area of original OEF; two sites (F4 and F5) along McArthur River in existing pit area; general observations in TSF area;
- Ecostudy – two sites in TSF area; one site in river upstream of expansion area; and
- NT Fauna Atlas returned records for threatened species: Australian bustard, Mertens' water monitor, yellow-spotted monitor and Carpentarian grasswren in areas on or close to the expansion areas. It is expected that some of these localities are in error.

A full list of species, comprising 258 species recorded to date, was included in the Phase II EIS (URS/MRM 2005a). Many of these species however occur in habitats which will remain undisturbed by the project, particularly the sandstone ranges and plateaux east of the development.

In addition to these surveys and reporting, Mr. Paul Barden (EMS) has maintained a database of formal and incidental fauna observations around the McArthur River site since 2003 over the course of many surveys including the 2005 EIS, 2006 PER, 2007 grasswren survey, and the 2006-2011 riparian bird monitoring surveys. These database records have been extracted for this review and are included in Appendix A. Staff at McArthur River Mine also maintained bird records for the area between 1999 and 2002.

3.3 Riparian Bird Monitoring Program

This section describes the recent and ongoing terrestrial fauna field investigations undertaken at McArthur River in response to recommendations by the NT Government in its approval of the 2006 PER for the Phase 2 Expansion of the mine, and commitments undertaken by Xstrata as part of that process (EMS 2008; 2009a; 2010a; 2010b).

As a component of approvals for the diversion of the McArthur River, a commitment was included in the Public Environmental Report (PER) and Mine Management Plan (MMP) to conduct a riparian bird monitoring program. The objective of the program was to monitor riparian birds in the vicinity of the Project area and to assess the progress of rehabilitation works in the vicinity of the rechanneling works for Barney Creek and the McArthur River. A key requirement of the expansion approval was the restoration of a functioning riparian corridor that can provide for the dispersal and movement of riparian birds and other wildlife between habitats up and downstream of the diversion. The monitoring program focused on riparian birds and in particular on two key riparian indicator species, the buff-sided robin (*Poecilodryas cerviniventris*) and the purple-crowned fairy-wren (*Malurus coronatus*

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macgillivrayi). These species were chosen as indicators due their known strong habitat association with riparian forest and woodland habitats. Buff-sided robin is listed under the *TPWC Act* as “Near Threatened” while purple-crowned fairy-wren is listed (in error – see Section 3.5.1) as Vulnerable.

3.3.1 Study Approach

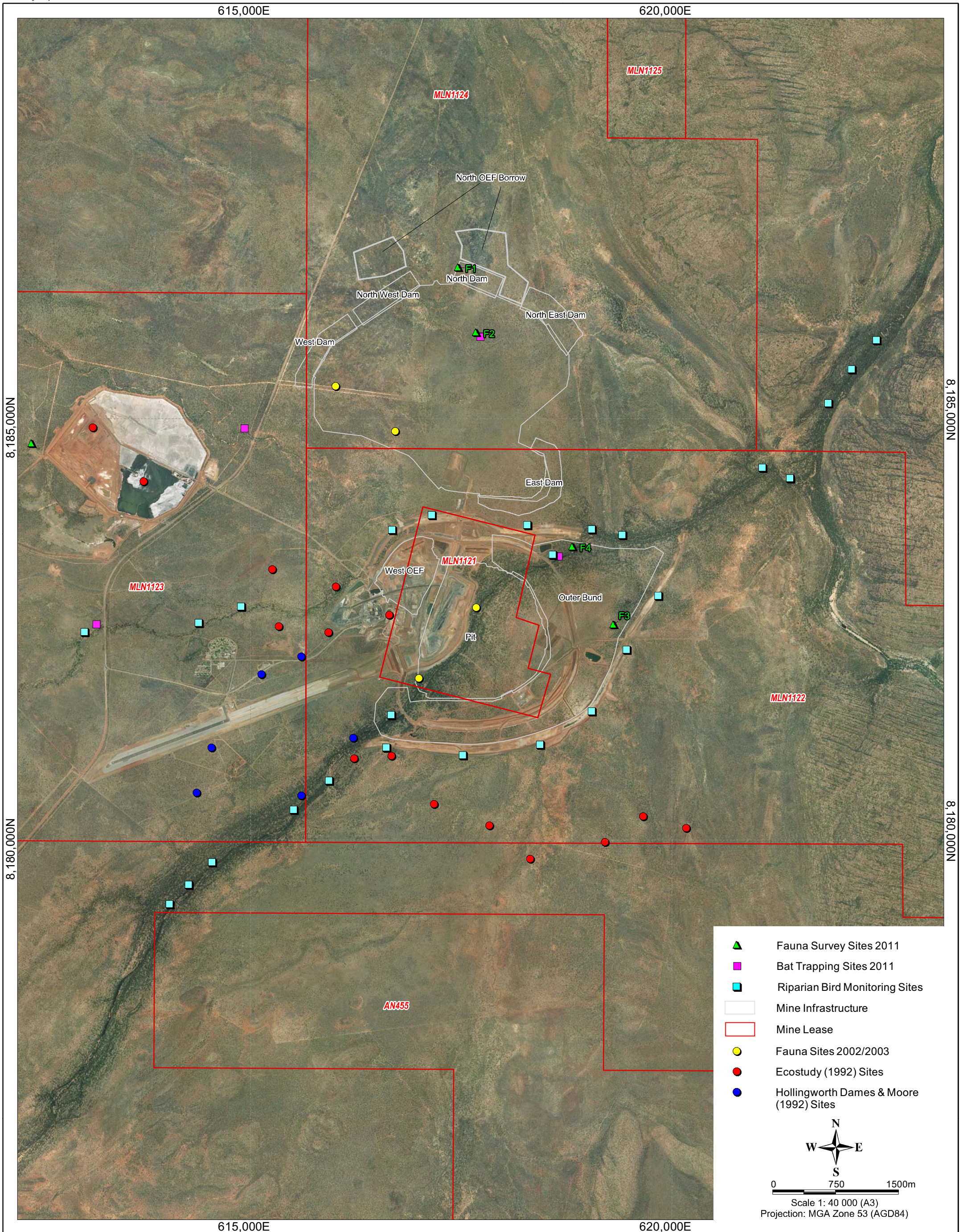
The riparian bird monitoring program commenced in 2006 and included bi-annual sampling conducted in the late wet season/early dry season and late dry season. Each seasonal sample included:

- seasonal monitoring of riparian bird communities at the sample sites established during the late dry season 2006;
- assessment of seasonal changes in the abundance and distribution of the riparian bird assemblage and riparian habitat specialist species;
- supplementary colour banding of riparian birds and riparian indicator species; and
- assessment of movements of colour banded birds during seasonal riparian bird monitoring.

3.3.2 Study Area and Sample Sites

Twenty six riparian bird monitoring sites were established in November 2006 on the McArthur River, McArthur River diversion and Barney Creek. Each site included a lower bank (riverine/stream corridor) and adjacent higher bank (floodplain) plot area to sample riparian forest/woodland and adjacent riparian woodland/low open woodland habitat (56 survey plots). During the course of the monitoring program a number of sites have been added or relocated due to refinement of the monitoring methodology and to accommodate on-going clearing and mining activities within the study area. The following monitoring sites have been established (Figure 3-1):

- Riparian vegetation on the McArthur River upstream of the open cut pit and river re-alignment (5 sites, 10 survey plots);
- Riparian vegetation on the McArthur River downstream of the open cut pit and river re-alignment (5 sites, 10 survey plots);
- Riparian vegetation on the McArthur River between the inlet and outlet and adjacent to or within the bunds protecting the open cut pit (6 sites, 12 survey plots). These sites may have been impacted by the diversion of water from the existing McArthur River channel and the proximity of mining activity. An additional site (PIT6) was added in April 2008 due to the loss of an existing site (PIT2) as construction activities progressed;
- McArthur River diversion channel (rehabilitation or riparian restoration area) (6 sites, 12 survey plots). These sites represent a restoration treatment within the McArthur River re-alignment where the restoration of the riparian corridor is to be undertaken. Monitoring of higher bank reference survey plots was commenced in April 2007 (6 survey plots); and
- Barney Creek riparian corridor and re-alignment. Three sites (6 survey plots) are located on Barney Creek upstream of the re-alignment (reference) and three sites (6 survey plots) are located on the re-alignment of Barney Creek (riparian restoration). Monitoring of higher bank survey plots was commenced in April 2007. Survey sites were re-organised during 2007 following the clearing of vegetation, construction of the bund wall and re-alignment channel. An additional site (BC6) was added in November 2007.



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3.3.3 Methods

Riparian birds were sampled by searching established 100 m x 200 m plots for 20 minutes and recording all birds seen or heard within the designated area. Timed area searches were repeated four times per season in lower bank riparian plots and twice per season in higher bank floodplain plots (total 6 x 20 minute timed area surveys per site per seasonal sample). During each survey standard habitat data were collated at survey plots.

The monitoring commitments for the colour banding component of the riparian bird monitoring program included:

- maintenance of a base population of uniquely colour-banded buff-sided robins and purple-crowned fairy-wrens to enable monitoring of bird movements and home range areas;
- conducting of treatment colour banding of additional riparian bird species to enable assessment of movements of these birds between banding sites and other areas;
- continuation of seasonal monitoring of riparian bird communities incorporating observations/re-sightings of colour banded birds; and
- identification of relevant information relating to seasonal or other movements of colour banded riparian birds, home range areas and habitat associations of riparian indicator species.

3.3.4 Results

Since the commencement of riparian bird monitoring in November 2006 ten seasonal surveys of riparian birds have been conducted, incorporating 1,656 20 minute / 2 ha searches across 56 sites, with 55,086 bird observations documented. A total of 141 bird species have been recorded within survey plots, and 172 bird species have been recorded from the wider McArthur River Station riparian habitat and adjacent floodplain habitats in the vicinity of the project area. During the course of the riparian bird monitoring program feedback has been provided to MRM regarding rehabilitation planning, management of riparian fauna, fencing and management of ecological issues within restoration areas. A list of bird species recorded at each site is presented in Appendix B.

During the course of the colour banding component of the project (between August 2007 and June 2011) 200 purple-crowned fairy-wrens have been captured and individually colour marked, with 27 recaptures and 331 re-sighting records. During the same period 33 buff-sided robins have been individually colour marked with 73 re-sightings recorded. Two hundred and thirty one birds of other species have been captured and banded during the program.

A number of changes in the composition and abundance of riparian and woodland bird species have been recorded across the seasonal samples undertaken between November 2006 and May 2010. Some changes are evident in the bird populations present at some rehabilitation sites (e.g. Barney Creek BC5) as regenerating vegetation becomes established. However there is little or no regenerating vegetation present at most sites on the McArthur River diversion and as a consequence bird communities at these sites remain species poor.

Analysis of habitat data indicate that bird species diversity is positively correlated with indicators based on canopy cover, condition and vegetation structure, with higher quality sites as measured by riparian condition supporting higher numbers of bird species. There has been minimal change in species composition over time at many rehabilitation sites and condition scores and other measures of habitat quality remain low.

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Buff-sided robin and purple-crowned fairy-wren have not been detected in core restoration areas during the monitoring period (between 2007 and 2011), and observations of banded birds have not detected any movements up and downstream of the McArthur River diversion. None of the marked purple-crowned fairy-wrens remaining within the pit bund walls have been observed to move out of the pit area into adjacent remnant habitat.

A notable finding of the riparian bird monitoring program is an apparent increase in abundance of purple-crowned fairy-wren within the cattle exclusion fence between the diversion inlet and the southern bund, particularly in higher bank riparian woodland habitat. This increase has occurred concurrent with an expansion of cane grass distribution in this area and suggests that while some cattle are still present in this area the fencing is reducing the overall impact of cattle grazing in the riparian woodland. It is likely that this effect is also occurring within the area below the northern bund and outlet at the downstream end of the diversion. Research at other sites has found that cattle grazing can have a significant impact on purple-crowned fairy-wren abundance, in particular by impacting dense stands of cane grass that are preferred nesting and foraging habitats. The establishment of an expanding population of small birds between the diversion inlet and outlet is highly desirable, as these areas will eventually provide a reservoir of birds that may potentially colonise rehabilitation areas on the McArthur River diversion and Barney Creek diversion as these areas develop suitable habitat.

3.4 Fauna Survey of Expansion Areas 2011

3.4.1 Study Approach

Results from the literature review were used in the design of a new field investigation. Large amounts of existing data were available; much of the existing data were current and related directly to locations within or adjacent to the Project area, and much of the area was already in a disturbed state. For these reasons, it was concluded that primary data collection was generally not required to the same level as a 'greenfield' site where no previous baseline data existed. The objectives of the field investigation were to:

- collect primary quantitative data only from sites/habitats where previous surveys were under-represented, or using methods not previously applied;
- collect primary observational data from areas directly affected by the Project;
- undertake semi-quantitative visual inspection of sites and habitats in the proposed expansion areas to identify and understand potential impacts from the project and to develop management strategies; and
- undertake targeted surveys to identify the presence of any threatened species and their occurrence in the proposed expansion area.

3.4.2 Habitats

Habitats within the Project expansion areas were described through reference to existing vegetation and soils data (URS/MRM 2005) and descriptions based on field observations and pro-forma data sheets completed at each of the sample sites.

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Northern OEF

The northern OEF area is a generally flat cracking soil plain dominated primarily by lowland woodland communities. Vegetation is dominated by *Bauhinia cunninghamii* and *Eucalyptus microtheca* with *Excoecaria parvifolia* along the stream lines. There is a sparse mid stratum, and an understory of grasses, including spinifex. In some areas, treeless grasslands predominate. A small ephemeral stream line drains the area to the north. This stream line offers refuge to fauna, especially frogs, and the drying pools present in some areas attract nomadic birds such as finches. There are few tall trees suitable as denning sites or for hollow-nesting bird species. The ground cover is generally sparse, with fallen branches and termitaria providing the only cover for terrestrial fauna. Generally, terrestrial fauna in this area would rely on burrows along the stream lines or cracks in the soil for refuge sites. Parts of this area have been largely excluded from cattle due to fencing. In fenced areas, the native grass understory is prolific and grassland bird species are common.

Pit and Eastern OEF

The pit and eastern OEF area outside the bund has a high diversity of fauna habitats. The old channel of the McArthur River is still extant in this area and is still a functioning riparian system. This is a riparian corridor of woodland to open forest dominated by *Melaleuca argentea* and *Casuarina cunninghamii*, with a fringing band of *Barringtonia acutangula* along the water's edge. At the time of the survey, water was present along the channel, offering habitat for aquatic fauna such as turtles, crocodiles and frogs. The tall riparian vegetation offers refuge, feeding and nesting habitat for a range of bird species such as parrots and honeyeaters, and for more specialised species such as white-browed robin.

A riverine woodland community still occurs either side of the old river bed along the high banks. Ground cover is generally dense, either with cane grass. Exclusion of cattle in this area has meant expansion in native cane grass cover in most areas. This has benefited many species including purple-crowned fairy-wren.

The remainder of this area is a coolabah-dominated lowland woodland community. This area is subject to seasonal flooding which has probably increased due to the river diversion redirecting flows. There was evidence during the field surveys that most of this area had been inundated by between 4 and 20 m of floodwaters during the 2011 wet season. In areas adjacent to the diversion, significant sand deposition had smothered vegetation up to 200 m inland of the channel.

Two small rock outcrops are present in this area. They both rise about 25 m above the surrounding areas. These outcrops are sparsely vegetated, with a few individual *Ficus* spp. established on them. These outcrops provide refuge for terrestrial fauna in flood conditions, but are probably too small to support any specialist rock-dwelling species.

Tailings Storage Facility

This area is a low-lying plain of lowland woodland communities dominated by *Corymbia terminalis* and *Eucalyptus chlorophylla*. Much of this area is seasonally inundated, particularly as the existing tailings facility and a new bund to the west restrict water flow. This has created an artificial wetland in the area of the proposed TSF expansion.

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3.4.3 Sampling Sites

Four systematic survey sites were sampled within the study area, including two sites in the proposed OEF expansion area and two sites in the eastern OEF (outer bund) expansion area. An additional site in the TSF expansion area was sampled opportunistically both day and night, and using remote bat echolocation detection. Locations of the sampling sites are shown in Figure 3-1.

3.4.4 Survey Methods

The fauna survey incorporating the main vertebrate fauna trapping program was undertaken between 30 May and 6 June 2011. Other survey components, including site inspections, incidental observations and remote bat echolocation detection, were undertaken between 30 May and 23 June 2011.

Standard biological survey techniques were used during field surveys, including a number of live capture/release trapping techniques, standard and general observational (birds and mammals), habitat searches (reptiles and amphibians), as well as methods to indirectly detect the presence of terrestrial fauna. The survey focussed on terrestrial vertebrate taxa. Fauna surveys were conducted under NT Parks and Wildlife Permit No. 33658 and CDU Animal Ethics Clearance No. A06025.

Fauna sampling at standard sites complied with the standard methodology for inventory and monitoring as outlined by the NT Government (DIPE 2002). The basic unit for each standard site is a 50 x 50 m trapping quadrat. Observational surveys and searches (e.g. reptile searches, bird surveys) were conducted within a one ha search area centred on the trapping grid. At each site, frogs, reptiles, birds and mammals present were recorded, using a combination of trapping, observational survey and search techniques. A number of additional sampling methods were also used, including hair tubes, funnel traps, remote overnight ultrasonic bat detection, remote cameras and remote audio recordings.

Additional surveys were conducted outside the main standard fauna sites to assess the presence of threatened fauna species in the wider project area. Habitat data for fauna sites was collected at each site following standard procedure and data forms (DIPE 2002).

At each systematic fauna survey site, the following standard methods were used.

Elliott Trapping for Small Mammals

Twenty-three traps (20 Elliott 'A' type and 3 Elliott 'B' type) were set approximately 8 m apart around the perimeter of the 50 x 50 m quadrat, with five type "A" traps along each side and the type "B" traps on three corners. Traps were baited with a peanut butter, honey and oat mixture and left open for three nights. Traps were checked early each morning and late afternoon.

Wire Cage Trapping

One wire cage trap was set on a corner of each quadrat. Traps were baited with apple and the Elliot trapping mixture and left open for three nights. Traps were checked early each morning and late afternoon.

Pitfall Trapping

Pitfall traps were used to capture frogs, reptile and small mammals. At each site four 20 l pitfall buckets were set along a 10 m drift fence. Pitfall lines were left open for three nights. Traps were checked early each morning and late afternoon/early evening for captures.

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Hair Tubes for Small to Medium-sized Mammals

Five ground-mounted hair tubes (Faunatech) were set approximately 10 m apart along a transect within the trapping quadrat at each site. The hair tubes were baited with a honey, peanut butter and oat mixture and left on site for 16 nights.

Funnel Traps

Two reptile funnel traps were placed along each of the four pit trapping drift fences at each site. The traps were unbaited. They were left active for three days and were checked daily.

Diurnal Bird Counts

Eight 10 minute/1 ha timed area diurnal bird counts were undertaken at each systematic site within representative habitat (80 minutes per site, total 320 minutes across four sites). Timed/area searches involved walking through a habitat area for 10 minutes recording all bird species seen or heard within the broad habitat type. Birds seen adjacent to the sample plot or overflying the site but not using habitats with the plot were recorded as incidental sightings. Bird counts were conducted between dawn and 0900 hours or in the late afternoon (1400 hrs to dusk). Birds observed incidentally during time spent within habitats or sites were recorded as incidental records.

Diurnal Searches

Four 10 minute active diurnal searches were conducted at each systematic site within the one ha plot. Active searching involved recording all individuals (small mammals, reptiles, amphibians) found active or sheltering underneath or within fallen woody debris, rocks, litter and peeling bark. Active searches were undertaken between 0830 and 1400 hours.

Nocturnal Searches

Four 10 minute active nocturnal searches were undertaken at each systematic site within the one ha plot. Active searches involved the use of headlamps and spotlights, and recording all individuals (small mammals, reptiles and amphibians) found active on the ground or in trees, or underneath fallen debris, rocks, litter and peeling bark. Frogs heard calling at each site were also recorded during this time.

Spotlighting Survey and Call Playback

A spotlighting census involved an observer within the study area with a 50 watt spotlight for a total of 40 minutes per systematic site. The spotlight survey was undertaken in the area within and adjacent to the one ha quadrat. The spotlight survey included a two minute broadcast of calls of selected species, including masked owl and barking owl, with a two minute gap between each call to listen for call responses and scan the area with the spotlight.

Ultrasonic Microbat Call Detection

Ultrasonic microbat call detection was used to sample microchiropteran bats. Ultrasonic call detection was conducted at each systematic site for five nights of remote sampling using Anabat CF ZCAIM systems, commencing at dusk with effective sampling for approximately 11.5 hours per night. Additional incidental hand held Anabat recordings were collected during the spotlight survey period at each site (40 minutes per systematic site). Recorded calls were analysed by Paul Barden, Ecological Management Services. Overnight remote sampling was also conducted at the MRM camp (four nights) and two hours of hand-held recordings were compiled at the TSF.

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Remote Camera

A remote camera with a motion and heat trigger activation was placed at each site for a total of five nights. Cameras were placed on trees and the area in front of the camera was baited with standard trap bait.

Harp Trapping for Microbats

Harp traps were used to capture low flying microchiropteran bats. Where suitable sites were available, harp traps were set on systematic sites. However harp trapping was not undertaken at some sites due to an absence of suitable flyways or suitable trapping sites. Harp trapping was undertaken at sites 2 and 4 and traps were also set on Surprise Creek (north of the TSF) and Barney Creek (south of the TSF). Traps were set for six nights at each site for a total of 24 harp trap nights.

