AM Coal Mine – Aquatic Ecology Assessment




Alpha Coal Project

Aquatic Ecology Assessment

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arc
AustralAsian Resource Consultants

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LIST OF ABBREVIATIONS

ºC	-	degrees Celsius
%	-	percent
AARC	-	AustralAsian Resource Consultants Pty Ltd
ACARP	-	Australian Coal Association Research Program
ACTFR	-	Australian Centre for Tropical Freshwater Research
ANZECC	-	Australia and New Zealand Environment and Conservation Council
ARD	-	Acid Rock Drainage
AS/NZS	-	Australian Standard / New Zealand Standard
AUSRIVAS	-	Australian River Assessment System
DEEDI	-	Department of Employment, Economic Development and Innovation
DERM	-	Department of Environment and Resource Management
DNR	-	Department of Natural Resources
EC	-	Electrical Conductivity
EPBC Act	-	Environment Protection and Biodiversity Conservation Act 1999
EPCA	-	Application for Exploration Permit (Coal)
EPT	-	Ephemeroptera, Plecoptera, and Trichoptera taxa
ESA	-	Environmentally Sensitive Area
FFG	-	Functional Feeding Group
HPPL	-	Hancock Prospecting Pty Ltd
ISQG	-	interim sediment quality guidelines
km	-	kilometre(s)
LP Act	-	Land Protection (Pest and Stock Route Management) Act 2002
m	-	metre(s)
MDL	-	Mineral Development License

MLA	-	Mining Lease Application
mg/L	-	milligrams per Litre
mm	-	millimetre(s)
NMD	-	Neutral Mine Drainage
µS/cm	-	microSiemens per centimetre
n/a	-	not applicable
NATA	-	National Association of Testing Authorities
NC Act	-	Nature Conservation Act 2002
NCWR	-	Nature Conservation (Wildlife) Regulation 2006
NTU	-	Nephelometric Turbidity Units
SIGNAL	-	Stream Invertebrate Grade Number – Average Level
TDS	-	Total Dissolved Solids
WONS	-	Weed of National Significance

EXECUTIVE SUMMARY

AustralAsian Resource Consultants conducted an Aquatic Ecology Assessment of the Hancock Prospecting Pty Ltd Alpha Coal Project (the Project) in March 2009 (Wet Season), March 2010 (Wet Season), June 2010 (Dry Season) and June 2011 (Dry Season). The additional June 2011 dry season aquatic ecology survey was specifically requested by the Department of Environment and Resource Management in order to assess aquatic environmental values during dry periods.

Methodology

A total of 50 aquatic sites were assessed to determine the overall condition of the available aquatic ecosystems within the Project site. Water samples were taken where surface water was present. The results of surface water were compared to the Australia and New Zealand Environment and Conservation Council Guidelines.

Macro-invertebrate sampling of waterbodies was undertaken and Stream Invertebrate Grade Number – Average Level bi-plots constructed (based on the identification results), giving a broad scale measure of stream health based on the 'waterbug' pollution sensitivities.

Vertebrates were assessed, with trapping, spotlighting, and drag netting conducted, as well as incidental fauna observations.

Results

The Project site contained drainage lines and creeks with a range of stream orders. Pastoral dams, lacustrine wetlands and palustrine wetlands were also present within the Project site. The majority of the drainage lines held little to no water during the wet or dry season surveys, despite recent rainfall events. This ephemerality is common in the region.

The results from the baseline surveying of water quality on and surrounding the Project site show that water exceeds trigger values provided in the Australia and New Zealand Environment and Conservation Council (2000) Aquatic Ecosystems Guidelines at one or more sites for pH, Electrical Conductivity, Total Nitrogen, Total Phosphorous, Nitrate, Turbidity, Aluminium, Arsenic, Cadmium, Chromium, Copper, Lead, Manganese, Selenium, Zinc, and Nickel. Further, Sulphate, Aluminium and Uranium levels exceeded the proposed trigger values provided in the Australia and New Zealand Environment and Conservation Council (2000) Livestock Drinking Water Guidelines for beef cattle.

A total of five amphibian species (one introduced), 25 aquatic birds (13 of which are listed under the EPBC Act as Migratory and / or Marine), two mammals (one introduced), two reptiles, six crustacean and eight fish species were identified during the Aquatic Flora and Fauna field surveys. The Terrestrial Flora and Fauna surveys identified a further five amphibians and one mammal which have habitat requirements intrinsically linked to aquatic areas.

The Feral Pig (*Sus scrofa*) (identified within riparian habitat during all surveys) is listed as a Class 2 pest under the Land Protection (Pest and Stock Route Management) Act 2002.