Vehicle Spotlighting

Vehicle spotlighting was conducted opportunistically along the margins of the study area and while driving between survey sites at night.

Scat Collection, Tracks and Signs

Searches were conducted for predator and non-predator scats during diurnal searches. Searches for scats suitable for analysis were undertaken during surveys and other time spent on site. Tracks and other signs noted during the survey were inspected and identified.

Remote Audio Recording

A remote audio recorder was set at each systematic site to record birds and nocturnal animals over a three day period. Each recorder was set to record at three time periods each day to cover early morning, early evening and nocturnal sampling periods, including 0630 to 0900 hrs, 1800 to 2000 hrs and 2300 to 2400 hrs.

3.4.5 Results

Overall results from the surveys recorded 10 frogs, 15 reptiles, 20 mammals and 77 bird species within the three main project component areas (Appendix A). These totals include data from both the systematic site surveys, and from general observations through the area. All species recorded during the survey, and the expansion areas of the Project in which they were observed, are listed in Appendix C. Detailed results of the various trapping/observation programs are presented in Appendix D.

Pitfall trapping caught 21 frogs from three species, three skinks from two species, and two small mammals of one species. Funnel trapping caught 15 frogs from four species, five skinks from three species, and a single snake. No captures were made in the Elliot and cage trapping program.

Active searches located 53 frogs from eight species, 20 lizards from three species, and individuals from two snake species. Hair funnels recorded a single species, the dingo (*Canis lupus dingo*), at one site (S3).

201 microchiropteran bats comprising seven species were trapped at four sites across 24 harp trap nights. A large percentage of captures were made on Surprise Creek near the northern TSF margin (183 captures) and the trapping site was in close proximity to a roost site. The most commonly trapped species was the northern cave bat (*Vespadelus caurinus*), while the large-footed Myotis (*Myotis adversus*) and hoary wattled bat (*Chalinolobus nigrogriseus*) were also common. A number of species

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that were trapped during the survey, including the orange leaf-nosed bat (*Rhinonictis aurantia*), northern long-eared bat (*Nyctophilus arnhemensis*) and hoary wattled bat, have not been previously recorded in the vicinity of the mine site.

Nine species of microchiropteran bats were recorded by echolocation call detection using Anabat detectors. Commonly detected species included the northern freetail bat (*Chaerephon jobensis*), northern cave bat, Gould's wattled bat (*Chalinolobus gouldii*) and hoary wattle bat. A number of long-eared bat (*Nyctophilus* sp.) were recorded but these cannot be separated to species using the Anabat system. The inland cave bat (*Vespadelus finlaysoni*) potentially occurs in the local area, however none of the calls detected during the survey fit the known echolocation characteristics of this species.

Seventy-seven bird species were observed within the study area at standard survey sites during the current survey. Nocturnal bird species recorded at systematic sites included the tawny frogmouth (*Podargus strigoides*), spotted nightjar (*Eurostopodus argus*), Australian owlet nightjar (*Aegotheles cristatus*), southern boobook (*Ninox novaeseelandiae*) and barking owl (*Ninox connivens*).

3.5 Species of Conservation Significance

The status of threatened species was assessed with regard to NT and Commonwealth listings under the legislation described in Section 2.

A search of the EPBC Act Protected Matters database identified six threatened species of national conservation significance as being potentially present, or that their habitat is likely to occur, in the Project area. They include three bird species, one mammal species, one reptile species and one fish species. In addition to the Commonwealth listed threatened species, a further 15 migratory species have been identified as potentially occurring in the area. It is important to note that the MNES database has inherent limitations based on the accuracy of geographic data for some matters. In particular, confirmation of the presence of threatened or migratory species at a given site is not possible from the database, as data presented are for potential occurrences of species within a general area, rather than for known occurrences at a specific site. The relative reliability of this database must be borne in mind as species highlighted by this search do not necessarily correlate to an actual observation.

There are no EPBC-listed Threatened Ecological Communities in the Project area.

Lists of threatened species under NT legislation are presented on the NRETAS website: <http://www.nt.gov.au/nreta/wildlife/animals/threatened/specieslist.html>

There is no search tool for NT threatened species, so the list was reviewed with respect to the species lists for McArthur River (Appendix A) to determine likely NT threatened species in the area. Additionally, the NT Fauna Atlas search for the McArthur River area identified three bird and two reptile species of NT conservation significance as present in the area. These records are from actual observations and include locality coordinates.

The NT threatened species list is currently under review and at the time of writing (August 2011), a list of proposed changes has been published for public comment at:

(<http://www.nt.gov.au/nreta/wildlife/animals/threatened/index.html>).

Several of the species known or potentially occurring in the McArthur River area are affected by the proposed changes. While these amendments have no legislative weight at present and may differ

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from the finalised listings, they have been taken into consideration in the following assessment sections.

3.5.1 Threatened Species

An assessment of the complete fauna list recorded in the area against Commonwealth and NT listings (Section 2.1) identified some additional threatened species. Threatened species known or expected in the McArthur River area are listed in Table 3-1. The current status and occurrence of threatened terrestrial fauna species in the McArthur River area is discussed in the following sections. Discussion on aquatic species of conservation significance is provided in Section 4.5. Only species in the three threatened categories (Critically Endangered, Endangered and Vulnerable) have been assessed.

Table 3-1 Threatened species known or potential in the McArthur River area.

Common Name	Scientific Name	TPWC Act Status*+	EPBC Act Status*
Fishes			
freshwater sawfish	<i>Pristis microdon</i>	VU	VU
Reptiles			
Gulf snapping turtle	<i>Elseya lavarackorum</i>	LC	EN
Mertens' water monitor	<i>Varanus mertensi</i>	VU	.
yellow-spotted monitor	<i>Varanus panoptes</i>	VU	.
Birds			
emu	<i>Dromaius novaehollandiae</i>	VU (NT)	.
Australian painted snipe	<i>Rostratula australis</i>	VU	VU
purple-crowned fairy-wren (eastern subsp.)	<i>Malurus coronatus macgillivrayi</i>	VU (NT)	-
grey falcon	<i>Falco hypoleucos</i>	NT (VU)	-
red goshawk	<i>Erythrorhynchus radiatus</i>	VU	VU
Australian bustard	<i>Ardeotis australis</i>	VU LC)	.
masked owl	<i>Tyto novaehollandiae kimberli</i>	VU	VU
Carpentarian grasswren	<i>Amytornis dorotheae</i>	EN	.
Gouldian finch	<i>Erythrura gouldiae</i>	EN (VU)	EN
Mammals			
northern quoll	<i>Dasyurus hallucatus</i>	CR	EN

* V = Vulnerable; EN = Endangered; CR = Critically Endangered; LC = Least Concern; NT = Near Threatened
+ Status in brackets indicates proposed new status under current NT Threatened Species revision.

Carpentarian Grasswren (Amytornis dorotheae)

The Carpentarian grasswren (*TPWC Act* – Endangered; *EPBC Act* – unlisted) inhabits the rugged, spinifex-covered sandstone hills and plateaux of the southern Gulf of Carpentaria. It has been recorded in the region from Nathan River Station (NT) to the Mt. Isa/Gunpowder area of Qld (Lewis 2006). This species was well known from the Glyde River area near McArthur River Mine as this site is the type locality where specimens were first collected in 1914. The species was observed many times at this site up until the mid 1980's (Martin & McKean 1986). Since then, Carpentarian grasswrens

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have been discovered at more accessible locations, and bird observers no longer visit the Glyde River to see this bird. The bird has not been regularly seen in the McArthur River region since the mid 1990's (Perry 2005). Intensive surveys for this species were undertaken in the Glyde River area in 2007 (URS 2007) and the general McArthur River – Borrooloola area in 2009 (Harrington *et al.* 2009) but no observations of this species were recorded. Perry (2005 & 2011) undertook surveys of all previously known Carpentarian grasswren locations in 2005, but also failed to locate the species in the Borrooloola area. The most recent published record of this species in the region was from Caranbirini Waterhole in 2006 (Howes 2006). Based on these recent survey results, the continued survival of this species in the McArthur River area is in doubt. The most likely cause of the decline of this species is cited as uncontrolled burning in the sandstone ranges (Lewis 2006; Perry 2005).

There are two records of this species occurring on or near the northern OEF area. As this site has completely unsuitable habitat for this species, these records are surprising, and are almost certainly erroneous.

The NT Fauna Atlas lists a 1980 record of the Carpentarian grasswren from a locality near Surprise Creek (S16.41855 E136.08119). However, since numerous other species are listed under the exact same coordinates, it is most likely that the observer used a single coordinate for all observations made in the area, rather than the recorded locality being accurate for that species. Unfortunately, this erroneous record has also been mapped on the NT Government's information sheet for its Sites of Conservation Significance for the Borrooloola area (NRETAS 2009).

In 2005, a Charles Darwin University student undertook a Masters project on the Carpentarian grasswren (Perry 2005). In that document (Section 4.5.3), there are two maps which indicate the area covered by the northern OEF to be "high quality Carpentarian grasswren habitat", with an inference that the mine will have a significant impact on this species. This section of the thesis is at odds with the rest of the document in that no supporting data are included. The layout of mine components in these maps is incorrect and statements made about mining impacts are unqualified. The mapped grasswren habitat site is not based on any data presented elsewhere in the study and the boundaries of this habitat polygon are not defined elsewhere in the study. It is unclear if this area was even surveyed in that study. It is also stated in the study that the site is noted by Martin & McKean (1986) to be "excellent" grasswren habitat. However, this site was never surveyed in that study and advice from the senior author of the 1986 study is that the mapped area is unsuitable for Carpentarian grasswrens.

The sandstone and spinifex range habitat to which this species is specialised does not occur on or near any of the Project expansion areas. The closest areas of potential habitat are on the Bukalara Range, several kilometres to the north-east and east of the Project area. Therefore, even if this species persisted in these areas, there is no likelihood of the Project having any impact on these populations.

Gouldian Finch (Erythrura gouldiae)

The Gouldian Finch (*TPWC Act* – Endangered; *EPBC Act* – Endangered; NT proposed revision to Vulnerable) is a small, brightly coloured bird endemic to the savannah landscapes of northern Australia. Once widespread and common, it is now confined to a few widely scattered areas. Gouldian finches occupy two different landscape components. During the dry season and late wet season, they live on wooded hillsides dominated by a group of Eucalypts known as "snappy gums". In the wet season, they move out across lowland drainage areas where they feed on a variety of native grasses. Gouldian finches appear to be threatened by: a parasitic air sac mite; trapping for the bird trade;

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pastoral practices; and most importantly, changing fire regimes (Palmer & Woinarski 2006). There is recent evidence (several sightings in new areas) that Gouldian finch populations have recently stabilised, and may be increasing. For these reasons, the NT Government review of Threatened Species is recommending a status change from Endangered to Vulnerable for this species (NT Government 2011).

There are recent records for this species from the Borroloola area and at Caranbirini Waterhole (NRETAS 2009). Additionally, there is anecdotal evidence from McArthur River mine security workers of Gouldian finch sightings on the Carpentaria Highway near the TSF area during mid 2008. These observations were made by persons familiar with the species and are believed to be genuine. Investigations of these areas later in the 2008 dry season failed to locate any birds, however seeding grasses that were present earlier in the dry season had subsequently been burned and no finches were located. There are also recent records of this species on Pungalina Station, 100 km to the east of McArthur River (AWC 2009).

Given the nomadic nature of this species and the recent observations, there is some likelihood that it could occasionally visit areas covered by The Project. There is no evidence however, that these areas are of importance to this species.

Northern Quoll (Dasyurus hallucatus)

The northern quoll (*TPWC Act* – Critically Endangered; *EPBC Act* – Endangered) is a medium-sized marsupial carnivore. It is distributed across northern Australia, but has been in decline over the past few decades, possibly through the effects of feral cats, disease or changed fire regimes. However, more recently the species has suffered a dramatic decline due to the spread of the cane toad (*Rhinella marina*), as quolls are thought to be particularly vulnerable to toad poisoning (Woinarski 2006b).

There are historical records of this species from the McArthur River area. Scats and dens were found on Barney Hill in 1992 (Ecostudy 1992) and in the Glyde River area in 2002 (URS/MRM 2005). It is not known if these represented recent populations or are old traces. No direct evidence of this species has been recorded in the area since then.

Mertens' Water Monitor (Varanus mertensi)

Mertens' water monitor (*TPWC Act* – Vulnerable; *EPBC Act* – unlisted) is a semi-aquatic species which occurs across tropical Australia. The primary threatened process for this species is due to poisoning from the introduced cane toad. The species has suffered a marked decline in areas where toads have invaded (Ward et al. 2006a).

Mertens' water monitor has been widely reported in the McArthur River area, and is still known to be present despite the cane toad threat. A large specimen was recorded in the TSF area in June 2011 (Plate 3-1).

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Plate 3-1 Merten's water monitor at the TSF expansion area, June 2011.



Yellow-spotted Monitor (Varanus panoptes)

The yellow-spotted monitor (*TPWC Act* – Vulnerable; *EPBC Act* – unlisted) is a large ground-dwelling monitor found across the tropical savannahs of northern Australia. As with Mertens' water monitor, this species is under threat due to poisoning from the introduced cane toad (Ward *et al.* 2006b).

This species has been observed in the area of McArthur River mine on numerous occasions, generally in grassland, floodplain and riparian woodland habitats. It is likely to be present in the northern and eastern OEF and TSF area where suitable habitat exists.

Emu (Dromaius novaehollandiae)

The emu (*TPWC Act* – Vulnerable; *EPBC Act* – unlisted; NT proposed revision to Near Threatened) is a large and well-known flightless bird which is distributed across the entire Australian mainland. There has been a documented decline in this species in the NT, possibly associated with high frequencies of fires (Taylor & Woinarski 2006). The NT Government review of threatened species is recommending a status change from Vulnerable to Near Threatened for this species, based on evidence that the decline has been poorly quantified, and that there are stable populations in central Australia (NT Government 2011).

Based on compiled records (Appendix A), emus are present, but naturally very uncommon in the McArthur River area. Recent observations have been in the area to the east of the McArthur River diversion in open grassland and low open woodland. There may be occasional occurrences on the Project expansion areas, but these sites are not important habitats for this species.

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Australian Painted Snipe (Rostratula australis)

The Australian painted snipe (*TPWC Act* – Vulnerable; *EPBC Act* – Vulnerable) is a wader of around 220 to 250 mm in length. This species is generally inconspicuous, and occurs solitarily or in only small parties. This species generally is more common in eastern Australia, but there are some records from the NT, including the Borroloola area. Australian painted snipe occur in shallow, vegetated, freshwater swamps, claypans or inundated grassland (including temporary wetlands). A decline in this species in the NT has been attributed to cattle grazing (Taylor *et al* 2006).

Despite a significant level of bird survey effort in the McArthur River area since 2006, this species has never been recorded in the area. It is also absent from previous survey records. There is a possibility that this species could occasionally traverse the area. An unidentified snipe was flushed from reeds present on the McArthur River diversion in 2008; however the species could not be determined (P Barden, pers. obs.).

Red Goshawk (Erythrotriorchis radiatus)

The red goshawk (*TPWC Act* – Vulnerable; *EPBC Act* – Vulnerable) is a large, reddish brown species of hawk. It occurs across northern Australia, from Broome in WA, to SE Queensland. Its preferred habitat is tall Eucalyptus forest and riparian forests, such as paperbarks. It builds a conspicuous stick nest in riparian forest usually close to a watercourse. Threatening processes for this species include land clearing for agriculture, illegal egg collecting, shooting and fire (Woinarski 2006b).

There was a “tentative” sighting of this species made in riparian habitat along Barney Creek during a 1992 fauna survey (Ecostudy 1992). However, since that time, no further sightings have been made in the area even though intensive long term monitoring of riparian birds has been undertaken at McArthur River since 2006. It is considered unlikely that this species nests, or is a regular visitor to the McArthur River Mine area.

Australian Bustard (Ardeotis australis)

The Australian bustard (*TPWC Act* – Vulnerable; *EPBC Act* – unlisted; NT proposed revision to Least Concern) is Australia’s heaviest flying bird. It is widespread and generally scarce in the NT but the Barkly Tablelands area is a known stronghold for this species. Bustards typically prefer grassland, low shrubland and low woodland habitats. There have been reported widespread declines in this species throughout its range, possibly due to a variety of factors including predation, altered fire regimes, hunting, disturbance, habitat alteration, pesticides and grazing (Ziembicki 2006). The NT Government review of threatened species is recommending a status change from Vulnerable to Least Concern for this species, based on variability of previous bird atlassing methodologies, and a national review that indicated the population to be relatively stable in northern Australia (NT Government 2011).

Australian bustards are commonly observed around the McArthur River mine area, in all open habitats. They were regularly sighted in all areas of The Project expansion (eg. northern OEF; TFS; Pit and east OEF) during the June 2011 field surveys (Plate 3-2). It is likely that this species has benefitted from the management of the mining area, as cattle exclusion in most areas has meant a return to native grassland habitats, thus favouring local bustard populations.

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Plate 3-2 Australian bustards on the TSF bund wall, June 2011.



Masked Owl (Tyto novaehollandiae kimberli)

The masked owl (*TPWC Act* – Vulnerable; *EPBC Act* – Vulnerable) is a large, dark owl species. The subspecies *kimberli* is distributed across the NT, but there are very few records. This species occurs mainly in tall Eucalyptus forest but also roosts in monsoon rainforest. There is a probability that this species is in decline, with the likely contributing factors being a broad scale reduction in medium sized mammals (the primary prey item) due to changed burning regimes (Woinarski & Ward 2006).

The NT Fauna Atlas contains one record of a masked owl sighting from 1977, about 2 km east of McArthur River mine. Extensive bird surveys in the area since then, including specific call playback for this species, have not yielded any further records. It is considered unlikely that this species is currently present in the area.

Grey Falcon (Falco hypoleucos)

The grey falcon (*TPWC Act* – Near Threatened; *EPBC Act* – unlisted; NT proposed revision to Vulnerable) is sparsely distributed across large areas of arid and semi-arid Australia. A recent national assessment has concluded that the population is fewer than 1000 mature individuals, and therefore the NT Government review of threatened species has recommended that it be placed in the Vulnerable category (NT Government 2011).

This species inhabits inland timbered plains and tree-lined watercourses. Identified threats include overgrazing, habitat loss in marginal farming areas, and loss of large nest trees (Garnett & Crowley 2000). Grey falcons have been observed at McArthur River incidentally during the course of the

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riparian bird monitoring surveys. Sightings have been made at two sites along the McArthur River about 3 km downstream of the mine pit (Appendix B).

Purple-crowned Fairy-wren (eastern subsp) (Malurus coronatus macgillivrayi)

The purple-crowned fairy-wren (eastern subspecies) (*TPWC Act* – Vulnerable; *EPBC Act* – unlisted; NT proposed revision to Near Threatened) is a small, sedentary bird restricted to riverine fringes, creeks and lakes where there are pandanus or paperbark thickets, tall canegrass, or other dense low cover. This subspecies occurs in the southern gulf region of the NT across to adjacent areas of Queensland (Pizzey & Knight 2002). This subspecies has been erroneously classified as Vulnerable under the *TPWC Act* due to the mistaken transposing of another subspecies in the gazettal. This error is proposed for amendment in the NT Government review of threatened species (NT Government 2011) and the status downgraded to Near Threatened.

This species is found along the McArthur River and Barney Creek in the McArthur River Mine area and a monitoring program is in effect (see Section 3.3).

3.5.2 Migratory and Marine Species

Species listed as Migratory or Marine under the *EPBC Act* which occur, or may occur in the MRM area are listed in Table 3-2. There are no data to suggest that the McArthur River Mine area supports important habitat (DEWHA 2009) for any listed migratory or marine species.

Table 3-2 Migratory and Marine Species of the MRM Area.

Common Name	Scientific Name	EPBC Classification	Occurrence in MRM area
great egret	<i>Ardea modesta</i>	Migratory Marine Bird Migratory Wetlands Species Listed Marine Species	Regular visitor in low numbers to wetland and riverine environments.
cattle egret	<i>Ardea ibis</i>	Migratory Marine Bird Migratory Wetlands Species Listed Marine Species	Regular visitor in low numbers in cleared areas around cattle.
Gouldian finch	<i>Erythrura gouldiae</i>	Migratory Terrestrial Species	Refer to Section 3.5.1
white-bellied sea-eagle	<i>Haliaeetus leucogaster</i>	Migratory Terrestrial Species Listed Marine Species	Occasionally forages along McArthur River main channel.
rainbow bee-eater	<i>Merops ornatus</i>	Migratory Terrestrial Species Listed Marine Species	Common aerial species.
buff-sided robin	<i>Poecilodryas cerviniventris</i>	Migratory Terrestrial Species	Refer Section 3.3. Resident in riparian forest along McArthur River.
common sandpiper	<i>Actitis hypoleucos</i>	Migratory Wetlands Species Listed Marine Species	Occasionally present in small numbers in diversion area.
sharp-tailed sandpiper	<i>Calidris acuminata</i>	Migratory Wetlands Species Listed Marine Species	Occasionally present in small numbers in diversion area.

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Common Name	Scientific Name	EPBC Classification	Occurrence in MRM area
marsh sandpiper	<i>Tringa stagnatilis</i>	Migratory Wetlands Species Listed Marine Species	Occasionally present in small numbers in diversion area.
common greenshank	<i>Tringa nebularia</i>	Migratory Wetlands Species Listed Marine Species	Occasionally present in small numbers in diversion area.
Oriental plover	<i>Charadrius veredus</i>	Migratory Wetlands Species Listed Marine Species	Infrequent visitor to marshes and river bank habitats.
Oriental pratincole	<i>Glareola maldivarum</i>	Migratory Wetlands Species Listed Marine Species	Infrequent visitor to open grassy areas.
magpie goose	<i>Anseranas semipalmata</i>	Listed Marine Species	Occasional visitor in small numbers to wetland areas including TSF area
freshwater crocodile	<i>Crocodylus johnstoni</i>	Listed Marine Species	Common along McArthur River and Surprise/Barney Creeks.
estuarine crocodile	<i>Crocodylus porosus</i>	Migratory Marine Species Listed Marine Species	Occasional reports from McArthur River near mine site. Populations in lower McArthur River area.

3.6 Summary of Fauna Investigations

Overall results indicate that a total of approximately 24 frog, 62 reptile, 189 bird and 32 mammal species occur in the McArthur River Mine area (Appendix A). They include three Endangered species, six Vulnerable species, and 15 migratory/marine species. Recent surveys have not recorded any of the Endangered species within areas affected by the Project. However, the Vulnerable species Australian bustard, Mertens' water monitor, yellow-spotted monitor and emu are known to occur in these areas.

Results of the field verification surveys conducted in 2011 and described in Section 3.4 show that even now, species previously undetected in the area are being found, as the 2011 survey recorded one reptile and five mammal species not previously reported.

A breakdown of species recorded in each of the three major expansion area component sites is shown in Appendix C. A total of 89 vertebrate species were observed in the northern OEF areas, 75 species in the eastern OEF area and 59 in the TSF area. These figures are however not directly comparable due to differences in search effort, especially in the TSF area where no systematic trapping was undertaken. The figures do however reflect fewer ground dwelling vertebrates in the eastern OEF area compared to the northern OEF area. The eastern OEF area is subject to regular and significant flooding, and ground mammals and reptiles are generally unable to establish permanent populations because of this. The eastern OEF had good populations of frogs (refer Appendix D) due to moist conditions created by the dense shading and proximity of permanent water. However, ground dwelling small mammals were absent, and reptiles were generally represented by semi-aquatic species or arboreal species such as lizards of the genera *Gehyra* and *Cryptoblepharus*.

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A number of feral or domestic animals are present in the area. These include the cane toad (*Rhinella marina*), and mammal species such as donkey, pig and cattle. The latter species is present due to the area being an active cattle station.

Environmental conditions in the three main project component areas are generally good although their close proximity to mining areas has presented some disturbances, including clearing for tracks and infrastructure, noise and dust, and some evidence of leachate in drainage lines near the OEF areas.

Cattle exclusion fencing in the northern and eastern OEF areas has generally improved wildlife habitat. Although the fencing program has not entirely excluded cattle from these areas, numbers present are low enough to cause minimal impact and regrowth of native grasses has expanded. In the low woodland areas of the northern OEF, this has led to enhanced grassland habitat ideal for species such as the Vulnerable Australian bustard. In the pit and eastern OEF areas the expansion of cane grass habitat due to cattle exclusion has resulted in increased habitat availability for the purple-crowned fairy wren, a species that represents an important indicator of riparian habitat quality.

Habitats in the eastern OEF area are by far the most complex and diverse of any of the proposed expansion areas. This area has riverine/aquatic habitats, tall riparian forest, upper bank habitats, floodplains and small rocky outcrops. The existing riparian forest along the old McArthur River channel and Barney Creek is still in an intact condition and still a functioning ecosystem. It provides roosting, feeding and refuge habitat for a range of species.

A number of bat roost sites have been detected within the broader Project area during current and previous surveys, including sites within road culverts and bridges, sandstone caves and crevices in the nearby Bukalara Range, and in large riparian trees (mainly river redgum *Eucalyptus camaldulensis*) on the McArthur River channel. In some cases the latter sites support colonies of 200 to 300 bats and at least one long term colony of northern freetail bats (*Chaerephon jobensis*) is present within a large river redgum on the old McArthur River channel within the eastern OEF component of the project area.

Aquatic Ecology

This section describes the current field monitoring investigations undertaken at McArthur River in response to recommendations by the NT Government in its approval of the 2006 PER for the Phase 2 Expansion, and commitments undertaken by Xstrata as part of that process. These studies are ongoing and data collected are current. As such, no additional studies specific to the Phase 3 Development Project were required.

4.1 Previous Studies

4.1.1 Database Searches

Results of the database searches described in Section 3.1 returned one fish record, two crocodile records and one turtle record. All of these species are well documented in the McArthur River area from previous and current studies.

4.1.2 Fishes

Aquatic surveys of the McArthur River area were first initiated by Mount Isa Mines, who commissioned a study of the aquatic fauna (mainly fishes) of the river near the mine site in 1975 (Midgley 1975). Additional fish surveys were also carried out in the region, including the McArthur and adjacent streams by H. Midgley, a private consultant under contract to the NT Government (Midgley 1982; 1994).

General surveys of aquatic fauna (fish and macroinvertebrates) were conducted in the mine project area for the original Draft Environmental Impact Statement during 1992 (Hollingsworth Dames & Moore, 1992a); and again for the Phase 2 expansion project EIS in 2005 (URS/MRM 2005). An NT Museum survey of the fishes and macroinvertebrates of Barney and Surprise Creeks was undertaken in 1993 (Hanley 1993).

A commitment of the 2006 PER was to undertake a more complete survey of the aquatic fauna of the McArthur River area, with particular reference to freshwater sawfish (*Pristis microdon*) populations. This survey was completed in 2006 (RPS, Bowman, Bishaw & Gorham 2006). Additional aquatic studies have included: preparation of a sawfish management plan (Indo-Pacific Environmental 2009b); investigation of the Glyde River area for suitability as a potential biodiversity offset (Indo-Pacific Environmental 2007b); and investigation of metals and lead isotopes in fishes (Indo-Pacific Environmental 2009d).

These surveys have yielded a total of 47 fish species recorded from freshwaters of the McArthur River, including tidal freshwaters downstream of the mine. Of these, 27 are considered freshwater species (i.e. breed in freshwater) and 20 species can be regarded as estuarine vagrants (Appendix E).

Subsequent to these surveys, regular semi-annual monitoring of fishes has been undertaken and is ongoing (Indo-Pacific Environmental 2006a, 2007; 2008; 2009a; 2009b; 2010a and 2010b). The results of these ongoing studies are summarised in Section 4.2.

4.1.3 Aquatic Reptiles

Aquatic reptiles have not been formally recorded as part of the monitoring program to date. However, researchers conducting the surveys have informally recorded two crocodile species, three freshwater turtles and one file snake as occurring in the McArthur and Glyde systems (Table 4-1). Data on

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aquatic reptiles captured during the biannual surveys of fishes has been collected since 2010 (Indo-Pacific Environmental 2010b).

Table 4-1 Aquatic Reptiles of the McArthur and Glyde Rivers

Common Name	Scientific Name
freshwater crocodile	<i>Crocodylus johnsoni</i>
estuarine crocodile	<i>Crocodylus porosus</i>
Worrell's turtle	<i>Emydura worrelli</i>
snapping turtle	<i>Elseya</i> sp.
northern longneck turtle	<i>Chelodina rugosa</i>
Arafura file snake	<i>Acrochordus arafurae</i>

4.1.4 Macroinvertebrates

A number of studies have documented the macroinvertebrates of the McArthur River in sampling associated with the development of the McArthur River Mine. Pre-mine and establishment phase surveys were commenced by Midgley (1975), with aquatic surveys throughout the McArthur and Glyde River systems, including sites within and downstream of the current project area. These surveys focussed on freshwater fishes but include records of molluscs and crustacean species. Dames & Moore (1977) completed a study of the freshwater biota of the McArthur River system, sampling a total of eleven sites throughout the catchment, including areas upstream and downstream of the mine lease, Barney Creek, and the Glyde River. Hollingsworth Dames & Moore (1992) sampled four aquatic sites in the vicinity of the McArthur River Mine site, including the McArthur River, and Surprise and Barney creeks. Macroinvertebrates, crustaceans and molluscs were sampled as a component of these surveys. Hanley (1993) sampled freshwater fishes and macroinvertebrates at sites on Barney and Surprise creeks within the project area.

During assessments for the proposed expansion of the MRM (2002-2003) 12 additional macroinvertebrate sites were sampled on the main McArthur River channel and on the Glyde River for the expansion EIS URS/MRM (2005). Subsequent surveys were undertaken at a number of sites during the construction of the diversion and open cut bund protection walls, commencing in the late dry season 2008 (Indo-pacific environmental 2008). These surveys followed AUSRIVAS sampling protocols and included five sites on the main channel of the McArthur River (Indo-pacific Environmental 2008).

Monitoring of macroinvertebrates in the MRM area is continuing (eg. EMS 2009) and is summarised in Section 4.4.

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4.2 Fish Monitoring Program

4.2.1 Study Approach

In 2006 an ongoing program to monitor fish populations in the McArthur River was initiated as part of the regulatory requirements for the conversion of mining operations from underground to open cut which included the diversion of the McArthur River proper. The objectives of the program, which were outlined in the project PER aimed to monitor:

- fish populations in permanent and semi-permanent pools;
- populations of the freshwater sawfish, a Vulnerable species;
- fish diversity in temporary or semi-permanent pools and riffles;
- heavy metal levels in aquatic biota; and
- fish passage success through the diversion channel by:
 - implementing a tagging program of key fish species;
 - assessing temporal migration patterns of the fishes within the river and determining habitat associations and the utilisation of the diversion; and
 - sampling of key sites within the diversion as well as both upstream and downstream.

The biannual sampling regime of the monitoring program has been modified since 2006 to address new questions raised on the functionality of the diversion and as rehabilitation of the aquatic habitat in the diversion has occurred. Since 2009 a greater sampling effort has aimed to investigate:

- the suitability of the aquatic habitat in the diversion for fishes by comparing the suite of species present in the diversion to that occurring in naturally vegetated reaches immediately above and below;
- the use of the diversion as a thoroughfare for fishes through additional netting and expansion of the existing tagging program; and
- the effectiveness of large woody debris piles placed in the diversion in April 2010 as habitat for fishes.

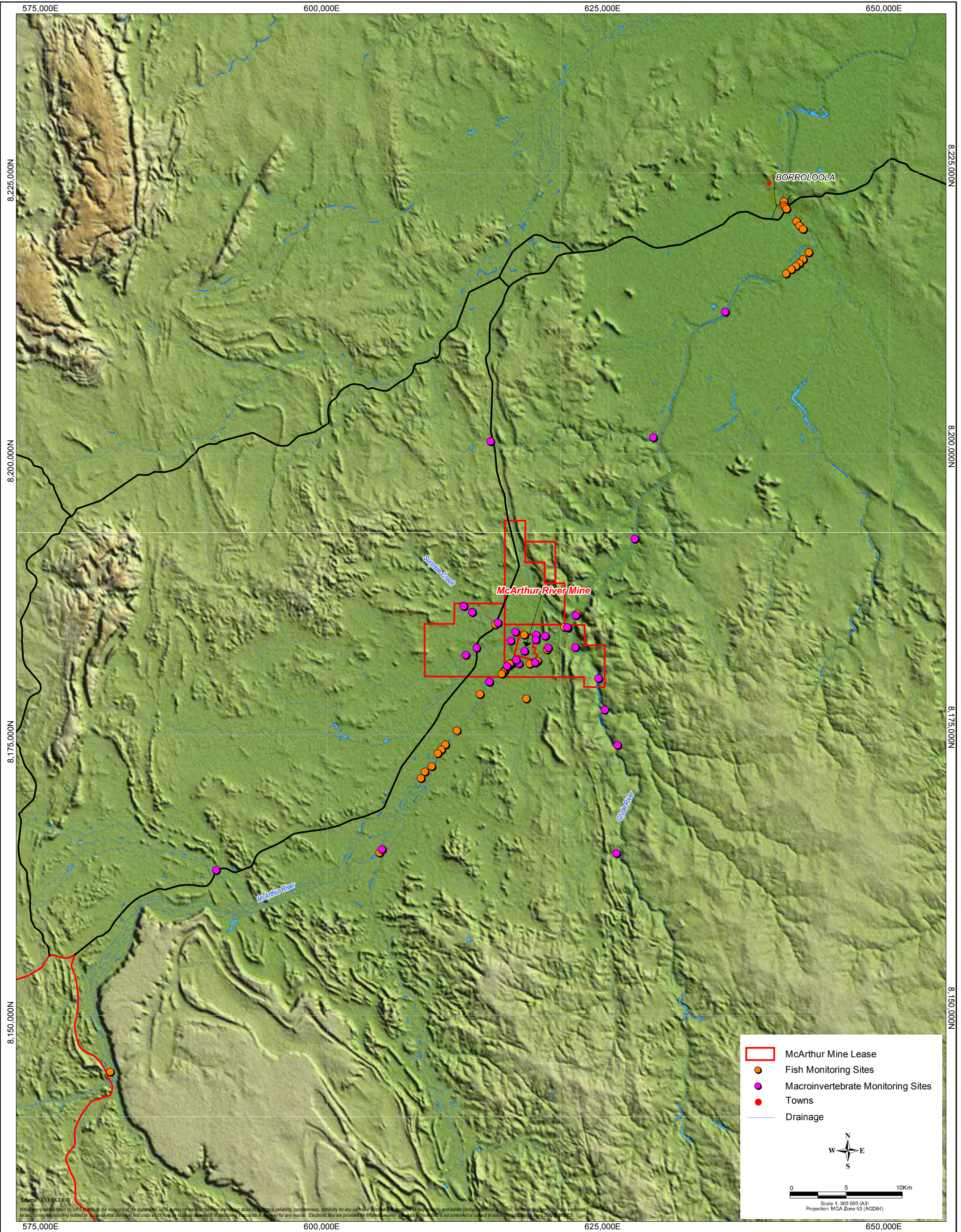
4.2.2 Study Area and Sample Sites

The McArthur River in the vicinity of the MRM and upstream has a well-defined main channel with moderate riparian vegetation, a low number of major tributaries and very few permanent lowland swamps. While some spring feeding is known to occur, the availability of aquatic habitat in the McArthur River is season driven with the main channel remaining connected throughout the year only after large wet seasons. In particularly dry years the river in the vicinity of the mine exists as a series of disconnected pools separated by large sections of dry bed. Remnant pools present in the dry season subsequently represent important refugia for fishes and in close proximity of the mine include Djirrinmini, Cattleyard and Eight Mile waterholes. A large volume of permanent water also remains in the Glyde River (its confluence with the McArthur River is approximately 2 km south of the mine) throughout the year due to the presence of extensive deep gorges. Similar to the McArthur River, flow will cease in the late dry season in dry years. Several large pools occur further upstream including Bessie Springs on the McArthur River and in the Kilgour River, a large tributary which feeds into the McArthur River approximately 25 km upstream of the mine. In recent years, the intrusion of

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groundwater into the diversion has led to the creation of additional aquatic habitat that persists throughout the year.

Fish survey sites selected for the monitoring program were identified at those locations where water was likely to remain throughout the year and where access to the river was available. Annual survey sites include those as far upstream as Bessie Springs and as far downstream as below Burketown Crossing (Figure 4-1) and include main channel and tributary sites (in particular Surprise and Barney Creeks). Several sites have also been surveyed for fishes in Glyde River as part of an investigation into its suitability as a biodiversity offset in 2007 (Indo-Pacific Environmental 2007b). The implementation of the “Sampling Procedure for Metal and Lead Isotope Analysis in Fishes and Macro-invertebrates” (Indo-Pacific Environmental 2009e) in 2009 has also led to fishes being monitored further upstream at Top Crossing, about 60 km upstream of the mine.



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4.2.3 Methods

Sampling for fishes occurs annually in the early dry (as soon as sites become accessible after the wet season) and late dry seasons. Fish community structure in the McArthur River is examined using a variety of methods, which includes fyke, seine and gill nets and electrofishing equipment. Visual survey and line fishing techniques are also utilised. The sampling equipment used and the methods of their use aims to avoid mortality of fishes at all times.

Fyke (migration) nets are one of the techniques used to monitor the movement of fishes through the diversion and additionally compare the diversity of fishes present in the diversion to those occurring in naturally vegetated stretches immediately up and down stream. Sampling generally occurs at three sites within the river diversion and at two sites above and below the diversion in each season. Fyke nets are a funnelling net with two nets being deployed at each sampling site, one facing upstream and the other downstream. The mouth of the net is held open by a rigid aluminium frame, which was secured to the bottom with the use of a star picket. The wings of each net are then strung to the nearest bank or held in place with a picket driven into the bed, with this arrangement acting to channel fish into the mouth of the net. As fishes move into the funnel, suspended screens prevent fishes exiting the nets. In order to minimise the risk of drowning amphibians and aquatic reptiles the end of the net (the bunt) is tied up above the water line. Fyke nets are set at each site for three consecutive nights, being checked early each morning with the number and length of fishes recorded prior to release.

Electrofishing is also conducted at the majority of fyke net sites to ensure that the full suite of species present in that locality are accounted for. This sampling tool is also used to sample fishes occurring in large woody debris piles in placed in the diversion for comparison to the fishes occurring on bare bank and for the collection of samples for metal analysis. Electrofishing is conducted using a Smith Root LR-24 backpack electrofisher and a small scoop net. Transects of variable but known length are electrofished at each sampling site and a fish per metre abundance calculated. Stunned fish are kept, allowed to revive in an aerated tub of freshly-collected water prior to being identified, measured and released.

Gill nets are utilised at long-term monitoring sites, including below and above the Burketown Crossing, Djirrinmini Waterhole, and Eight Mile Waterhole, with the aim of assessing the distribution of *Pristis microdon* and larger bony fishes. Gill nets were utilised in Bessie Spring until 2009, however the consistency of the fauna observed and distance upstream suggested it was not suitable habitat for *P. microdon*. Gill nets are a maximum of 40 m long, and comprised of two sinking monofilament panels each 20 m long, and of 100 mm and 150 mm stretched mesh, respectively. Gill nets are generally utilised during daylight hours as most gill net sampling sites a) are remote, b) have large on-water transiting distances with numerous in-water hazards, c) are inhabited by both estuarine and freshwater crocodiles, which are more active and thus captured more frequently at night, and/or d) by-catch mortality is increased at night.

The tagging of bony fishes has been conducted since 2007. The main aim of the tagging program is to investigate the passage of fishes through the diversion, with a number of species being tagged. Several MRM employees residing in the township of Borroloola have additionally been trained in tagging procedures and have been provided with tagging kits for use on barramundi *Lates calcarifer*. All tagged fish are entered into a tagging database maintained by MRM. Fish are tagged with individually numbered 40 mm (PDX) or 100 mm (PDS) dart tags (Hallprint fish tags) depending on size

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which are dull in colour to reduce the likelihood of detection by predatory species. Tags are generally placed near the origin of the second dorsal fin. In 2010 the MRM tagging program partnered with a recently initiated tagging program in the lower reaches of the McArthur River coordinated by Infofish as part of a population assessment of barramundi.

In the case of cartilaginous fish, such as *Pristis microdon* and *Carcharhinus leucas*, a cattle style tag, supplied by the NT Government Department of Resources – Fisheries, is placed in the dorsal fin of captured individuals prior to release. Each tag carries an individual number and contact details for Fisheries. Information such as capture locations, size and sex of individuals tagged is forwarded to Fisheries and contribute to the NT Shark Tagging Program. A genetic sample (small amount of tissue removed from the fin prior to applying the tag) is also preserved in DMSO (Dimethyl sulfoxide) and forwarded to NT Fisheries for inclusion in their database.

4.2.4 Results

A total of 47 species of fish have been recorded from freshwaters of the McArthur River. Thirty two species of fish have been recorded from non-tidal waters, with the additional 15 species known from tidally influenced freshwaters in the vicinity of Burketown Crossing (Appendix E). Twenty seven species of fish are considered to be freshwater species, i.e. capable of breeding in freshwater. Three elasmobranch species have been also been recorded, with *Himantura dalyensis* (formerly known as *H. chaophraya*) and *Carcharhinus leucas* being recorded from tidal and freshwaters, and *P. microdon* which has been captured as far upstream as Eight Mile Waterhole. A total of 28 records (including 19 captures) of freshwater sawfish (*P. microdon*) have been collected between March 2006 and June 2011 (see Section 4.5).

Approximately 1200 fish have been tagged with a PDS or PDX dart tag since 2007. Thirty two recaptures have been recorded with a vast majority (29) being of *Neoarius paucus*. The recaptures of all individual of this species near their site of first capture suggest strong site fidelity occurs. Several of these individuals have been re-captured up to three times over successive years. Three *L. calcarifer* have also been recaptured. Two *L. calcarifer* tagged upstream of MRM were re-captured in later years near the mouth of the McArthur River, indicating movement downstream through the diversion.

Baseline sampling conducted between 2006 and 2008, i.e. prior to the opening of the diversion, indicated *Melanotaenia splendida inornata* to be the most abundant species occurring in the McArthur River during both the early and late dry seasons. *Leiopotherapon unicolor*, *Ambassis maclaeyi*, *Ambassis mulleri*, *Amniataba percoides* and *Glossogobius giurus* were also captured in high abundances between 2006 and 2008. These species were also well represented in the original McArthur River channel designated for realignment, with a total 29 species (21 freshwater) of fish known from that section and waterholes immediately upstream. Statistical comparison of survey site species data over those years indicated a relative stability in the suite of species present within each sample site in each season and year, as well as the occurrence of a comparable suite of species between sample sites in the vicinity of the mine.