Two Class 2 declared weed species under the Land Protection (Pest and Stock Route Management) Act 2002 were identified within riparian habitats, Parthenium (*Parthenium hysterophorus*) and Lantana (*Lantana camara*). Further, two weed species not declared were identified, with Noogoora Burr (*Xanthium pungens*) and Buffel Grass (*Cenchrus ciliaris*) being seen at many sites.

No Rare or Threatened animal or plant species were identified during the survey. Many of the creeks are fringed by Regional Ecosystem 10.3.14 (*Eucalyptus camaldulensis* woodland), which has an "Of Concern" Department of Environment and Resource Management Biodiversity Status, due to weed infestation by species including Parkinsonia (*Parkinsonia aculeata*), and habitat degradation.

The Stream Invertebrate Grade Number – Average Level Index was developed by the National River Health Program as a tool for the bioassessment of water pollution and looks at the taxonomic composition of the invertebrate assemblage to determine river 'health'. Once plotted on an objective bi-plot graph, an indication of types of pollution and other physical and chemical factors can be interpreted, and a basic estimate of river health can be determined. Results from the wet season indicated the majority of aquatic study sites fell within quadrants of the graph that indicate high salinity or nutrient levels (may be natural), indicating urban, industrial or agricultural pollution. This is a likely result of numerous factors including the ephemeral nature of the broader catchment and disturbances such as cattle grazing. Results from the dry season indicated the majority of the study sites fell within quadrants of the graph that indicate a more favourable aquatic habitat. The macro-invertebrate faunal composition was found to be dominated by predatory taxa.

Habitat assessments showed all sites assessed fell within the moderate category, barring AQ6 (which fell into the good category) – refer to Table 13 in Section 6.7 for a summary of these habitat assessments. The low habitat scores are due to high erosion potential, lack of stable in-stream habitat and / or limited riparian vegetation.

Overall, AQ28, a lagoon / palustrine wetland had the greatest species richness and health, despite extensive cattle grazing surrounding the site.

Recommendations

A Pest Management Plan is recommended to control the pest species (plants and animals) identified within the Project site and to reduce the potential for infestation by new species.

A monitoring program is recommended to collect ongoing baseline data for water quality and faunal assemblages. Collection of this data will allow for future detection of any deviation from the 'normal' state of the Project site. Sites for ongoing monitoring should be located upstream (control site), midstream (impact site), and downstream (impact site) of the Project boundary. Reference data can also be collected from similar creek systems not connected to the Project, e.g. upstream of any confluences between impact creeks and Native Companion Creek.

Water quality will be monitored and site-specific trigger and target values will be developed, in line with the Queensland Water Quality Guidelines (2006) and as part of the EA negotiations.

Generic recommendations for the Project include minimising disturbance areas, and stabilising any disturbance adjacent to creeks that has arisen, as soon as possible.

1.0 INTRODUCTION

AustralAsian Resource Consultants Pty Ltd (AARC) was commissioned by Hancock Prospecting Pty Ltd (HPPL) to conduct an Aquatic Ecology Assessment within the site of the proposed Alpha Coal Project (the Project).

The Alpha Coal Project is a proposed open-cut coal mining and export operation in Central Queensland, on Mining Lease Application (MLA) 70426.

Once the Alpha Coal Project is operational, coal is proposed to be mined by draglines, shovels and trucks, processed on site, and then transported by rail to a proposed port site at Abbot Point.

One of the waterways within the Project, Lagoon Creek, will need to be partly diverted early in the life of the mine, as it limits the placement of infrastructure and the early development of steady-state dumping operations. A detailed and comprehensive aquatic assessment of the site was required to be able to adequately address the potential impact these works may have on surface water, stream morphology, flora and fauna.

A total of four surveys were undertaken in order to be able to fully describe the aquatic flora and fauna and watercourses of the Project site during both the wet and dry seasons.

The following aquatic ecology surveys were undertaken during development of the EIS:

- **16th March 2009 to 21st March 2009 –** full aquatic ecology survey for sampling sites AQ1 to AQ35, planned to capture watercourses during periods of peak flow volumes;
- **15th March 2010 to 22nd March 2010 -** full aquatic ecology survey for sampling sites AQ36 to AQ42, planned to capture watercourses during periods of peak flow volumes;
- **27th June 2010 to 29th June 2010 –** habitat assessment for sampling sites AQ43 to AQ48; and
- **13th June 2011 to 22nd June 2011 –** full aquatic ecology survey for sampling sites AQ4 to AQ49.

Note that the fourth survey was conducted following discussions with the Department of Environment and Resource Management (DERM) and comprised the full suite of aquatic assessments in order to capture seasonal variation in the aquatic flora and fauna of the Project site.