In contrast sampling after the opening of the diversion (2009 and 2010) indicated that a depauperate suite of species existed within the diversion channel with both diversity and abundance of fishes being far lower than those present in the original channel (i.e. 17 species of fish in the diversion cf. 29 species prior to realignment) and in naturally vegetated sections above and below the diversion. Of particular interest was the lack of small prey species including *M. splendida inornata* (the most abundant species in the river) and the very high abundances and larger sizes of aggressive

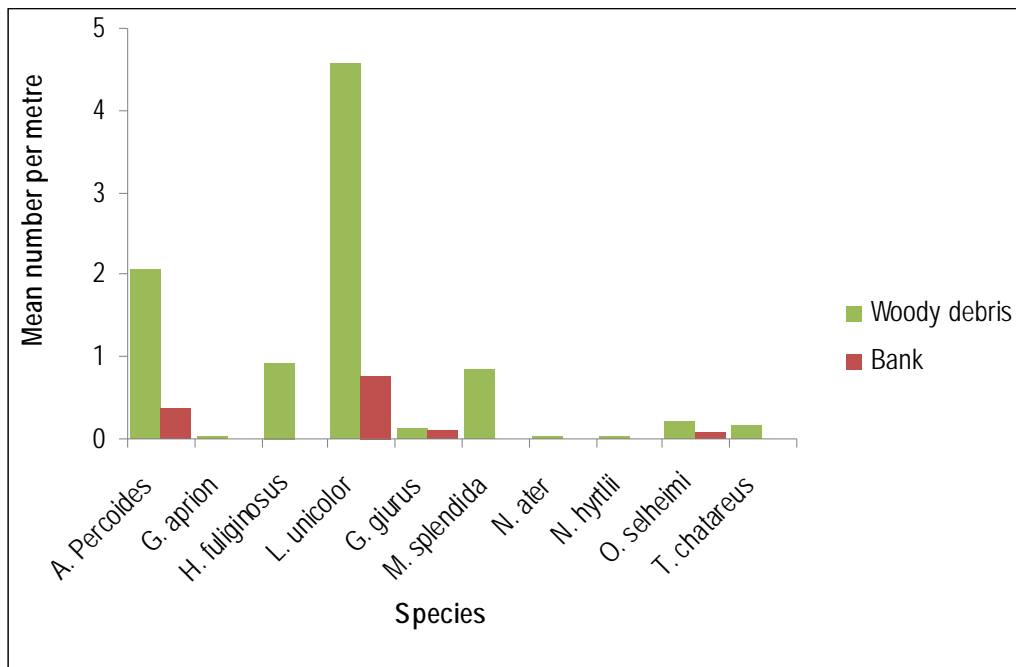
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piscivorous species, including *Glossamia aprion* and *Amniataba percooides*. This reduced diversity was attributed to the lack of suitable habitat for fishes (e.g. no woody debris or rock benthos), high level of predation in the diversion and reduced water quality (including elevated water temperatures and light attenuation).

The introduction of large woody debris was considered to be a vitally important rehabilitation strategy for aquatic habitats within the diversion. Large woody debris not only provides habitat and protection for smaller (prey) species but encourages the deposition of river sediments. Sandy (as opposed to rock) benthos is known to favour a number of species occurring in the McArthur River. Furthermore accumulated sediments which advance up the banks of the diversion provide establishment sites for riparian vegetation. Numerous piles of large woody debris were introduced into the diversion in June 2010. Despite being in place for only a few months the effectiveness of the large woody debris as fish habitat was assessed in September 2010 by comparing the fish abundances at woody debris piles to those occurring along areas of open bank with limited habitat structure (i.e. typical of the diversion prior to commencement of this program). A significantly higher species diversity and abundance was found to be occurring at woody debris sites as opposed to bare bank (Figure 4-2). *Glossamia aprion*, *Hephaestus fuliginosus* and *Toxotes chatareus* were only recorded from woody debris sites. Other species, including *L. unicolor*, *A. percooides* and *M. splendida inornata*, were also recorded at much higher abundances at woody debris than open bank sites. The presence of *M. splendida inornata* was particularly notable, as this was the first time the species had been detected in the diversion since its construction, despite being the most commonly encountered fish species in the McArthur River. The introduction of woody debris into the diversion will continue annually as part of the ongoing rehabilitation strategy.

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Figure 4-2 Histogram displaying the abundance (mean n per m) of each of the fish species encountered during electrofishing transects conducted around piles of woody debris and adjacent areas of open bank within the diversion in September 2010.



4.3 Metals in Aquatic Fauna Monitoring Program

4.3.1 Study Approach

The monitoring requirement for heavy metals in aquatic biota is outlined in Section 11.2.4 of the PER for the Phase 2 expansion (URS/MRM 2006). It reads in part, “fish tissue and liver samples will be collected annually during the course of the monitoring program from every site and for heavy metals analysis. If mussels or crustaceans are encountered they will be collected also, although based on previous observations, these groups are not abundant in the river. Collected samples will be frozen and forwarded to a certified laboratory for analysis, most likely by ICP-MS scan”. Samples of muscle and liver tissue from fish and muscle and hepatopancreas tissue from the giant freshwater prawn *Macrobrachium rosenbergii* were subsequently collected and analysed annually since 2005. Inconsistencies in the species used and subsequent difficulties in comparative analysis between 2005 and 2009 however, led to the development and implementation of the ‘Sampling Procedure for Metals and Lead Isotope Analysis in Fishes and Macro-Invertebrates of the McArthur River’ in 2010 (Indo-Pacific Environmental 2009e).

4.3.2 Study Area and Sample Sites

The Sampling Procedure identified twelve sample sites throughout the McArthur River catchment. Sites are located as far downstream as the Burketown Crossing, within the mine lease (including with the diversion, and Surprise and Barney Creeks) and as far upstream Top Crossing. Sites that are not in the immediate vicinity of the mine include those which are considered to be outside of the area that the MRM ore body is likely to directly influence. Reference samples are additionally collected from

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two adjacent systems, the Limmen Bight (~150 km NW of MRM) and Wearyan Rivers (~80 km NE of MRM) to provide background levels from the region.

4.3.3 Methods

Since the implementation of the Sampling Procedures in 2010, sampling for *Nematalosa erebi* (bony bream), *Melanotaenia splendida inornata* (chequered rainbowfish) and *Leiopotherapon unicolor* (spangled perch) is undertaken in the early dry season (Plate 4-1). The giant freshwater prawn (*Macrobrachium rosenbergii*) and freshwater mussels are also collected when encountered. Five mature individuals of each species are collected per site when possible.

Muscle and liver tissue are collected from *N. erebi* and *L. unicolor*, while *M. splendida inornata* is analysed whole (head, tail, fin and gut removed). The muscle tissue is only analysed from *M. rosenbergii*. Tissue is acid digested ($\text{HNO}_3 + \text{H}_2\text{O}_2$) and analysed by inductively coupled plasma mass spectrometry (ICP-MS) for a standard suite of 16 metals, the metalloid arsenic, and lead isotope ratios ($^{207}\text{Pb}/^{206}\text{Pb}$ and $^{208}\text{Pb}/^{206}\text{Pb}$). These concentrations are subsequently compared to the maximum permitted concentration (MPC) of metal contaminants outlined in Standard 1.4.1 (Contaminants and natural toxicants) of Food Standards Australia New Zealand (2009). An additional MPC for zinc is also applied from Food Standards Australia New Zealand 2000 (Standard A12. Metals and contaminants in food).

Plate 4-1 Fish and crustacean collected for metal and lead isotope analysis in the McArthur River, including (clockwise from top left) *Nematalosa erebi*, *Melanotaenia splendida inornata*, *Macrobrachium rosenbergii* and *Leiopotherapon unicolor*.



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4.3.4 Results

Of the ~450 individual fish and crustaceans analysed between 2005 and 2008, very few MPC exceedances have been recorded with only five and 13 individuals exceeding values for lead and copper, respectively. These exceedances were observed in individuals collected in the vicinity of the mine however a number were captured upstream. Sampling in 2010 in accordance with the Sampling Procedure saw a total of 134 individuals collected and analysed. Of these, five *M. splendida inornata* exceeded the MPC for lead, one was collected in close proximity to the mine, two were collected well upstream and two were collected from the reference site located on the Wearyan River.

In all years, lead isotope values have been shown to approach that of the MRM ore body with increased proximity to the mine. The introduction of lead into riverine systems may occur via several avenues, including (i) through the expression of ground water (percolating through the ore body), or (ii) through the direct contact of riverine waters with exposed lead forms (which may be naturally occurring or associated with mining extraction). While it is not possible to determine which avenue of lead exposure is predominant, the reduction of isotope values with distance from the mine (in both up and downstream directions) in all years has suggested the exposure of fishes to waters supplemented by the exchange of ground water to be a likely source. Monitoring will continue annually in accordance with the Sampling Procedure.

4.4 Macroinvertebrate Monitoring Program

MRM established an aquatic fauna assessment program as part of the approvals for the McArthur River diversion works and commissioned a program of biological monitoring of receiving waters and diversions which included the use of aquatic macroinvertebrates as indicators. The program was developed in consultation with the NT Government (DR-PIFR).

4.4.1 Study Approach

The value of aquatic macroinvertebrates in monitoring the condition of instream conditions and water quality has long been recognised. The rationale behind the use of aquatic macroinvertebrates in biological monitoring is based on the fact that the results can have greater ecological meaning than physico-chemical measurements, unless contamination or disturbance of waterways is so severe that the implications of chemical results for the ecology of the river are obvious (Halse *et al.* 2007). Macroinvertebrates have been chosen as indicator organisms as they are ubiquitous, have a relatively well-known taxonomy and are easily sampled (Halse *et al.* 2007).

Monitoring of aquatic macroinvertebrates of the McArthur River main channel commenced at 5 sites in April and May 2007 and during the late dry season 2007 (Indo-Pacific Environmental 2008). Following consultation with DR-PIFR the program was expanded to incorporate an expanded number of sites commencing in the wet season recessional flow period between April and May 2008. Sampling was repeated in the 2009, 2010 and 2011 recessional flow periods. Sampling for the program is limited to one seasonal sample per year based with the NT AUSRIVAS protocol (Lamche 2007).

Sampling is timed to coincide with the recessional flow period four to six weeks after the last wet season storm flush. This enables sampling that integrates the effects of wet season flows while capturing maximum biodiversity (Lamche 2007). The optimum sampling period in the NT wet/dry tropics is four to six weeks following the cessation of wet season storm flushing events, enabling macroinvertebrates to recolonise stream habitats following flood disturbance (Lamche 2007).

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Sampling is generally conducted earlier on minor tributaries (Surprise and Barney Creek) and later on larger tributaries (Glyde River and McArthur River).

4.4.2 Study Area and Sample Sites

Macroinvertebrate sampling sites were selected within the context of the local tributaries, mine operations and facilities and diversions and were designed to sample reference sites, diversion sites and sites potentially influenced by a gradient of contaminant concentrations relating to mine operations. The main study area is located on the McArthur River and associated tributaries from the Kilgour River confluence (20 km upstream of the diversion) to the lower McArthur River (approximately 9 km upstream of Borroloola). A number of offstream reference sites are located outside this area on Leila Creek, Amelia Creek, the Glyde River, Wearyan River and Robinson River.

Sites were initially selected in consultation with DR-PIFR. A list of potential sites was developed in November 2007 and these sites were inspected in April 2008 to determine suitability for incorporation into the sampling program. Sites were located in close proximity to existing MRM surface water (SW) sites where possible. Twenty four sites were initially selected for sampling, however a number of these sites have been removed from the program or have not been sampled during some years due to an absence of surface water, unsuitable habitats or absence of safe sampling sites (estuarine crocodile hazard) or access limitations. A number of additional reference sites have been added during the course of the program in an effort to locate suitable reference sites in catchments removed from mining operations. Three sites in the pit area were not sampled after 2008 following the construction of the bund and operation of the McArthur Diversion as these sites were no longer accessible or did not support surface water. Macroinvertebrate sampling site locations are shown in Figure 4-1. The sites include:

- three potentially exposed sites and one upstream reference site on Surprise Creek upstream of the Barney Creek confluence;
- one site on Barney Creek above the Barney Creek Diversion and one site on the Barney Creek diversion;
- one site on the McArthur River below the Barney Creek diversion and between the McArthur River inlet and outlet;
- three sites on the McArthur River diversion;
- three sites on the McArthur River below the McArthur River diversion;
- three sites on the McArthur River above the McArthur River diversion;
- five reference sites on the Glyde River and associated tributaries; and
- a number of reference sites removed from the mine area, including Leila Creek, the Wearyan River and Robinson River (sampled in the 2011 survey).

4.4.3 Methods

In the NT AusRivAS models have been developed for the Darwin – Daly region (Lamche 2007), however there are no models available for the eastern section of the NT. As such DR-PIFR has recommended that sampling and laboratory processing be conducted following established AusRivAS protocols, while data analysis should employ traditional methods for the assessment of site conditions and comparison of sites. In this program most aspects of sampling and laboratory processing closely followed established NT protocols (Lamche 2007) with reference to Lloyd & Cook (2002) and QDNRM

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(2001) for sampling of riffle habitats. The methodology and site selection was developed in consultation with DR-PIFR during 2007/2008.

At each site a range of standard surface water, fluvial sediment, spatial and habitat variables were measured during sampling. At sites that corresponded with established surface water monitoring sites data from MRM's ongoing SW and fluvial sediment sampling program were used. Environmental variable measures generally conform to standard NT AusRivAS protocols (Lamche 2007, Lloyd & Cook 2002). Environmental variables were measured to assess the extent of the potential impacts on surface water and sediments by mining activities and natural habitat factors and to enable interpretation of differences in macroinvertebrate assemblages between sites and treatments.

Sample collection follows standard AusRivAS sampling procedures. Each macroinvertebrate sample is collected using a 250 micron mesh net with an opening of 35 cm at the base. The length of habitat sampled is 10 m per habitat sample, and samples are collected on separate lengths of habitat if a contiguous 10 m length is not present. Samples are collected at edge habitats at all sites and at riffle habitat if this is present at a site. Field and laboratory processing of macroinvertebrate samples generally follows the NT AusRivAS manual (Lamche 2007).

Macroinvertebrates are identified in accordance with the AusRivAS Family Level methodology described in Lamche (2007). As requested by DRDPFIR the main focus of the analysis was the identification to family level for analysis purposes. However macroinvertebrates were identified to lower taxonomic levels or species types where possible. Analysis of the macroinvertebrate data is undertaken using multivariate routines in PRIMER 6 (Plymouth Routines In Multivariate Ecological Research) (Clarke & Gorley 2006) and PERMANOVA+ for PRIMER (Anderson *et al.* 2008).

4.4.4 Results

Combined results of family-level taxa recorded at each site during the macroinvertebrate sampling program is presented in Appendix F. Key results from analysis of the macroinvertebrate data undertaken for the project to date (EMS 2009b) are described in the following section.

Aquatic macroinvertebrate taxa numbers from edge habitats were lowest at exposed sites on Surprise Creek and Barney Creek downstream of mine processing areas and the TSF, and at reconstructed sites on the diversions. There was a general increase in taxa numbers indicating recovery at downstream reference sites.

Analysis indicates that during some sampling periods a number of surface water variables, (Cu and log Pb), habitat variables (% vegetation cover 100 m reach) and spatial variables (latitude) had a significant relationship with the macroinvertebrate species derived multivariate data ($p < 0.05$). Percentage vegetation cover (100 m reach) alone accounted for 22% of the variability in the data and was the most important variable.

During 2009 macroinvertebrate communities at riffles established within the McArthur River diversion were found to be similar to those at reference sites. This indicates that riffle habitats within the diversion have been rapidly colonised by macroinvertebrates following commencement of operation of the diversion, despite the absence of habitat features such as riparian vegetation.

The site groups with the highest dissimilarity levels for riffle habitat macroinvertebrates were reference sites and exposed sites, indicating that elevated levels of contaminants and degraded water quality

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had a greater influence on riffle macroinvertebrates than the disturbance and habitat changes at diversion sites.

Riffle habitats at exposed sites on Surprise Creek/Barney Creek diversion showed a greater level of impairment when compared to both reference and McArthur River diversion sites. Important factors are likely to be related to elevated levels of metals and sulphates associated with mining activities adjacent to Barney Creek and the TSF.

The best combination of variables explaining the distribution of sites based on macroinvertebrates at riffle habitats were pH, log turbidity, EC, As SW, Zn SW and % cobble (riffle habitat).

There is evidence of a gradient of elevated metals, sulphate and other parameters associated with the Surprise/Barney Creek system. Impacts on macroinvertebrate communities are illustrated by significant negative correlations between macroinvertebrate taxa numbers in response to increasing levels of key variables (e.g. Cu, Pb, SO₄). These relationships were less pronounced during the 2009 recessional flow period, possibly in part due to improved seasonal flow conditions and reduced effects of evapoconcentration of pollutants.

Macroinvertebrate data indicate that there is an increasing spatial trend in taxa numbers indicating a recovery of macroinvertebrate communities at downstream sites on the McArthur River (MR17, MR18). This confirms evidence from surface water monitoring which indicates that some variables (e.g. Zn, SO₄) show a decreasing trend at downstream sites (MRM 2008).

Significant negative correlations were observed between macroinvertebrate community data (taxa number) and surface water metals (e.g. Pb), indicating adverse impacts on biota in receiving waters. The correlation between taxa numbers and percentage silt/clay at edge habitats was also negative, indicating the impacts of excessive deposition of fine sediment and general disturbance on aquatic macroinvertebrates.

The correlation between edge habitat taxa numbers and riparian vegetation parameters (% vegetation cover 100 m reach and % vegetation cover edge) were positive, with sites with higher percentages of vegetation cover recording higher numbers of macroinvertebrate taxa. These habitat correlations indicate that riparian vegetation condition is an important factor in relation to the condition of instream macroinvertebrate populations in edge habitats.

Sampling conducted in 2008 and 2009 demonstrated that there are impacts on aquatic biota (macroinvertebrates) associated with elevated levels of metals, sulphate and other water chemistry parameters associated with the Surprise – Barney Creek system. The results also demonstrate that macroinvertebrate communities within the diversion sites are significantly different to reference sites when comparing edge habitats and that this is in part related to the absence of riparian vegetation and stream morphology factors.

Riffle sites within the McArthur River have been rapidly colonised by macroinvertebrates and are not significantly different to reference sites on the basis of macroinvertebrate abundance data. Riffle sites on exposed sections of Surprise Creek and the Barney Creek diversion display macroinvertebrate communities that were significantly different (impaired) when compared with reference sites or McArthur River diversion sites.

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4.5 Species of Conservation Significance

Freshwater Sawfish (Pristis microdon)

The freshwater sawfish (*TPWC Act* – Vulnerable; *EPBC Act* – Vulnerable) is known from a number of large river systems across northern Australia. It prefers muddy and sandy substrates in estuaries and freshwater reaches of rivers, and is known to move significant distances upstream in the major rivers, having been recorded over 400 km inland (Thorburn *et al.* 2007). The species is known to use the freshwaters of rivers as nurseries where they attain length of up to three metres, before leaving the rivers to mature and breed (Thorburn *et al.* 2007). The decline of sawfish populations throughout the world has been well documented (Simpfendorfer 2000; Pogonoski *et al.* 2002). While limited historical data exists for Australian populations anecdotal evidence collected throughout northern Australia suggests there has been a region wide decline of the species (Thorburn *et al.* 2003). Records of interactions by commercial fishers in the Northern Territory (Field *et al.* 2008) and Queensland (Peverell 2005) also reflect the capture of *P. microdon* as bycatch in prawn, finfish and shark fisheries. Furthermore, records of the Queensland Shark Control Project collected between 1970 and 1990 indicate a clear decline in the number of Pristids captured, despite a relatively constant fishing effort over that time. The primary threat to this species in Australia is commercial gill netting, and although this no longer permitted in freshwaters in northern Australia (Larson *et al.* 2006), interactions in marine waters remain.

Few historical records of the species occurrence in the McArthur River exist. Midgley (1975) reported *P. microdon* from the main channel and tributaries (including the Glyde and Kilgour Rivers) and at a number of those sites reported them as being ‘common’. A survey of freshwater elasmobranchs of northern Australia conducted in 2002 also reported the capture of one individual in brackish waters below Burketown Crossing (Thorburn *et al.* 2003). A total of 28 records (including 19 captures) of *P. microdon* have been collected during the biannual sampling of fishes for MRM between March 2006 and June 2011 (Appendix G). With the exception of a 2050 mm individual captured in June 2011, most have been small and between one and two years of age. A single recapture has been recorded during the study, with an individual captured in waters above the Burketown Crossing in September 2009 recaptured one year later in the same area, and which had grown ~550 mm in that year.

Captures during the current study suggest that the recruitment of juveniles appears correlated to the magnitude and duration of the wet season, i.e. greater numbers are encountered after large wet seasons. Sustained waters of a long wet season facilitate upstream recruitment by a) providing increased depth and thus reduced obstruction by barriers including rock bars, sand bars and barrages, and b) the extended time available for upstream migration. The rainfall associated with the 2006/2007 and 2007/2008 seasons was below average and captures of *P. microdon* in those years were low. In contrast, the 2008/2009, 2009/2010, 2010/2011 wet seasons were large. The fact that sampling during 2009, 2010 and 2011 resulted in the collection of ten, seven and five (early dry season only) records for the species lends credence to this hypothesis.

Gulf Snapping Turtle (Elseya lavarackorum)

The Gulf snapping turtle (*TPWC Act* – Least Concern; *EPBC Act* – Endangered) is a large short necked turtle originally described from fossil specimens found at Riversleigh, Queensland, but is now known to be an extant species (Thomson *et al.* 1997). It is reported by DSEWPC (2011b) to occur in several large river systems of the southern gulf including the Roper, Limmen Bight, Robinson and

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Calvert Rivers in the NT, across to the Nicholson River in Queensland. However, this distribution and associated mapping is at odds with recent research that suggests this species is confined to the Nicholson River drainage system in Queensland, and that *Elseya* turtles from the McArthur River are currently referable to the more widespread *E. dentata* taxa (Georges & Merrin 2008; Georges & Thomson 2010).

There are no measures of decline in *E. lavarackorum*, but it is very poorly known and threats are cited as stock degradation and habitat loss of river banks. The species has also been caught in fishing nets (DSEWPC 2011b).

During the course of regular fish monitoring surveys at McArthur River in 2007, eight individuals of a large *Elseya* sp, potentially this species, were captured incidentally by gill netting at a location in the lower Glyde River. These specimens were all released. Despite a significant effort of netting for fish at various locations in the main channel of the McArthur River and in other areas since 2006, no other records of this turtle have been made even though other turtle species (e.g. *Emydura worrelli*) are regularly captured.

The specific identity of *Elseya* turtles in the Glyde River is not clear, but based on current research they may be referred to as *E. dentata*. However, it is also noted that specimens of a large *Elseya* turtle collected recently at Calvert River (east of McArthur River in NT) appear genetically distinct from *E. lavarackorum* and *E. dentata* (AWC 2009). It is possible that the Glyde River form may be the same taxa.

Ecological Impact Assessment

The impacts of the Project on terrestrial and aquatic fauna are assessed in this section. The assessment is based on the baseline and monitoring data presented in this report assessed in conjunction with the various project components of the proposed Project expansion. The range of potential effects from proposed project components is based on descriptions of those project components supplied in a draft of the 'Project Components' section of the EIS provided by MET Serve dated 14 June 2011, including various drawings of the expansion footprint.

5.1 Terrestrial Fauna

5.1.1 Habitat Loss

The main Project components that will require expansion into areas of fauna habitat are: the northern OEF expansion; the pit, bund and eastern OEF expansion; and the TSF expansion. The potential impacts on terrestrial fauna of these Project components are assessed in this section.

Northern OEF

The majority (73%) of overburden from the expansion will be deposited on the open woodland/low open woodland plains immediately to the north of the existing OEF. This area will also include a small seasonal stream line flowing into Emu Creek, which will require a minor diversion. The OEF will also require several small dams to contain any PAF leachate emanating from the OEF. Small, semi-permanent waterholes and artificial dams are present in the area, but none are considered significant for fauna.

Based on the recent field surveys and extensive background data, the fauna species occurring in this area are generally common and wide-ranging forms, with no species really specialised to this woodland habitat. This habitat is widespread in the region, but is generally degraded by cattle grazing. The woodland and grassland habitats in the vicinity of the OEF expansion area are in somewhat better condition compared to other areas because of an active cattle exclusion program undertaken by MRM.

Australian bustard (Vulnerable) occur in this area and it is likely that emu (Vulnerable) may occasionally be present. Australian bustard in particular is common in this habitat, especially in grassland areas where it has benefitted from cattle exclusions. The Project will remove some of the habitat for these species, but the amount is relatively very minor considering the large areas of similar habitat available in the region. There is a small likelihood of Gouldian finches (Endangered) ranging into this area, particularly to access small waterholes. The impacts on this species cannot be assessed because to date, there are no observations on the site.

Pit Expansion and Eastern OEF

Based on drawings included in the draft EIS Project Description, the Project will include an expansion of the existing pit area to the edge of the existing bund wall; placement of overburden over the existing bund wall; and placement of overburden throughout the area east of the existing pit and bund, up to the confluence of the McArthur diversion channel and Barney Creek. It is proposed that the remaining old McArthur channel to the east and west of the current bund wall be also filled with overburden. It is indicated that the overburden placed in this area will be non acid-forming material.

The habitats present in these areas are diverse. These habitats and their ecological functions are described below:

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Riparian corridor habitat occurs along the old McArthur River channel (both upstream and downstream of the bund wall, and including some within the bund wall itself), and along Barney Creek. The extent of this habitat loss will be approximately 1.7 km linear in total. This habitat is characterised by a relatively narrow dense fringing riverine *Melaleuca argentea* tall closed forest. The canopy of the riverine forest is relatively dense and common plant species include *Melaleuca argentea*, *Eucalyptus camaldulensis*, *Casuarina cunninghamiana* and sparse *Pandanus aquaticus*. The dominant water's edge species is *Barringtonia acutangula*. This habitat provides refuge, feeding, and roosting sites for a range of species, especially birds. One bird species, buff-sided robin (Near Threatened), appears restricted to this habitat type.

Permanent moist conditions provide dry season refuge habitat for many species, especially frogs. Large canopy trees provide important roost and breeding sites for birds, especially parrots and owls. A large bat roost (refer section 3.6) is known to be present, and it is considered likely that other undiscovered bat roosts are also present. These riparian areas currently provide movement corridor habitat which is used by fauna, especially birds, to disperse into areas they would otherwise be unable to populate.

These areas are likely to act as important refuge sites from which terrestrial riparian fauna species would be able to colonise restoration areas on the McArthur and Barney Creek diversions as these areas develop a suitable vegetation cover. If the rehabilitation of the McArthur River diversion is not effectively implemented, there may be some loss of current riparian habitat connectivity when the outer bund area is converted to an OEF as the back channels of the old river bed in these areas are still functioning as aquatic and terrestrial ecological systems.

Riparian woodland habitat occurs in fringing areas along the McArthur channel and Barney Creek. It is also present along the eastern part of the diversion channel, where it follows Bull Creek. Riparian woodland occurs along the high banks of the streams, adjacent to the riparian corridor. These areas often have a dense understory of cane grass, and are ideal habitat for the purple-crowned fairy-wren (Near Threatened). The eastern OEF area has been excluded from cattle through fencing, and this has resulted in an expansion of cane grass growth, and a subsequent expansion of purple-crowned fairy-wrens in the area. This bird has a highly restricted habitat and studies show that they do not move far from their territories. There are known colonies of this species both within the bund wall, and in the western and eastern old McArthur channel areas. These colonies would be lost when the planned expansion occurs in these areas. The proposed infilling of the riparian woodland between the diversion, diversion inlet and outlet would potentially restrict the ability of riparian fauna to colonise restoration areas on the McArthur and Barney Creek diversions and would potentially further reduce the ability of riparian fauna species to move up and downstream of the diversion if the rehabilitation of the McArthur River diversion is not effectively implemented.

Coolibah low open woodland/shrubland habitat is present as a floodplain between Barney Creek and the diversion channel. During the 2011 surveys, the whole area showed evidence that it had been inundated during the previous wet season. Australian bustard (Vulnerable) use this area. These areas represent an important staging area for riparian species that will potentially colonise restoration areas on Barney Creek and the McArthur River diversion. Surveys indicate that this area is supporting increasing areas of cane grass and associated riparian birds, including purple-crowned fairy-wren.

Hill Woodland occurs on two small rocky outcrops within the eastern OEF area. It is not considered that these outcrops are large enough to support major populations of any specialist species.

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5.1.2 Future Habitat Rehabilitation

Xstrata made commitments in the 2005 EIS and subsequent 2006 PER to rehabilitate the McArthur River diversion channel and restore it to a functioning riparian ecosystem (URS/MRM 2006, Section 4.6). This involves rehabilitating not only the in-stream and bankside habitats, but also extends some way into the adjacent natural vegetation. The eastern EOF will leave a minimum of 75 m from the crest of the river but has some potential to threaten this habitat rehabilitation effort (and therefore threaten the return of riparian fauna into these areas) if appropriate rehabilitation of the McArthur River diversion is not effectively implemented. This may occur through the following means:

- Encroachment of the edges of the OEF into the rehabilitation zone may have direct impacts on the rehabilitation effort, and a subsequent stalling of the function of the area as a riparian corridor for terrestrial fauna;
- A decrease in connectivity between the diversion channel and adjacent natural habitats may occur due to placement of the eastern OEF. This may decrease the ability of fauna to repopulate the areas under rehabilitation along the diversion channel because access to these areas from natural habitats may be distant, and will be blocked by disturbances if appropriate rehabilitation of the McArthur River diversion is not effectively implemented;
- The loss of remaining riparian corridor habitats along the old McArthur River channel (Section 5.1.1.) may further reduce potential sources of fauna populations available to recolonise the rehabilitated areas; and
- The additional filled areas on the floodplain associated with the eastern OEF may potentially have other impacts on riparian vegetation and on the restoration effort on the McArthur River and Barney Creek diversions. Issues that may negatively impact riparian fauna, riparian vegetation and restoration sites may include increased flow velocities, increased inundation times, increased deposition of sediment, higher flood levels and increased erosion. The combined effects may increase the difficulty and length of time required to develop ecologically robust and self-sustaining restoration areas on the diversions, and further decrease the connectivity of riparian habitats along the McArthur River riparian corridor. These issues are further discussed in Section 5.2.

5.2 Aquatic Ecology

The majority of aquatic impacts from the proposed Phase 3 Expansion Project arise from the development of the eastern OEF and expansion of the pit bund

5.2.1 Loss of Staging Habitat

The old McArthur River channel both upstream and downstream of the pit currently contains areas of deep, permanent water. These areas are still-water refuges and off river sites which provide safe resting and staging areas for aquatic fauna even when conditions in the main McArthur River and the diversion channel are unfavourable, such as in flood periods and in low flow periods. This ecological function may be lost when these two areas are covered by the eastern OEF expansion although they may also be impacted by groundwater drawdown due to the pit expansion

5.2.2 Loss of Floodplain Function

The area of the outer bund currently acts as a floodplain. During field surveys in 2011 it was noted that this whole area had been covered to depths of between 4 and 20 m during the previous wet season. This area currently acts as an off-channel refuge for aquatic fauna during the height of the wet season,

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and may also act as a breeding site for aquatic fauna. This floodplain function will be lost when the outer bund area is converted to an OEF.

With the loss of the outer bund area as a floodplain, there may be an increase in water flows downstream in the McArthur River, and a backup of waters in Barney Creek. This is likely to impact negatively on rehabilitation projects, sedimentation, and aquatic ecology downstream of the mine and in Barney Creek. Restriction of the floodplain channel is also likely to impact upstream migration of fishes as flow rates are likely to increase in the vicinity of the diversion due to a reduction in floodplain width. Some amelioration of this impact may occur through the increased inundation of the floodplain opposite. Riparian vegetation and woody debris on the floodplain which retard flow and provide resting areas for fishes migrating upstream would also be lost in the event the outer bund is used as an additional OEF. At this point in time the aquatic habitat present in the diversion is of a poor quality and it is likely that a majority of upstream migration of fishes is currently via the flooded edges of the flood plain.

5.2.3 Increased Flow Velocities

The establishment of the eastern OEF may restrict the width of the floodplain available for inundation during the wet season. This restriction is likely to result in an increase in flow velocity through the diversion and along the western edge. Erosion rates could increase. This erosion may prevent the deposition of fine sediments necessary for the re-establishment of bank vegetation and the successful rehabilitation of the diversion. The successful colonization of seedlings may also decrease due to uprooting and scouring by flowing water.

5.2.4 Potential Chemical Effects

While it is planned that only NAF overburden will be placed in the eastern OEF area adjacent to the river, the full separation of PAF and NAF overburden is may be problematic. It is therefore conceivable that some PAF overburden would be deposited in the eastern OEF area. This may have implications for the water chemistry of the McArthur River and Barney Creek. Fishes and *Macrobrachium* species have recorded elevated metal concentrations in the vicinity of MRM in the past. The use of this area as an additional OEF has potential to introduce additional quantities of metals into the McArthur River if appropriate mitigation measures are not effectively implemented.

Drainage lines located to the north of the northern OEF enter the McArthur River downstream of the diversion channel. The deposition of salts is apparent in these drainage lines. An increase in the size of the northern OEF may introduce additional contaminants in the McArthur River downstream of the mine if appropriate water management infrastructure around the northern OEF bunding is not maintained.

Management and Monitoring

6.1 Management Options

Considerations for the management of impacts have been based on the following three principles:

- **avoid** - to the extent possible, developments should be designed to avoid or minimise ecological impacts;
- **mitigate** - where certain impacts are unavoidable through design changes, mitigation measures should be introduced to ameliorate the ecological impacts of the project; and
- **offset** - the residual impacts of the project, following the implementation of mitigation measures, should be compensated to offset what would otherwise be a net loss of biodiversity.

The following section provides recommendations to reduce the impacts on terrestrial and aquatic fauna based on these principles.

The following avoidance options are recommended:

- Encroachment of the eastern OEF area within close proximity of Barney Creek and the McArthur diversion may have negative impacts on terrestrial and aquatic ecology, as well as potential to negatively impact on rehabilitation efforts. In order to maintain these areas as functioning ecosystems, it is recommended that appropriate setbacks from these landscape features be maintained.

The following mitigation options are recommended:

- Increased planting of the diversion batters and planting of established trees to stabilise banks should be undertaken when the eastern OEF is established. This should help prevent excessive erosion due to elevated flow rates and provide slow back waters to aid in upstream fish migration.
- Additional baffling may be required on the western diversion wall to reduce erosion which may potentially occur as a result of increased flow rates.
- Appropriate water management infrastructure should be incorporated into the expanded northern OEF to prevent flow of contaminants into the McArthur River via drainage lines entering below the diversion channel.
- The feasibility of a program to relocate populations of purple-crowned fairy-wrens and buff-sided robins from within the pit area and the two old McArthur River channel sites should be investigated. These populations have been monitored in the long term and will be lost when the planned expansion of the pit and eastern EOF proceeds if they do not relocate through natural or assisted means. The birds could be captured and released in areas where there is suitable habitat, and where there are no competing territories.

6 Management and Monitoring

The following *offset* option is recommended:

- A proposed biodiversity offset program has already been submitted to the NT Government for the Phase 2 expansion (Xstrata Zinc, 2011). Part of that package includes a cattle exclusion zone surrounding the McArthur River from the mine site downstream to the McArthur River Station boundary. During the course of the 2011 field surveys, the value of the current cattle exclusion program in assisting habitat rehabilitation was obvious. It is recommended that the planned cattle exclusion zone (as per the offset program) be implemented as a component of the Project, and should be expanded away from the river to include woodland plains habitats similar to those found in the northern OEF area. Consideration should also be given to expanding the cattle exclusion zone along the river upstream of the mine site.

6.2 Monitoring Options

If development of the eastern OEF results in loss of the two old channel McArthur River areas then it is recommended that surveys of aquatic fauna of these areas should be undertaken to identify their importance as dry season refugia and wet season resting areas, and to aid in the management of the impacts of this project component.

Continuation of the current riparian bird and aquatic ecology programs is recommended and may require some modifications to ensure that additional impacts from the Project are adequately addressed. In particular, it is desirable to increase the frequency of monitoring for metal and metalloid accumulation in aquatic fauna when the eastern OEF is established.

Should the option to increase cattle exclusion areas be adopted, a monitoring program to assess the success of habitat improvement and fauna communities, including threatened species and indicator species, should be established.

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Limitations

URS Australia Pty Ltd (URS) has prepared this report in accordance with the usual care and thoroughness of the consulting profession for the use of MET Serve Pty Ltd and only those third parties who have been authorised in writing by URS to rely on the report. It is based on generally accepted practices and standards at the time it was prepared. No other warranty, expressed or implied, is made as to the professional advice included in this report. It is prepared in accordance with the scope of work and for the purpose outlined in the Proposal dated 1 April 2011.

The methodology adopted and sources of information used by URS are outlined in this report. URS has made no independent verification of this information beyond the agreed scope of works and URS assumes no responsibility for any inaccuracies or omissions. No indications were found during our investigations that information contained in this report as provided to URS was false.

This report was prepared between May and August 2011 and is based on the conditions encountered and information reviewed at the time of preparation. URS disclaims responsibility for any changes that may have occurred after this time.

This report should be read in full. No responsibility is accepted for use of any part of this report in any other context or for any other purpose or by third parties. This report does not purport to give legal advice. Legal advice can only be given by qualified legal practitioners.

Appendix A Combined List of Fauna Records for the McArthur River Area 1992-2011

A

Appendix A - Combined List of Fauna Records for the McArthur River Area 1992-2011

Common name	Scientific name	URS/MRM 2003	Ecostudy (1992)	Hollingswood Dames & Moore (1992)	Martin & McKean (1986)	Tytre (1992)	MRM bird obs (1999-2002)	NRETAS (2011)	P. Barden Records 2003-2011	Current Study (S. 3.4)
Amphibians										
Bilingual Froglet	<i>Crinia bilingua</i>							x	x	
Desert Froglet	<i>Crinia deserticola</i>	x	x	x		x		x	x	x
Northern Spadefoot Toad	<i>Notaden melanoscaphus</i>							x	x	
Ornate Burrowing Frog	<i>Opisthodon ornatus</i>	x	x	x		x		x	x	x
Stonemason Toadlet	<i>Uperoleia lithomoda</i>					x		x	x	
Floodplain Toadlet	<i>Uperoleia inundata</i>					x		x	x	
Giant Frog	<i>Litoria australis</i>	x	x	x		x		x	x	
Hidden-ear Frog	<i>Litoria cryptotis</i>					x		x	x	
Knife-foot Frog	<i>Litoria cultripes</i>		x	x		x		x	x	
Long-footed Frog	<i>Litoria longipes</i>								x	
Striped Burrowing Frog	<i>Litoria alboguttata</i>							x		
Bicolor Tree Frog	<i>Litoria bicolor</i>		x			x		x	x	
Green Tree Frog	<i>Litoria caerulea</i>	x	x	x		x		x	x	x
Saxicoline Tree Frog	<i>Litoria coplandi</i>								x	
Peter's Frog	<i>Litoria inermis</i>	x	x			x		x	x	x
Daly Waters Frog	<i>Litoria maculosa</i>							x		
Rockhole Frog	<i>Litoria meiriana</i>	x							x	
Rocket Frog	<i>Litoria nasuta</i>		x			x		x	x	x
Pale Frog	<i>Litoria pallida</i>	x	x	x		x		x	x	x
Roth's Tree Frog	<i>Litoria rothi</i>	x	x	x		x		x	x	x
Desert Tree Frog	<i>Litoria rubella</i>		x					x	x	x
Tornier's Frog	<i>Litoria tornieri</i>								x	
Wotjulum Frog	<i>Litoria wotjulumensis</i>	x	x			x		x	x	x
*Cane Toad	<i>Rhinella marina</i>	x	x	x		x		x	x	x
	24	10	13	8	0	15	0	19	22	10