This report provides a comprehensive and contemporary account of the aquatic flora and fauna assessment of the Alpha Coal Project. Results from both the wet and dry season surveys are presented and discussed, along with a risk assessment of potential impacts of the proposed Project on the aquatic flora and fauna values of the site.

1.1 OBJECTIVES

The main objectives of the Aquatic Ecology Assessment were as follows:

- Assess the aquatic ecology values currently present on site;
- Conduct an aquatic ecology database search and literature review;

- Undertake a dry season aquatic ecology survey;
- Utilise the field and analytical data to describe the aquatic environments on the Project site;
- Develop a qualitative risk assessment to identify and manage potential Project impacts upon sensitive aquatic species;
- Identify potential Project impacts upon the aquatic environment; and
- Develop suitable impact mitigation strategies in order to protect the aquatic environment.

1.2 SCOPE OF STUDY

To assess the ecological values of the watercourses on the Project site, the following scope of works was undertaken:

- A literature and database review prior to each survey, to identify species of conservation significance known from the region (the most recent results are provided in Appendix A). These searches enabled such species to be targeted during the field survey component of the study;
- Field surveys employing standard methodologies to describe stream morphology and determine the composition of aquatic flora and fauna species inhabiting the Project site, particularly species of conservation significance; and
- The preparation of a report to HPPL describing the significant ecological features identified and outlining possible management strategies to reduce any foreseeable impacts associated with proposed mining activities.

2.0 PROJECT DESCRIPTION

Sections 2.1 to 2.5 describe the relevant aspects of the Project site, including location, local geography, topography, local water courses, regional climate, and current land uses, all of which have a bearing on aquatic ecology.

2.1 PROJECT LOCATION

The Project site is located in Central Queensland approximately 420 kilometres (km) west of Rockhampton, 360 km southwest of Mackay, and 130 km southwest of Clermont. The closest residential area to the Project is the township of Alpha, located approximately 50 km south of the Project site. The location of the Project site is shown in Figure 1 below.