Common name	Scientific name	URS/MRM 2003	Ecostudy (1992)	Hollingswood Dames & Moore (1992)	Martin & McKean (1986)	Tytre (1992)	MRM bird obs (1999-2002)	NRETAS (2011)	P. Barden Records 2003-2011	Current Study (S. 3.4)
Reptiles										
Freshwater Crocodile	<i>Crocodylus johnstoni</i>	x	x	x				x	x	
Worrell's Turtle	<i>Emydura worrelli</i>	x	x	x				x	x	x
Northern Yellow-faced Turtle	<i>Emydura tanybaraga</i>							x		
Immaculate Gecko	<i>Diplodactylus immaculatus</i>		x							
Northern Dtella	<i>Gehyra australis</i>	x	x	x				x	x	x
Borroloola Gecko	<i>Gehyra borroloola</i>	x	x					x	x	
Northern Spotted Rock Dtella	<i>Gehyra nana</i>		x							
Pale-striped Ground Gecko	<i>Lucasium immaculatum</i>							x		
House Gecko	<i>Hemidactylus frenatus</i>	x	x					x		
Binoe's Gecko	<i>Heteronotia binoei</i>	x	x	x	x			x	x	
Sandstone Heteronotia	<i>Heteronotia planiceps</i>	x							x	
Zig-zag Gecko	<i>Oedura rhombifer</i>		x					x		
Beaked Gecko	<i>Rhynchoedura ornata</i>		x					x		
Sharp-snouted Delma	<i>Delma nasuta</i>	x							x	
Excitable Delma	<i>Delma tinctoria</i>		x							
Burton's Legless Lizard	<i>Lialis burtonis</i>	x	x						x	
Northern Hooded Scaly-foot	<i>Pygopus steelescotti</i>							x		
Ring-tailed Dragon	<i>Ctenophorus caudicinctus</i>	x	x	x	x				x	
Yellow-sided Two-lined Dragon	<i>Diporiphora magna</i>		x	x				x		
Gilbert's Lashtail	<i>Amphibolurus gilberti</i>	x	x	x				x	x	x
Friilled Lizard	<i>Chlamydosaurus kingii</i>									x
Long-tailed Earless Dragon	<i>Tympanocryptis tetraporophora</i>								x	
Ridge-tailed Monitor	<i>Varanus acanthurus</i>		x					x		
Merten's Water Monitor	<i>Varanus mertensi</i>			x				x	x	x
Yellow-spotted Monitor	<i>Varanus panoptes</i>	x	x					x	x	
Storr's Monitor	<i>Varanus storri</i>		x	x				x		
Black-tailed Monitor	<i>Varanus tristis</i>		x							
Bauxite Rainbow-skink	<i>Carlia amax</i>	x	x	x	x			x	x	x
Shaded-litter Rainbow-skink	<i>Carlia munda</i>	x	x	x				x	x	
Agile Snake-eyed Skink	<i>Cryptoblepharus zoticus</i>	x	x	x					x	
Metallic Snake-eyed Skink	<i>Cryptoblepharus metallicus</i>	x	x	x				x	x	x
Helen's Ctenotus	<i>Ctenotus helenae</i>							x		
Bar-shouldered Ctenotus	<i>Ctenotus inornatus</i>	x	x	x				x	x	
Robust Ctenotus	<i>Ctenotus robustus</i>		x						x	
Leopard Ctenotus	<i>Ctenotus pantherinus</i>								x	x
Red-sided Ctenotus	<i>Ctenotus pulchellus</i>		x					x		
Straight-browed Ctenotus	<i>Ctenotus spaldingi</i>		x	x				x		x
Stripe-headed Finesnout Ctenotus	<i>Ctenotus striaticeps</i>	x							x	
Hosmer's Skink	<i>Egernia hosmeri</i>		x	x				x		
Northeastern Orange-tailed Slider	<i>Lerista orientalis</i>		x					x		
Common Dwarf Skink	<i>Menetia greyii</i>		x							
Northern Dwarf Skink	<i>Menetia maini</i>	x	x	x				x	x	x
Fire-tailed Skink	<i>Morethia ruficauda</i>		x							
Ornate Soil-crevice Skink	<i>Notoscincus ornatus</i>		x							
Northern Soil-crevice Skink	<i>Proablepharus tenuis</i>		x					x		
Centralian Blue-Tongued Lizard	<i>Tiliqua multifasciata</i>							x		
Northern Bluetongue	<i>Tiliqua scincoides</i>	x								
Robust Blind Snake	<i>Ramphoithyphlops ligatus</i>			x				x		
Children's Python	<i>Antaresia childreni</i>	x	x					x	x	
Water Python	<i>Liasis fuscus</i>		x						x	
Olive Python	<i>Liasis olivaceus</i>	x						x	x	x
Black-headed Python	<i>Aspidites melanocephalus</i>	x	x					x	x	x
Arafura File Snake	<i>Acrochordus arafurae</i>	x						x	x	
Common Tree Snake	<i>Dendrelaphus punctulata</i>	x	x					x	x	x
Freshwater Snake	<i>Tropidonophis mairii</i>	x						x		x
Greater Black Whipsnake	<i>Demansia atra</i>	x		x					x	
Olive Whipsnake	<i>Demansia olivacea</i>			x						
Lesser Black Whipsnake	<i>Demansia vestigiata</i>							x	x	
Ringed Brown Snake	<i>Pseudonaja modesta</i>			x				x		
Western Brown Snake	<i>Pseudonaja nuchalis</i>				x				x	
King Brown Snake	<i>Pseudechis australis</i>				x			x		
Curl Snake	<i>Suta suta</i>		x					x	x	x
Bandy-bandy	<i>Vermicella annulata</i>								x	
	62	27	39	21	5	0	0	39	32	15

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Birds										
Emu	<i>Dromaius novaehollandiae</i>	x	x						x	
Brown Quail	<i>Coturnix ypsilophora</i>			x				x	x	x
Magpie Goose	<i>Anseranas semipalmata</i>	x		x			x	x	x	
Wandering Whistling-Duck	<i>Dendrocygna arcuata</i>						x		x	
Green Pygmy-goose	<i>Nettapus pulchellus</i>						x		x	
Black Swan	<i>Cygnus atratus</i>	x						x	x	
Pacific Black Duck	<i>Anas superciliosa</i>	x					x	x	x	
Grey Teal	<i>Anas gracilis</i>	x		x			x	x	x	
Pink-eared Duck	<i>Malacorhynchus membranaceus</i>	x					x	x	x	
Hardhead	<i>Aythya australis</i>	x					x	x		
Radjah Shelduck	<i>Tadorna radjah</i>								x	x
Hoary-headed Grebe	<i>Poliiocephalus poliocephalus</i>	x					x	x	x	
Australasian Grebe	<i>Tachybaptus novaehollandiae</i>						x	x	x	
Darter	<i>Anhinga melanogaster</i>	x					x		x	
Pied Cormorant	<i>Phalacrocorax varius</i>	x					x	x	x	x
Little Pied Cormorant	<i>Phalacrocorax melanoleucas</i>	x						x	x	
Little Black Cormorant	<i>Phalacrocorax sulcirostris</i>	x	x				x		x	
Australian Pelican	<i>Pelicanus conspicillatus</i>	x					x		x	
White-necked Heron	<i>Ardea pacifica</i>	x		x			x	x	x	x
Great-billed Heron	<i>Ardea sumatrana</i>	x							x	
White-faced Heron	<i>Ardea novaehollandiae</i>	x	x	x			x	x	x	x
Pied Heron	<i>Ardea picata</i>						x			
Great Egret	<i>Ardea modesta</i>	x		x	x		x	x	x	x
Intermediate Egret	<i>Ardea intermedia</i>	x		x			x	x	x	x
Little Egret	<i>Egretta garzetta</i>						x		x	x
Cattle Egret	<i>Ardea ibis</i>						x			
Nankeen Night Heron	<i>Nycticorax caledonicus</i>	x	x	x	x			x	x	x
Black Bittern	<i>Ixobrychus flavicollis</i>	x							x	
Straw-necked Ibis	<i>Threskiornis spinicollis</i>						x	x	x	
Australian White Ibis	<i>Threskiornis molucca</i>								x	
Glossy Ibis	<i>Plegadis falcinellus</i>						x		x	
Royal Spoonbill	<i>Platalea regia</i>						x		x	
Black-necked Stork	<i>Ephippiorhynchus asiaticus</i>	x					x	x	x	x
Bush Stone-curlew	<i>Burhinus grallarius</i>							x		
Eastern Osprey	<i>Pandion cristatus</i>	x							x	
Black-breasted Buzzard	<i>Hamirostra melanosternon</i>		x				x		x	
Black Kite	<i>Milvus migrans</i>	x	x	x			x	x	x	x
Whistling Kite	<i>Haliastur sphenurus</i>	x	x	x			x	x	x	x
Square-tailed Kite	<i>Lophoictinia isura</i>								x	
Black-shouldered Kite	<i>Elanus axillaris</i>							x		
White-bellied Sea-eagle	<i>Haliaeetus leucogaster</i>	x	x				x	x	x	
Pacific Baza	<i>Aviceda subcristata</i>								x	x
Spotted Harrier	<i>Circus assimilis</i>						x	x		
Brown Goshawk	<i>Accipiter fasciatus</i>		x	x			x	x		x
Collared Sparrowhawk	<i>Accipiter cirrhocephalus</i>		x	x			x	x	x	
Red Goshawk	<i>Erythrotriorchis radiatus</i>		x							
Little Eagle	<i>Hieraetus morphnoides</i>								x	
Wedge-tailed Eagle	<i>Aquila audax</i>	x	x				x	x	x	
Australian Hobby	<i>Falco longipennis</i>	x	x	x			x	x	x	
Brown Falcon	<i>Falco berigora</i>		x	x			x	x	x	x
Australian Kestrel	<i>Falco cenchroides</i>			x			x	x	x	
Peregrine Falcon	<i>Falco peregrinus</i>	x	x						x	
Grey Falcon	<i>Falco hypoleucos</i>								x	
Brolga	<i>Grus rubicunda</i>	x		x			x	x	x	x
Buff-banded Rail	<i>Gallirallus philippensis</i>	x						x	x	
Dusky Moorhen	<i>Gallinula tenebrosa</i>	x					x			
Purple Swamphen	<i>Porphyrio porphyrio</i>	x							x	
Eurasian Coot	<i>Fulica atra</i>	x					x	x		
Australian Bustard	<i>Ardeotis australis</i>	x	x	x			x	x	x	x
Red-chested Button-quail	<i>Turnix pyrrhorthorax</i>	x		x				x	x	
Red-backed Button-quail	<i>Turnix maculosa</i>	x	x					x	x	
Little Button-quail	<i>Turnix velox</i>	x		x				x	x	
Common Greenshank	<i>Tringa nebularia</i>						x	x		
Black-winged Stilt	<i>Himantopus himantopus</i>	x		x			x	x	x	x
Red-capped Plover	<i>Charadrius ruficapillus</i>						x			

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Oriental Plover	<i>Charadrius veredus</i>	x						x	x	
Marsh Sandpiper	<i>Tringa stagnatilis</i>								x	
Common Greenshank	<i>Tringa nebularia</i>								x	
Common Sandpiper	<i>Actitis hypoleucos</i>									
Sharp-tailed Sandpiper	<i>Calidris acuminata</i>								x	
Black-fronted Dotterel	<i>Elseyornis melanops</i>	x		x			x	x	x	
Red-kneed Dotterel	<i>Erythrogonys cinctus</i>						x			
Masked Lapwing	<i>Vanellus miles</i>	x		x			x	x	x	x
Oriental Pratincole	<i>Glareola maldivarum</i>							x	x	
Australian Pratincole	<i>Stiltia isabella</i>	x					x	x	x	
Whiskered Tern	<i>Chlidonias hybrida</i>								x	
Peaceful Dove	<i>Geopelia striata</i>	x	x	x	x		x	x	x	x
Diamond Dove	<i>Geopelia cuneata</i>		x	x			x	x	x	x
Bar-shouldered Dove	<i>Geopelia humeralis</i>	x	x	x			x	x	x	x
Crested Pigeon	<i>Ocyphaps lophotes</i>	x	x	x	x		x	x	x	x
Spinifex Pigeon	<i>Geophaps plumifera</i>	x							x	
Common Bronzewing	<i>Phaps chalcoptera</i>		x	x			x	x	x	x
Red-tailed Black-Cockatoo	<i>Calyptorhynchus banksii</i>	x	x	x			x	x	x	x
Sulphur-crested Cockatoo	<i>Cacatua galerita</i>	x	x	x	x		x	x	x	x
Galah	<i>Cacatua roseicapilla</i>	x	x	x			x	x	x	x
Budgerigar	<i>Melopsittacus undulatus</i>		x	x	x					
Red-collared Lorikeet	<i>Trichoglossus rubritorquis</i>	x	x	x			x	x	x	x
Varied Lorikeet	<i>Psitteuteles versicolor</i>		x	x	x		x	x	x	x
Northern Rosella	<i>Platycercus venustus</i>	x	x	x			x	x	x	x
Red-winged Parrot	<i>Aprosmictus erythropterus</i>	x	x	x			x	x	x	x
Cockatiel	<i>Nymphicus hollandicus</i>		x	x	x		x	x	x	
Pallid Cuckoo	<i>Cacomantis pallidus</i>	x		x			x	x	x	x
Brush Cuckoo	<i>Cacomantis variolosus</i>			x			x	x	x	
Black-eared Cuckoo	<i>Chalcites osculans</i>	x						x	x	
Horsfield's Bronze-Cuckoo	<i>Chrysococcyx basalis</i>		x	x			x	x	x	
Little Bronze-Cuckoo	<i>Chalcites minutillus</i>								x	
Channel-billed Cuckoo	<i>Scythrops novaehollandiae</i>	x	x	x			x	x	x	
Eastern Koel	<i>Eudynamys orientalis</i>	x		x			x	x	x	
Pheasant Coucal	<i>Centropus phasianinus</i>	x	x	x			x	x	x	
Barking Owl	<i>Ninox connivens</i>	x							x	x
Southern Boobook Owl	<i>Ninox novaeseelandiae</i>	x	x	x			x	x	x	x
Masked Owl (mainland Top End)	<i>Tyto novaehollandiae kimberli</i>							x		
Barn Owl	<i>Tyto alba</i>		x	x				x		
Tawny Frogmouth	<i>Podargus strigoides</i>	x	x				x	x	x	x
Spotted Nightjar	<i>Eurostopodus argus</i>		x	x			x	x		x
Australian Owlet-nightjar	<i>Aegotheles cristatus</i>	x	x	x	x			x	x	x
Azure Kingfisher	<i>Alcedo azurea</i>	x		x			x	x	x	x
Sacred Kingfisher	<i>Todiramphus sanctus</i>	x	x	x			x	x	x	x
Red-backed Kingfisher	<i>Todiramphus pyrrhopygia</i>	x	x				x	x	x	x
Forest Kingfisher	<i>Todiramphus macleayii</i>								x	
Blue-winged Kookaburra	<i>Dacelo leachii</i>	x	x	x			x	x	x	x
Rainbow Bee-eater	<i>Merops ornatus</i>	x	x	x	x		x	x	x	x
Dollarbird	<i>Eurystomus orientalis</i>	x		x			x	x	x	
Black-tailed Treecreeper	<i>Climacteris melanura</i>		x				x	x	x	
Variegated Fairy-wren	<i>Malurus lamberti</i>	x			x			x	x	
Red-backed Fairy-wren	<i>Malurus melanocephalus</i>	x	x	x	x		x	x	x	x
Purple-crowned Fairy-wren	<i>Malurus coronatus</i>	x	x	x			x	x	x	x
Carpenterian Grasswren	<i>Amytornis dorotheae</i>				x			x		
Striated Pardalote	<i>Pardalotus striatus</i>	x	x	x	x		x	x	x	x
Red-browed Pardalote	<i>Pardalotus rubricatus</i>		x					x	x	
Weebill	<i>Smicromis brevirostris</i>	x	x	x	x		x	x	x	x
White-throated Gerygone	<i>Gerygone albogularis</i>		x	x			x	x	x	x
Silver-crowned Friarbird	<i>Philemon argenticeps</i>	x	x	x			x	x	x	x
Little Friarbird	<i>Philemon citreogularis</i>	x	x	x			x	x	x	x
White-gaped Honeyeater	<i>Lichenostomus unicolor</i>	x	x	x	x		x	x	x	x
White-throated Honeyeater	<i>Melithreptus albogularis</i>		x	x			x	x	x	x
Grey-headed Honeyeater	<i>Lichenostomus keartlandi</i>						x		x	
Yellow-tinted Honeyeater	<i>Lichenostomus flavescens</i>	x	x	x	x		x	x	x	x
Grey-fronted Honeyeater	<i>Lichenostomus plumulus</i>	x	x					x	x	
Dusky Honeyeater	<i>Myzomela obscura</i>	x						x	x	
Brown Honeyeater	<i>Lichmera indistincta</i>	x	x	x	x		x	x	x	x

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Singing Honeyeater	<i>Lichenostomus virescens</i>		x	x	x		x	x	x	x
Rufous-throated Honeyeater	<i>Conopophila rufogularis</i>	x	x	x	x		x	x	x	x
Banded Honeyeater	<i>Cissomela pectoralis</i>	x	x				x	x	x	
Bar-breasted Honeyeater	<i>Ramsayornis fasciatus</i>			x			x	x	x	
Painted Honeyeater	<i>Grantiella picta</i>							x		
Black-chinned Honeyeater	<i>Melithreptus gularis</i>							x	x	x
Blue-faced Honeyeater	<i>Entomyzon cyanotis</i>		x	x			x	x	x	
Crimson Chat	<i>Epthianura tricolor</i>								x	
Buff-sided Robin	<i>Poecilodryas cerviniventris</i>	x	x				x	x	x	
Grey-crowned Babbler	<i>Pomatostomas temporalis</i>	x	x	x			x	x	x	x
Varied Sittela	<i>Daphoenositta chrysoptera</i>		x				x	x	x	
Rufous Whistler	<i>Pachycephala rufiventris</i>	x	x	x	x		x	x	x	x
Sandstone Shrike-thrush	<i>Colluricincla woodwardi</i>	x			x			x	x	
Grey Shrike-thrush	<i>Colluricincla harmonica</i>	x	x	x			x	x	x	x
Restless Flycatcher	<i>Myiagra inquieta</i>	x	x	x			x	x	x	x
Leaden Flycatcher	<i>Myiagra rubecula</i>		x	x			x	x	x	x
Shining Flycatcher	<i>Myiagra alecto</i>			x				x		
Apostlebird	<i>Struthidea cinerea</i>								x	
Jacky Winter	<i>Microeca fascinans</i>							x	x	
Australian Magpie-lark	<i>Grallina cyanoleuca</i>	x	x	x	x		x	x	x	x
Arafura Fantail	<i>Rhipidura dryas</i>	x							x	
Northern Fantail	<i>Rhipidura rufiventris</i>		x		x			x	x	
Grey Fantail	<i>Rhipidura fuliginosa</i>						x	x	x	
Willie Wagtail	<i>Rhipidura leucophrys</i>	x	x	x	x		x	x	x	x
Black-faced Cuckoo-shrike	<i>Coracina novaehollandiae</i>	x	x	x	x		x	x	x	x
White-bellied Cuckoo-shrike	<i>Coracina papuensis</i>		x	x	x		x	x	x	x
Varied Triller	<i>Lalage leucomela</i>	x								
White-winged Triller	<i>Lalage sueurii</i>	x	x	x			x	x	x	x
Olive-backed Oriole	<i>Oriolus sagittatus</i>	x	x	x			x	x	x	x
Figbird	<i>Sphecotheres viridus</i>						x			
Black-faced Woodswallow	<i>Artamus cinereus</i>	x	x	x	x		x	x	x	x
White-breasted Woodswallow	<i>Artamus leucorhynchus</i>			x	x		x	x	x	
Little Woodswallow	<i>Artamus minor</i>	x	x	x	x		x	x	x	
Masked Woodswallow	<i>Artamus personatus</i>							x	x	
White-browed Woodswallow	<i>Artamus superciliosus</i>							x		
Fork-tailed Swift	<i>Apus pacificus</i>							x	x	
Pied Butcherbird	<i>Cracticus nigrogularis</i>	x	x	x	x		x	x	x	x
Australian Magpie	<i>Gymnorhina tibicen</i>	x	x	x			x	x	x	x
Spangled Drongo	<i>Dicrurus bracteatus</i>								x	
Torresian Crow	<i>Corvus orru</i>	x	x	x			x	x	x	x
Australian Raven	<i>Corvus coronoides</i>	x							x	
Great Bowerbird	<i>Ptilonorhynchus nuchalis</i>	x	x	x	x		x	x	x	x
Singing Bushlark	<i>Mirafrja javanica</i>				x					
Brown Songlark	<i>Cincloramphus cruralis</i>							x	x	
Zebra Finch	<i>Taeniopygia guttata</i>						x			
Double-barred Finch	<i>Taeniopygia bichenovii</i>	x	x	x			x	x	x	x
Crimson Finch	<i>Neochmia phaeton</i>	x	x	x			x	x	x	x
Long-tailed Finch	<i>Poephila acuticauda</i>	x	x		x		x	x	x	x
Masked Finch	<i>Poephila personata</i>		x	x			x	x	x	x
Star Finch	<i>Neochmia ruficauda</i>							x		
Pictorella Mannikin	<i>Heteromunia pectoralis</i>			x				x		
Chestnut-breasted Mannikin	<i>Lonchura castaneothorax</i>	x		x			x	x	x	
Yellow Wagtail	<i>Motacilla flava tschutschensis</i>								x	
Mistletoebird	<i>Dicaeum hirundinaceum</i>		x	x			x	x	x	x
Fairy Martin	<i>Cincloramphus cruralis</i>	x		x			x	x	x	
Tree Martin	<i>Petrochelidon nigricans</i>		x				x	x	x	
Spinifexbird	<i>Eremionis carteri</i>				x					
Golden-headed Cisticola	<i>Cisticola exilis</i>			x			x	x	x	
	189	106	87	93	35	0	124	140	159	77

Common name	Scientific name	URS/MRM 2003	Ecostudy (1992)	Hollingswood Dames & Moore (1992)	Martin & McKean (1986)	Tytre (1992)	MRM bird obs (1999-2002)	NRETAS (2011)	P. Barden Records 2003-2011	Current Study (S. 3.4)
Mammals										
Short-beaked Echidna	<i>Tachyglossus aculeatus</i>	x	x		x				x	
Long-tailed Planigale	<i>Planigale ingrami</i>	x		x				x	x	x
Sugar Glider	<i>Petaurus breviceps</i>									x
Northern Quoll	<i>Dasyurus hallucatus</i>	x	x							
Rock Ringtail Possum	<i>Petropseudes dahli</i>	x							x	
Spectacled Hare-wallaby	<i>Lagorchestes conspicillatus</i>			x				x	x	
Agile Wallaby	<i>Macropus agilis</i>	x	x	x				x	x	x
Antilopine Kangaroo	<i>Macropus antilopinus</i>			x				x	x	x
Common Wallaroo	<i>Macropus robustus</i>	x	x	x	x			x	x	
Little Red Flying Fox	<i>Pteropus scapulatus</i>	x	x					x	x	x
Orange leafnosed bat	<i>Rhinonictes aurantia</i>									x
Common Sheathtail-bat	<i>Taphozous georgianus</i>	x							x	x
Yellow-bellied Sheathtail-bat	<i>Saccolaimus flaviventris</i>	x	x					x	x	x
Dusky Leaf-nosed Bat	<i>Hipposideros ater</i>	x						x	x	
Gould's Wattled Bat	<i>Chalinolobus gouldi</i>	x						x	x	x
Hoary wattle-bat	<i>Chalinolobus nigrogriseus</i>									x
Northern Myotis	<i>Myotis adversus</i>	x								x
Little Broad-nosed Bat	<i>Scotorepens greyii</i>	x								x
Northern Cave Bat	<i>Vespadelus caurinus</i>	x						x	x	x
Lesser Long-eared Bat	<i>Nyctophilus geoffroyi</i>		x							
Arnhem longeared bat	<i>Nyctophilus arhemensis</i>									x
Northern Freetail Bat	<i>Chaerephon jobensis</i>	x						x	x	x
Long-haired Rat	<i>Rattus villosissimus</i>			x				x		
Western Chestnut Mouse	<i>Pseudomys nanus</i>							x		
Delicate Mouse	<i>Pseudomys delicatulus</i>		x							
Water-rat	<i>Hydromys chrysogaster</i>									x
Common Rock-rat	<i>Zyzomus argurus</i>	x	x	x				x	x	
Dingo	<i>Canis lupus dingo</i>	x	x	x				x	x	x
*Donkey	<i>Equus asinus</i>	x	x	x				x	x	x
*Cattle	<i>Bos taurus/indicus</i>	x	x	x				x	x	x
*Pig	<i>Sus scrofa</i>	x	x						x	x
*Feral Cat	<i>Felis catus</i>	x	x					x	x	
	32	21	14	10	2	0	0	18	20	20

* = introduced species

Appendix B Riparian Birds

Common Name	Scientific Name	Barney Ck Sites						McArthur Diversion Sites						Downstream Sites					Pit Sites						Upstream Sites				
		MRBAR1	MRBAR2	MRBAR3	MRBAR4	MRBAR5	MRBAR6	MRDIV1	MRDIV2	MRDIV3	MRDIV4	MRDIV5	MRDIV6	MRDST1	MRDST2	MRDST3	MRDST4	MRDST5	MRPIT1	MRPIT2	MRPIT3	MRPIT4	MRPIT5	MRPIT6	MRUST1	MRUST2	MRUST3	MRUST4	MRUST5
Masked Lapwing	<i>Vanellus miles</i>		x	x	x	x	x	x	x	x	x	x																	
Black-fronted Dotterel	<i>Elsyornis melanops</i>			x	x			x	x	x	x	x							x										
Marsh Sandpiper	<i>Tringa stagnatilis</i>									x																			
Common Greenshank	<i>Tringa nebularia</i>							x	x	x	x																		
Common Sandpiper	<i>Actitis hypoleucos</i>							x	x	x																			
Sharp-tailed Sandpiper	<i>Calidris acuminata</i>									x	x																		
Red-backed Button-quail	<i>Turnix maculosus</i>																		x										
Australian Pratincole	<i>Stiltia isabella</i>				x	x		x																					
Whiskered Tern	<i>Chlidonias hybrida</i>							x	x			x																	
Red-tailed Black-Cockatoo	<i>Calyptorhynchus banksii</i>	x	x	x	x	x	x	x	x	x			x					x	x	x	x			x	x	x	x	x	
Galah	<i>Eolophus roseicapillus</i>	x	x		x	x	x		x	x				x				x	x	x	x	x		x	x	x	x	x	
Sulphur-crested Cockatoo	<i>Cacatua galerita</i>	x	x	x	x	x	x	x	x				x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	
Cockatiel	<i>Nymphicus hollandicus</i>					x														x									
Rainbow Lorikeet	<i>Trichoglossus haematodus</i>	x	x	x	x	x	x	x	x	x			x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	
Varied Lorikeet	<i>Psittuteutes versicolor</i>					x		x		x			x	x	x	x	x	x	x	x	x			x	x	x	x	x	
Northern Rosella	<i>Platycercus venustus</i>												x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	
Red-winged Parrot	<i>Aprosmictus erythropterus</i>	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	
Pheasant Coucal	<i>Centropus phasianinus</i>	x	x			x	x						x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	
Pallid Cuckoo	<i>Cacomantis pallidus</i>														x														
Brush Cuckoo	<i>Cacomantis variolosus</i>					x						x	x	x	x	x		x		x	x	x		x		x	x	x	
Black-eared Cuckoo	<i>Chalcites osculans</i>					x						x															x		
Horsfield's Bronze-Cuckoo	<i>Chalcites basalis</i>	x	x			x		x	x	x						x		x		x						x	x		
Little Bronze-Cuckoo	<i>Chalcites minutillus</i>																										x	x	
Eastern Koel	<i>Eudynamis orientalis</i>	x						x												x	x			x	x	x	x	x	
Channel-billed Cuckoo	<i>Scythrops novaehollandiae</i>	x						x								x		x		x				x	x	x			
Barking Owl	<i>Ninox connivens</i>				x								x	x	x					x		x						x	
Southern Boobook	<i>Ninox novaeseelandiae</i>																	x											
Azure Kingfisher	<i>Ceyx azurea</i>				x							x	x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	
Blue-winged Kookaburra	<i>Dacelo leachii</i>	x	x	x	x	x	x	x				x	x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	
Red-backed Kingfisher	<i>Todiramphus pyrrhopygia</i>	x	x			x				x	x	x									x								
Sacred Kingfisher	<i>Todiramphus sanctus</i>	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	
Rainbow Bee-eater	<i>Merops ornatus</i>	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	
Dollarbird	<i>Eurystomus orientalis</i>	x	x	x		x	x	x				x	x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	
Black-tailed Treecreeper	<i>Climacteris melanura</i>			x																									
Great Bowerbird	<i>Ptilonorhynchus nuchalis</i>	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	
Red-backed Fairy-wren	<i>Malurus melanocephalus</i>	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	
Variegated Fairy-wren	<i>Malurus lamberti</i>												x	x						x	x	x		x					
Purple-crowned Fairy-wren	<i>Malurus coronatus</i>			x	x			x				x	x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	
Weebill	<i>Smicronis brevirostris</i>	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x							
White-throated Gerygone	<i>Gerygone albogularis</i>	x	x										x	x		x	x				x	x		x	x	x	x	x	
Red-browed Pardalote	<i>Pardalotus rubricatus</i>					x																							
Striated Pardalote	<i>Pardalotus striatus</i>	x	x	x	x	x	x	x	x			x	x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	
Brown Honeyeater	<i>Lichmera indistincta</i>	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	
Banded Honeyeater	<i>Cissomela pectoralis</i>	x								x	x																		
Singing Honeyeater	<i>Lichenostomus virescens</i>				x	x	x			x	x	x																	
White-gaped Honeyeater	<i>Lichenostomus unicolor</i>	x	x	x		x				x			x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	
Yellow-tinted Honeyeater	<i>Lichenostomus flavescens</i>	x	x	x		x	x			x	x		x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	
Grey-fronted Honeyeater	<i>Lichenostomus plumulus</i>				x																								
White-throated Honeyeater	<i>Melithreptus albogularis</i>	x	x	x	x	x	x			x	x		x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	
Black-chinned Honeyeater	<i>Melithreptus gularis</i>																												
Little Friarbird	<i>Philemon citreogularis</i>	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	

Common Name	Scientific Name	Barney Ck Sites						McArthur Diversion Sites						Downstream Sites					Pit Sites						Upstream Sites				
		MRBAR1	MRBAR2	MRBAR3	MRBAR4	MRBAR5	MRBAR6	MRDIV1	MRDIV2	MRDIV3	MRDIV4	MRDIV5	MRDIV6	MRDST1	MRDST2	MRDST3	MRDST4	MRDST5	MRPIT1	MRPIT2	MRPIT3	MRPIT4	MRPIT5	MRPIT6	MRUST1	MRUST2	MRUST3	MRUST4	MRUST5
Silver-crowned Friarbird	<i>Philemon argenticeps</i>	x		x		x		x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Bar-breasted Honeyeater	<i>Ramsayornis fasciatus</i>																												
Rufous-throated Honeyeater	<i>Conopophila rufogularis</i>	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Blue-faced Honeyeater	<i>Entomyzon cyanotis</i>		x								x			x	x		x	x		x	x			x	x	x	x	x	x
Crimson Chat	<i>Epthianura tricolor</i>			x						x	x																		
Grey-crowned Babbler	<i>Pomatostomus temporalis</i>	x	x	x	x	x	x		x	x	x	x	x		x	x	x		x										x
Varied Sittella	<i>Daphoenositta chrysoptera</i>													x		x							x	x					
Black-faced Cuckoo-shrike	<i>Coracina novaehollandiae</i>	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
White-bellied Cuckoo-shrike	<i>Coracina papuensis</i>	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
White-winged Triller	<i>Lalage sueurii</i>		x	x	x	x	x		x	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x
Rufous Whistler	<i>Pachycephala rufiventris</i>	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Grey Shrike-thrush	<i>Colluricincla harmonica</i>					x				x		x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Olive-backed Oriole	<i>Oriolus sagittatus</i>	x	x			x	x		x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
White-breasted Woodswallow	<i>Artamus leucorhynchus</i>		x	x																									x
Masked Woodswallow	<i>Artamus personatus</i>	x			x	x	x	x	x	x				x			x			x	x								x
Black-faced Woodswallow	<i>Artamus cinereus</i>	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x					x				x		
Little Woodswallow	<i>Artamus minor</i>		x	x			x	x	x	x	x	x	x	x	x	x	x		x	x		x	x		x		x	x	
Pied Butcherbird	<i>Croacticus nigrogularis</i>	x	x	x	x	x	x	x	x	x	x	x				x	x		x	x		x		x	x	x	x	x	x
Australian Magpie	<i>Croacticus tibicen</i>	x	x	x			x			x	x	x	x		x	x	x	x	x				x		x	x	x	x	x
Spangled Drongo	<i>Dicrurus bracteatus</i>															x	x											x	
Northern Fantail	<i>Rhipidura rufiventris</i>												x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
Willie Wagtail	<i>Rhipidura leucophrys</i>	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Grey Fantail	<i>Rhipidura albiscapa</i>							x						x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Arafura Fantail	<i>Rhipidura dryas</i>															x			x	x								x	x
Torresian Crow	<i>Corvus orru</i>	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Magpie-lark	<i>Grallina cyanoleuca</i>	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Leaden Flycatcher	<i>Myiagra rubecula</i>	x		x		x	x				x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Restless Flycatcher	<i>Myiagra inquieta</i>	x										x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Apostlebird	<i>Struthidea cinerea</i>		x																										
Buff-sided Robin	<i>Poecilodryas cerviniventris</i>													x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Golden-headed Cisticola	<i>Cisticola exilis</i>	x																	x	x		x	x						x
Brown Songlark	<i>Cincloramphus cruralis</i>																										x		
Tree Martin	<i>Petrochelidon nigricans</i>		x					x	x			x	x														x	x	
Fairy Martin	<i>Petrochelidon ariel</i>															x	x	x											
Mistletoebird	<i>Dicaeum hirundinaceum</i>	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Crimson Finch	<i>Neochmia phaeton</i>			x		x		x							x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Double-barred Finch	<i>Taeniopygia bichenovii</i>	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Masked Finch	<i>Poephila personata</i>	x								x	x	x	x																x
Long-tailed Finch	<i>Poephila acuticauda</i>	x	x				x					x															x		x
Chestnut-breasted Mannikin	<i>Lonchura castaneothorax</i>		x	x		x				x																	x		
Yellow Wagtail	<i>Motacilla flava tschutschensis</i>																												

Appendix C Fauna Observations

Appendix C - Combined Results of Fauna Observations, June 2011

Common Name	Scientific Name	North OEF	Pit & East OEF	TSF
Amphibians				
Ornate Burrowing Frog	<i>Opisthodon ornatus</i>	x		
Green Tree-frog	<i>Litoria caerulea</i>	x	x	
Peter's Frog	<i>Litoria inermis</i>	x		
Rocket Frog	<i>Litoria nasuta</i>		x	
Pale Frog	<i>Litoria pallida</i>	x	x	
Roth's Tree-frog	<i>Litoria rothi</i>		x	
Red Tree-frog	<i>Litoria rubella</i>	x	x	
Desert Froglet	<i>Crinia deserticola</i>	x	x	
Wotjulum Frog	<i>Litoria wotjulumensis</i>			x
Cane Toad	<i>Rhinella marina</i>	x	x	
TOTAL		10	7	1
Reptiles				
Worrell's Turtle	<i>Emydura worrelli</i>		x	
Northern Dtella	<i>Gehyra australis</i>	x	x	
Two-Spined Rainbow Skink	<i>Carlia amax</i>	x		
Metallic Snake-eyed Skink	<i>Cryptoblepharus metallicus</i>	x	x	
Spalding's Ctenotus	<i>Ctenotus spaldingi</i>	x		
Leopard Ctenotus	<i>Ctenotus pantherinus</i>	x		
Northern Dwarf Skink	<i>Menetia maini</i>			x
Frilled Lizard	<i>Chlamydosaurus kingii</i>	x		
Gilbert's Dragon	<i>Amphibolurus gilberti</i>	x		
Mertens' Water Monitor	<i>Varanus mertensi</i>			x
Black-headed Python	<i>Aspidites melanocephalus</i>	x		
Olive Python	<i>Liasis olivaceus</i>			x
Keelback	<i>Tropidonophis mairii</i>		x	
Curl Snake	<i>Suta suta</i>	x		
Common Tree Snake	<i>Dendrelaphus punctulatus</i>		x	
TOTAL		15	5	3

Common Name	Scientific Name	North OEF	Pit & East OEF	TSF
Birds				
Brown Quail	<i>Coturnix ypsilophora</i>	x		
Radjah Shelduck	<i>Tadorna radjah</i>		x	
Pied Cormorant	<i>Phalacrocorax varius</i>			x
White-necked Heron	<i>Ardea pacifica</i>	x		x
White-faced Heron	<i>Egretta novaehollandiae</i>	x	x	x
Eastern Great Egret	<i>Ardea modesta</i>			x
Intermediate Egret	<i>Ardea intermedia</i>		x	x
Little Egret	<i>Egretta garzetta</i>	x		
Nankeen Night-Heron	<i>Nycticorax caledonicus</i>		x	
Black-necked Stork	<i>Ephippiorhynchus asiaticus</i>		x	x
Black Kite	<i>Milvus migrans</i>	x	x	x
Whistling Kite	<i>Haliastur sphenurus</i>	x		
Pacific Baza	<i>Aviceda subcristata</i>		x	x
Brown Goshawk	<i>Accipiter fasciatus</i>		x	
Brown Falcon	<i>Falco berigora</i>	x		
Brolga	<i>Grus rubicunda</i>			x
Australian Bustard	<i>Ardeotis australis</i>	x	x	x
Black-winged Stilt	<i>Himantopus himantopus</i>			x
Masked Lapwing	<i>Vanellus miles</i>		x	x
Peaceful Dove	<i>Geopelia striata</i>	x	x	x
Diamond Dove	<i>Geopelia cuneata</i>	x	x	
Bar-shouldered Dove	<i>Geopelia humeralis</i>	x	x	x
Crested Pigeon	<i>Ocyphaps lophotes</i>	x		
Common Bronzewing	<i>Phaps chalcoptera</i>	x	x	x
Red-tailed Black Cockatoo	<i>Calyptorhynchus banksii</i>	x		x
Sulphur-crested Cockatoc	<i>Cacatua galerita</i>		x	x
Galah	<i>Cacatua roseicapilla</i>	x		x
Red-collared Lorikeet	<i>Trichoglossus rubritorquis</i>	x	x	x
Varied Lorikeet	<i>Psitteuteles versicolor</i>	x		x
Northern Rosella	<i>Platyercus venustus</i>			x
Red-winged Parrot	<i>Aprosmictus erythropterus</i>	x	x	x
Pallid Cuckoo	<i>Cacomantis pallidus</i>	x		
Barking Owl	<i>Ninox connivens</i>	x	x	x
Southern Boobook Owl	<i>Ninox novaeseelandiae</i>	x		
Tawny Frogmouth	<i>Podargus strigoides</i>	x	x	
Spotted Nightjar	<i>Eurostopodus argus</i>	x	x	x
Australian Owlet-nightjar	<i>Aegotheles cristatus</i>	x		
Azure Kingfisher	<i>Alcedo azurea</i>		x	x
Sacred Kingfisher	<i>Todiramphus sanctus</i>		x	
Red-backed Kingfisher	<i>Todiramphus pyrrophygia</i>	x		
Blue-winged Kookaburra	<i>Dacelo leachii</i>	x	x	
Rainbow Bee-eater	<i>Merops ornatus</i>	x	x	x
Red-backed Fairy-wren	<i>Malurus melanocephalus</i>	x		
Purple-crowned Fairy-wren	<i>Malurus coronatus</i>		x	
Striated Pardalote	<i>Pardalotus striatus</i>	x	x	x
Weebill	<i>Smicrornis brevirostris</i>	x	x	

Common Name	Scientific Name	North OEF	Pit & East OEF	TSF
White-throated Gerygone	<i>Gerygone albogularis</i>	x	x	
Silver-crowned Friarbird	<i>Philemon argenticeps</i>	x		x
Little Friarbird	<i>Philemon citreogularis</i>			x
White-gaped Honeyeater	<i>Lichenostomus unicolor</i>	x	x	
White-throated Honeyeater	<i>Melithreptus albogularis</i>	x	x	
Yellow-tinted Honeyeater	<i>Lichenostomus flavescens</i>	x	x	
Brown Honeyeater	<i>Lichmera indistincta</i>	x	x	x
Singing Honeyeater	<i>Lichenostomus virescens</i>	x		x
Rufous-throated Honeyeater	<i>Conopophila rufogularis</i>	x	x	
Black-chinned Honeyeater	<i>Melithreptus gularis</i>	x	x	x
Grey-crowned Babbler	<i>Pomatostomas temporalis</i>			x
Rufous Whistler	<i>Pachycephala rufiventris</i>	x	x	x
Grey Shrike-thrush	<i>Colluricincla harmonica</i>	x	x	
Restless Flycatcher	<i>Myiagra inquieta</i>	x	x	
Leaden Flycatcher	<i>Myiagra rubecula</i>	x		x
Australian Magpie-lark	<i>Grallina cyanoleuca</i>	x	x	x
Willie Wagtail	<i>Rhipidura leucophrys</i>	x	x	x
Black-faced Cuckoo-shrike	<i>Coracina novaehollandiae</i>	x	x	
White-bellied Cuckoo-shrike	<i>Coracina papuensis</i>	x	x	
White-winged Triller	<i>Lalage sueurii</i>	x	x	
Olive-backed Oriole	<i>Oriolus sagittatus</i>	x	x	
Black-faced Woodswallow	<i>Artamus cinereus</i>	x	x	
Pied Butcherbird	<i>Cracticus nigrogularis</i>	x	x	x
Australian Magpie	<i>Cracticus tibicen</i>	x	x	
Torresian Crow	<i>Corvus orru</i>	x	x	x
Great Bowerbird	<i>Ptilonorhynchus nuchalis</i>	x	x	x
Double-barred Finch	<i>Taeniopygia bichenovii</i>	x	x	x
Crimson Finch	<i>Neochmia phaeton</i>		x	
Long-tailed Finch	<i>Poephila acuticauda</i>	x		
Masked Finch	<i>Poephila personata</i>	x		x
Mistletoebird	<i>Dicaeum hirundinaceum</i>	x		
TOTAL		77		
		58	51	42
		89	75	59
Mammals				
Long-tailed Planigale	<i>Planigale ingrami</i>	x		
Sugar Glider	<i>Petaurus breviceps</i>	x		
Agile Wallaby	<i>Macropus agilis</i>	x	x	x
Antilopine Wallaroo	<i>Macropus antilopinus</i>	x		
Little Red Flying-fox	<i>Pteropus scapulatus</i>	x		
Orange leafnosed bat	<i>Rhinonictis aurantia</i>			x
Yellow-bellied sheath-tail-bat	<i>Saccolaimus flaviventris</i>	x	x	
Common sheath-tail-bat	<i>Taphozous georgianus</i>		x	
Northern freetail-bat	<i>Chaerephon jobensis</i>	x	x	x
Gould's wattle-bat	<i>Chalinolobus gouldii</i>	x	x	x
Hoary wattle-bat	<i>Chalinolobus nigrogriseus</i>	x	x	x
Large-footed myotis	<i>Myotis adversus</i>		x	x
Arnhem long-eared bat	<i>Nyctophilus arhemensis</i>	x	x	x
Little broad-nosed bat	<i>Scotorepens greyii</i>	x	x	x
Northern cave bat	<i>Vespadelus caurinus</i>	x	x	x
Water-rat	<i>Hydromys chrysogaster</i>			x
Dingo	<i>Canis familiaris dingo</i>	x		x
Donkey	<i>Equus asinus</i>	x	x	x
Pig	<i>Sus scrofa</i>		x	
Cattle	<i>Bos indicus</i>	x	x	x
TOTAL		20	13	13

Appendix D Trapping Results

Appendix D - Results of Fauna Survey Program June 2011

Numbers indicate total observations; x = observed outside standard counts.

Common Name	Scientific Name	Site 1 (Nth OEF)	Site 2 (Nth OEF)	Site 3 (East OEF)	Site 4 (East OEF)
Pit Trapping Program					
Pale Frog	<i>Litoria pallida</i>		1		2
Red Tree-frog	<i>Litoria rubella</i>			1	1
Cane Toad	<i>Rhinella marina</i>		8	5	3
Metallic Snake-eyed Skink	<i>Cryptoblepharus metallicus</i>			1	1
Spalding's Ctenotus	<i>Ctenotus spaldingi</i>	1			
Long-tailed Planigale	<i>Planigale ingrami</i>		2		
Funnel Trapping Program					
Green Tree-frog	<i>Litoria caerulea</i>		1		
Pale Frog	<i>Litoria pallida</i>		4	1	4
Red Tree-frog	<i>Litoria rubella</i>	1			1
Cane Toad	<i>Rhinella marina</i>			1	2
Spalding's Ctenotus	<i>Ctenotus spaldingi</i>	2			
Leopard Ctenotus	<i>Ctenotus pantherinus</i>	1			
Metallic Snake-eyed Skink	<i>Cryptoblepharus metallicus</i>		1		1
Keelback	<i>Tropidonophis mairii</i>			1	
Elliot/Cage Trapping Program (no captures)					
Active Search Program					
Green Tree-frog	<i>Litoria caerulea</i>		1		2
Peter's Frog	<i>Litoria inermis</i>		5		
Rocket Frog	<i>Litoria nasuta</i>				1
Pale Frog	<i>Litoria pallida</i>		7	2	3
Roth's Tree-frog	<i>Litoria rothi</i>				2
Red Tree-frog	<i>Litoria rubella</i>		3	1	7
Desert Froglet	<i>Crinia deserticola</i>		2		
Cane Toad	<i>Rhinella marina</i>		15		2
Northern Dtella	<i>Gehyra australis</i>	1		2	2
Two-Spined Rainbow Skink	<i>Carlia amax</i>	1	2		
Metallic Snake-eyed Skink	<i>Cryptoblepharus metallicus</i>	1		10	1
Curl Snake	<i>Suta suta</i>		1		
Common Tree Snake	<i>Dendrelaphus punctulatus</i>			1	

Common Name	Scientific Name	Site 1 (Nth OEF)	Site 2 (Nth OEF)	Site 3 (East OEF)	Site 4 (East OEF)
Bird Census Program					
Brown Quail	<i>Coturnix ypsilophora</i>	x	10		
Radjah Shelduck	<i>Tadorna radjah</i>				2
Common Bronzewing	<i>Phaps chalcoptera</i>			1	
Diamond Dove	<i>Geopelia cuneata</i>		15	1	
Peaceful Dove	<i>Geopelia striata</i>	1	3	5	2
Bar-shouldered Dove	<i>Geopelia humeralis</i>		1	1	6
Tawny Frogmouth	<i>Podargus strigoides</i>	1		1	
Large-tailed Nightjar	<i>Caprimulgus macrurus</i>	x		x	
Black-necked Stork	<i>Ephippiorhynchus asiaticus</i>				2
Intermediate Egret	<i>Ardea intermedia</i>				2
White-faced Heron	<i>Egretta novaehollandiae</i>				7
Nankeen Night-Heron	<i>Nycticorax caledonicus</i>				3
Pacific Baza	<i>Aviceda subcristata</i>			1	
Black Kite	<i>Milvus migrans</i>	2	1	x	5
Whistling Kite	<i>Haliastur sphenurus</i>		x		
Brown Goshawk	<i>Accipiter fasciatus</i>			1	
Brown Falcon	<i>Falco berigora</i>		1		
Masked Lapwing	<i>Vanellus miles</i>			6	
Sulphur-crested Cockatoo	<i>Cacatua galerita</i>				17
Rainbow Lorikeet	<i>Trichoglossus haematodus</i>	x	x	2	10
Varied Lorikeet	<i>Psitteuteles versicolor</i>	x	x		
Red-winged Parrot	<i>Aprosmictus erythropterus</i>	2	2		1
Pallid Cuckoo	<i>Cacomantis pallidus</i>	x			
Barking Owl	<i>Ninox connivens</i>	x	x	3	1
Azure Kingfisher	<i>Ceyx azurea</i>				1
Blue-winged Kookaburra	<i>Dacelo leachii</i>			1	10
Red-backed Kingfisher	<i>Todiramphus pyrrhopygia</i>	x	1		
Sacred Kingfisher	<i>Todiramphus sanctus</i>				1
Rainbow Bee-eater	<i>Merops ornatus</i>			5	3
Great Bowerbird	<i>Ptilonorhynchus nuchalis</i>				5
Red-backed Fairy-wren	<i>Malurus melanocephalus</i>	13	2		
Purple-crowned Fairy-wren	<i>Malurus coronatus</i>				19
Weebill	<i>Smicronis brevirostris</i>	20	19	5	
White-throated Gerygone	<i>Gerygone albogularis</i>	1	1		
Striated Pardalote	<i>Pardalotus striatus</i>	x		12	11
Brown Honeyeater	<i>Lichmera indistincta</i>	5	5	21	
Singing Honeyeater	<i>Lichenostomus virescens</i>	5	3		
White-gaped Honeyeater	<i>Lichenostomus unicolor</i>				16
Yellow-tinted Honeyeater	<i>Lichenostomus flavescens</i>			17	22
White-throated Honeyeater	<i>Melithreptus albogularis</i>	5			2
Rufous-throated Honeyeater	<i>Conopophila rufogularis</i>				8
Black-faced Cuckoo-shrike	<i>Coracina novaehollandiae</i>	1		2	2
White-bellied Cuckoo-shrike	<i>Coracina papuensis</i>	2	1		3
White-winged Triller	<i>Lalage sueurii</i>	3	22	4	1
Rufous Whistler	<i>Pachycephala rufiventris</i>	2	2	1	9
Grey Shrike-thrush	<i>Colluricincla harmonica</i>				3
Olive-backed Oriole	<i>Oriolus sagittatus</i>				1
Black-faced Woodswallow	<i>Artamus cinereus</i>	2	20	5	
Pied Butcherbird	<i>Cracticus nigrogularis</i>		3	2	1
Australian Magpie	<i>Cracticus tibicen</i>	1		3	
Willie Wagtail	<i>Rhipidura leucophrys</i>	6	8	10	3
Torresian Crow	<i>Corvus orru</i>	3	2	x	1
Magpie-lark	<i>Grallina cyanoleuca</i>	x	2		2
Restless Flycatcher	<i>Myiagra inquieta</i>		2		
Mistletoebird	<i>Dicaeum hirundinaceum</i>		1	1	
Crimson Finch	<i>Neochmia phaeton</i>				35
Double-barred Finch	<i>Taeniopygia bichenovii</i>	2		4	13
Masked Finch	<i>Poephila personata</i>	1			
Long-tailed Finch	<i>Poephila acuticauda</i>	2			
Total number of observations		80	127	115	230
Total taxa	59	30	27	28	35
Number of 10 min/1ha bird counts		8	8	8	8

Common Name	Scientific Name	Site 1 (Nth OEF)	Site 2 (Nth OEF)	Site 3 (East OEF)	Site 4 (East OEF)
Hair Tube Program					
Dog/Dingo	<i>Canis familiaris</i>			1	
Camera Trapping Program					
Cane Toad	<i>Rhinella marina</i>				X
Bush Thick-knee	<i>Burhinus grallarius</i>		X		
White-necked Heron	<i>Ardea pacifica</i>		X		
Torresian Crow	<i>Corvus orru</i>			X	
Dingo	<i>Canis familiaris dingo</i>		X		
Cattle	<i>Bos sp</i>		X		
	Number of Taxa	0	4	1	1
	Number of Camera Nights	5	5	5	5
Anabat Program					
Yellow-bellied sheathtail-bat	<i>Saccolaimus flaviventris</i>		x	x	
Common sheathtail-bat	<i>Taphozous georgianus</i>			x	
Northern freetail-bat	<i>Chaerephon jobensis</i>	x	x	x	x
Gould's wattle-bat	<i>Chalinolobus gouldii</i>	x	x	x	x
Hoary wattle-bat	<i>Chalinolobus nigrogriseus*</i>	x	x	x	x
Longeared bat	<i>Nyctophilus sp**</i>	x	x		x
Little broadnosed bat	<i>Scotorepens greyii*</i>				x
Large-footed myotis	<i>Myotis adversus</i>			x	
Northern cave bat	<i>Vespadelus caurinus</i>	x	x	x	x
	Total No of Species/Taxa	5	5	6	6

NB: Anabat results are given as presence/absence only at each site

* Chalnig and Scorgrey overlap in frequency and identification is probable based on characteristic call features

** Nyctophilus sp can not be reliably separated using Anabat.

Trapping indicates that the most likely species is Nyctophilus arnhemensis

Harp Trapping Program	Site	Ht1	Ht2	Ht3	Ht4
	Site No/Locality	Surprise Ck nr Tailings TSF Nth 9-06-2011 to 15-06-2011	S2 North OEF 9-06-2011 to 15-06-2011	Barney Ck/TSF South 9-06-2011 to 15-06-2011	S4 East OEF 9-06-2011 to 15-06-2011
Orange leafnosed bat	<i>Rhinonicteris aurantia</i>	1		1	
Gould's wattle-bat	<i>Chalinolobus gouldii</i>	3			
Hoary wattle-bat	<i>Chalinolobus nigrogriseus</i>	13	1		1
Arnhem Longeared bat	<i>Nyctophilus arnhemensis</i>			6	1
Little broadnosed bat	<i>Scotorepens greyii</i>			1	
Large-footed myotis	<i>Myotis adversus</i>	24		3	4
Northern cave bat	<i>Vespadelus caurinus</i>	142			
	Total	183	1	11	6
	Harp Trap Nights	6	6	6	6

Appendix E Aquatic Surveys

Appendix E - Fishes of the McArthur River.

Common Name	Scientific Name	Below Burketown Crossing	Above Burketown Crossing	Diversion	Djirrinmini	Eight Mile	Upstream
Bull Shark	<i>Carcharhinus leucas</i>	x	x				
Freshwater Whipray	<i>Himantura chaophraya</i>	x					
Freshwater Sawfish	<i>Pristis microdon</i>	x	x	x	x	x	
Reticulated Glassfish	<i>Ambassis maclaeyi</i>	x	x	x	x	x	x
Northwest Glassfish	<i>Ambassis muelleri</i>	x	x				x
Barred Grunter	<i>Amniataba percoides</i>	x	x	x	x	x	x
Eel sp.	Anguillidae				x		
Toothless Catfish	<i>Anodontoglanis dahli</i>			x	x	x	x
Berney's Catfish	<i>Neoarius bernyi</i>	x	x		x	x	
Lesser Salmon Catfish	<i>Neoarius graeffei</i>	x	x	x	x	x	x
Salmon Catfish	<i>Neoarius leptaspis</i>		x		x	x	
Shovel-nosed Catfish	<i>Neoarius paucus</i>		x	x	x	x	x
Snub-nosed Garfish	<i>Arrhamphus sclerolepis</i>	x	x				
Selheim's Sole	<i>Brachirus selheimi</i>	x			x		x
Small-mouthed Catfish	<i>Cinatus froggatti</i>	x	x				
Milkfish	<i>Chanos chanos</i>	x	x	x	x		
Tadpole Goby	<i>Chlamydogobius ranunculus</i>	x					
Fly-specked Hardyhead	<i>Craterocephalus stercusmuscarum</i>	x	x	x	x	x	x
Giant Herring	<i>Elops hawaiiensis</i>	x	x			x	
Silver Biddies	<i>Gerres sp</i>	x	x				
Mouth Almighty	<i>Glossamia aprion</i>	x	x	x	x	x	x
Golden Goby	<i>Glossogobius aureus</i>	x	x	x	x	x	x
Flathead Goby	<i>Glossogobius giurus</i>	x	x	x	x	x	x
Sooty Grunter	<i>Hephaestus fuliginosus</i>	x	x	x	x	x	x
Barramundi	<i>Lates calcarifer</i>	x	x	x	x	x	x
Spangled Grunter	<i>Leiopotherapon unicolor</i>	x	x	x	x	x	x
Diamond-Scaled Mullet	<i>Liza alata</i>	x	x		x		x
Mullet	<i>Liza subviridis</i>	x	x				
Mullet	<i>Liza vaigiensis</i>	x	x				
Ox-eyed Herring	<i>Megalops cypinoides</i>	x	x		x	x	x
Checkered Rainbowfish	<i>Melanotaenia splendida inornata</i>	x	x	x	x	x	x
Purple-spotted Gudgeon	<i>Mogurnda mogurnda</i>						x
Bony Bream	<i>Nematalosa erebi</i>	x	x	x	x	x	x
Black Tandan	<i>Neosilurus ater</i>		x		x	x	x
Hyrtl's Tandan	<i>Neosilurus hyrtlii</i>		x	x	x	x	x
Sleepy Cod	<i>Oxyeleotris sp</i>	x	x				
Striped Sleepy Cod	<i>Oxyeleotris lineolata</i>			x	x		x
Rendahl's Catfish	<i>Oxyeleotris selheimi</i>	x	x	x	x	x	x
Spotted Scat	<i>Porochilus rendahli</i>						x
Silver Scat	<i>Scatophagus argus</i>	x					
Queenfish	<i>Scatophagus mutlifasciatus</i>	x					
Gulf Grunter	<i>Scomberoides commersonianus</i>	x					
Whiting	<i>Scortum ogiliby</i>		x	x	x	x	x
Freshwater Long-tom	<i>Sillago sp.</i>	x					
Seven-Spot Archerfish	<i>Strongylura krefftii</i>	x	x	x	x	x	x
Banded Archerfish	<i>Toxotes chatareus</i>	x	x	x	x	x	x
Fly River Garfish	<i>Zenarchopterus novaeguineae</i>	x	x				

Shading indicates estuarine vagrants

Appendix F Macroinvertebrates

Appendix F - Combined sub-family level taxa recorded in edge and riffle habitats, 2008 and 2009 recession sampling period (presence – absence)

Order/Class	Family/Sub-Family	SC1	SC2	SC10	SC24	BC4	BD5	MD6	MD7	MD8	MR11	MR12	MR13	MR14	MR15	MR16	MR17	MR18	GL19	GL21	GL22	GL23	AC20	
Oligochaeta	Oligochaeta		X			X	X	X	X			X	X			X	X	X		X		X	X	
Hirudinida	Glossiphoniidae																						X	
Gastropoda	Planorbidae	X	X	X							X	X	X	X	X	X	X	X	X	X	X	X	X	
Gastropoda	Ancylidae					X														X				
Bivalvia	Corbiculidae											X			X									
Bivalvia	Hydriidae														X			X						
Acarina	Arrenuridae			X											X									
Acarina	Eylaidae		X																					
Acarina	Hygrobatidae	X		X						X	X	X	X								X			
Acarina	Hydrodromidae			X							X												X	
Acarina	Limnesiidae	X	X	X	X			X	X		X				X		X	X	X	X	X	X	X	
Acarina	Oxidae			X															X					
Acarina	Unionicolidae			X	X		X				X	X				X			X	X		X		
Acarina	Acarina			X				X		X	X					X			X				X	
Decapoda	Atyidae					X					X	X	X	X	X	X	X	X		X	X	X	X	
Decapoda	Palaemonidae							X	X	X	X						X	X				X	X	
Collembola	Isotomidae				X									X								X	X	
Ephemeroptera	Baetidae	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Ephemeroptera	Caenidae	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Ephemeroptera	Leptophlebiidae		X						X		X	X			X								X	
Odonata	Isostictidae												X	X							X	X		
Odonata	Coenagrionidae	X	X											X					X				X	
Odonata	Protoneuridae	X		X							X	X			X	X	X	X		X	X	X	X	
Odonata	Aeshnidae	X													X		X							
Odonata	Gomphiidae	X		X	X			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Odonata	Macromiidae																				X			
Odonata	Libellulidae	X	X	X	X	X	X	X	X		X	X	X		X	X	X	X		X			X	
Odonata	Lindeniidae		X																				X	
Odonata	Urothemistidae										X						X					X		
Odonata	Odonata instar/unidentified		X		X			X	X								X	X					X	

Order/Class	Family/Sub-Family	SC1	SC2	SC10	SC24	BC4	BD5	MD6	MD7	MD8	MR11	MR12	MR13	MR14	MR15	MR16	MR17	MR18	GL19	GL21	GL22	GL23	AC20	
Hemiptera	Pleidae	X									X	X	X	X	X	X	X	X	X	X	X	X	X	
Hemiptera	Corixidae	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Hemiptera	Gerridae				X						X			X	X		X					X		X
Hemiptera	Nepidae										X		X									X		
Hemiptera	Notonectidae	X	X	X							X	X	X	X	X	X	X	X				X	X	X
Hemiptera	Gelastocoridae													X		X								
Hemiptera	Veliidae						X		X								X	X	X	X	X	X	X	X
Hemiptera	Mesoveliidae	X			X										X		X		X	X	X	X	X	X
Neuroptera	Sisyridae																						X	
Coleoptera	Hydrophilidae	X	X	X	X			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Coleoptera	Dytiscidae larval	X										X					X							
Coleoptera	Elmidae larval						X			X	X	X			X	X	X					X		X
Coleoptera	Elmidae								X	X	X	X	X	X	X	X	X	X		X			X	X
Coleoptera	Haliplidae	X		X																				
Coleoptera	Haliplidae larval			X								X												
Coleoptera	Hydraenidae	X		X	X				X		X	X		X	X	X	X	X	X	X	X	X	X	X
Coleoptera	Hydraenidae larval																X							
Coleoptera	Gyrinidae																X							
Coleoptera	Limnichidae										X							X				X	X	
Coleoptera	Scirtidae										X					X			X	X				X
Diptera	Ceratopogonidae: Ceratopogoninae		X	X	X		X	X	X	X	X	X			X	X	X	X	X	X	X	X	X	X
Diptera	Ceratopogonidae: Forcipomyiinae				X																			
Diptera	Ceratopogonidae: Dasyheleinae							X																
Diptera	Ceratopogonidae pupal				X		X									X					X	X	X	X
Diptera	Chironomidae: Chironominae	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Diptera	Chironomidae: Tanypodinae	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Diptera	Chironomidae: Orthocladiinae	X		X	X		X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X
Diptera	Chironomidae pupae	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X
Diptera	Chaoboridae												X									X		
Diptera	Culicidae: Culicinae	X	X	X	X	X	X		X		X	X		X	X	X	X		X				X	X
Diptera	Culicidae: Anophelinae				X	X	X				X					X	X					X		

Order/Class	Family/Sub-Family	SC1	SC2	SC10	SC24	BC4	BD5	MD6	MD7	MD8	MR11	MR12	MR13	MR14	MR15	MR16	MR17	MR18	GL19	GL21	GL22	GL23	AC20	
Diptera	Culicidae pupae														X			X	X					
Diptera	Dolichopodidae	X					X		X		X	X											X	
Diptera	Sciomyzidae															X					X			
Diptera	Simuliidae							X	X	X	X	X				X		X			X			X
Diptera	Stratiomyidae				X																		X	X
Diptera	Tabanidae	X			X		X	X	X	X	X	X	X	X	X		X	X			X	X	X	X
Diptera	Syrphidae																X							
Diptera	Empiidae								X		X	X												X
Trichoptera	Hydroptilidae				X		X	X	X			X					X	X			X	X		X
Trichoptera	Ecnomidae	X	X	X	X		X		X		X	X	X								X	X	X	X
Trichoptera	Hydropsychidae				X		X	X	X	X	X	X					X	X						X
Trichoptera	Leptoceridae	X	X	X							X	X	X	X	X	X	X	X	X	X	X	X	X	X
Trichoptera	Philopotamidae				X		X	X	X	X	X	X												X
Lepidoptera	Crambidae				X		X	X	X		X	X				X	X		X			X	X	

Appendix G Sawfish

Appendix G - Records of *Pristis microdon* in the McArthur River collected since 2006

Records include tag number, date recorded, location, sex, total length (TL mm), rostrum length (RL mm) and tooth count (TC) of the right and left sides.

Tag #	Date of record	Location	Sex	TL	RL	TC (R, L)
Not tagged	8/05/2006	Eight Mile Waterhole	M	998	248	21, 22
1819	1/12/2006	Djirrinmini Waterhole	F	980	250	19, 20
1801	4/05/2007	Above Burketown Crossing	F	920	222	21, 21
Found dead on bank	May-07	At Burketown Crossing	-	~950	-	-
Observed free swimming	Jun-07	~3km Below Burketown Crossing	-	~1000	-	-
1802	22/10/2007	Glyde River	F	1040	250	16, 18
Observed free swimming	25/04/2009	Upstream end of Diversion	-	~950	-	-
Found dead on bank	26/04/2009	At Burketown Crossing	-	930	-	-
1824	19/04/2009	Djirrinmini Waterhole	M	924	225	21, 21
1825	19/04/2009	Djirrinmini Waterhole	F	940	235	20, 19
1803	19/09/2009	Djirrinmini Waterhole	F	1150	275	19, 19
1804	20/09/2009	Eight Mile Waterhole	M	1100	270	21, 22
1805	21/09/2009	Above Burketown Crossing	M	1125	280	20, 21
1806	21/09/2009	Above Burketown Crossing	F	1160	285	19, 21
Observed free swimming	Nov-09	Diversion	-	-	-	-
Found dead on bank	Dec-09	Diversion	M	~820*	-	21, 19
1807	29/04/2010	Eight Mile Waterhole	M	1710	380	22, 21
1808	30/04/2010	Below Burketown Crossing	F	970	240	19, 19
1809	7/05/2010	Djirrinmini Waterhole	M	970	235	21, 22
Observed free swimming	May-10	Glyde River	-	-	-	-
6401	8/09/2010	Eight Mile Waterhole	M	1280	320	-
6406	9/09/2010	Below Burketown Crossing	M	1210	290	21, 21
Observed free swimming	9/09/2010	Below Burketown Crossing	-	~1200	-	-
6407	3/06/2011	Eight Mile Waterhole	F	1060	250	20,20
6408	3/06/2011	Eight Mile Waterhole	M	1030	250	23,22
Observed free swimming	1/05/2011	Diversion	-	~1000	-	-
6409	7/06/2011	Above Burketown Crossing	M	2070	450	21,23
6410	6/06/2011	Below Burketown Crossing	M	1040	250	22,22
Recapture						
1805	19/09/2010	Above Burketown Crossing		1666	-	-



URS Australia Pty Ltd
Level 16, 240 Queen Street
Brisbane, QLD 4000
GPO Box 302, QLD 4001
Australia

T: 61 7 3243 2111
F: 61 7 3243 2199

www.ap.urscorp.com