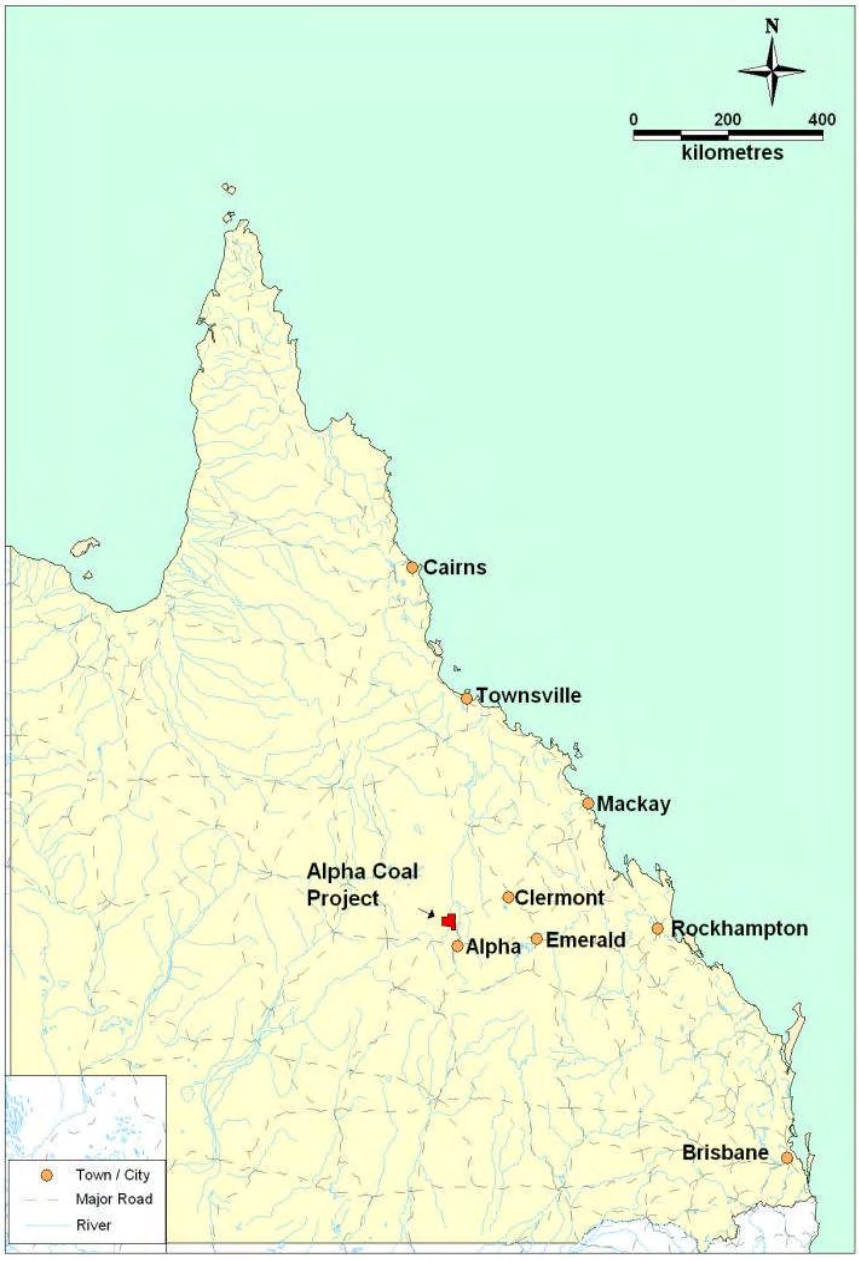


Figure 1: Project Location

2.2 LOCAL TOPOGRAPHY AND WATERWAYS

The Project site is predominantly situated on flat plains, with vegetated rises occurring along the eastern boundary of the site. These rises ascend approximately 70 metres (m) above the plains.

The Project site lies within the Burdekin Catchment. This catchment includes the Burdekin River and its tributaries north from Greenvale and south to Alpha, and coastal catchments between Giru and Bowen (Tropical Savannas CRC, 2008). The Burdekin Catchment is divided into sub-catchments, with the Project site falling in to the Belyando-Suttor Sub-catchment, which extends from south of Alpha north to the Belyando Crossing. The Belyando-Suttor Sub-catchment (shown in Figure 2) is the largest within the Burdekin River Basin, covering 73,335 square kilometres (Australian Natural Resources Atlas, 2007). The bold blue line indicates the boundary of the Surface Water Management Area: Belyando / Suttor.

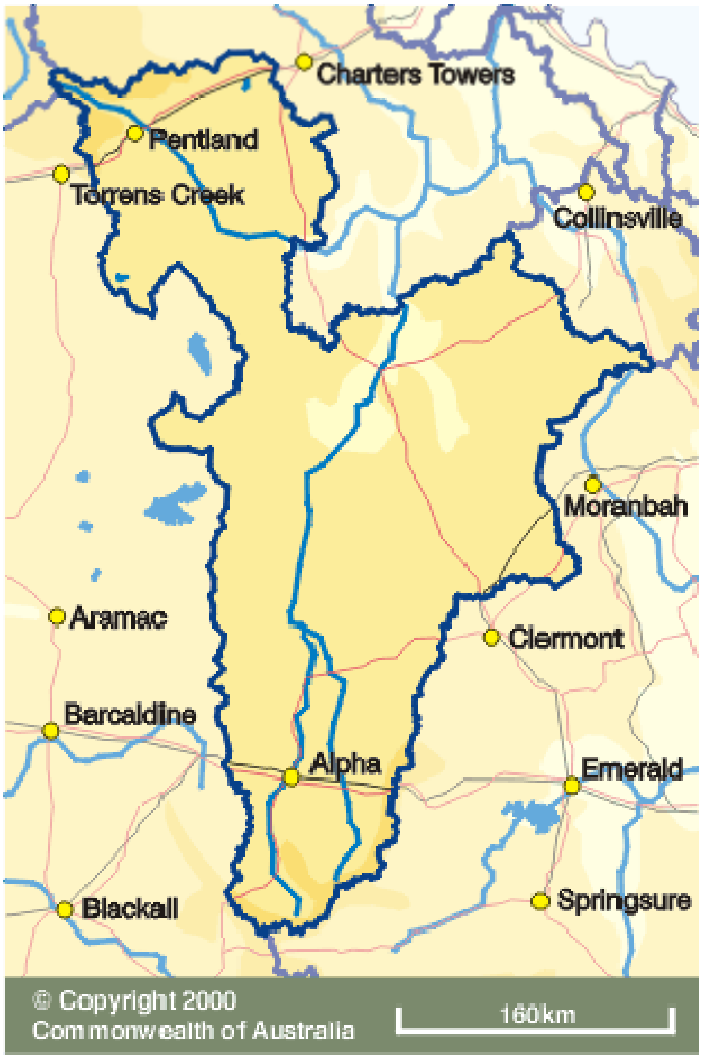


Figure 2: Belyando-Suttor Sub-Catchment[1]

[1] Sourced from Australian Natural Resources Atlas, 2007

The regional waterways are shown in Figure 3 below. The Native Companion Creek (which, at its closest point is seven km east of the Project site) flows in a northerly direction to join the Belyando River and then into the lower reaches of the Suttor River (Australian Natural Resources Atlas, 2007). Significant tributaries to the Belyando River include Alpha Creek, Mistake Creek, and Native Companion Creek.

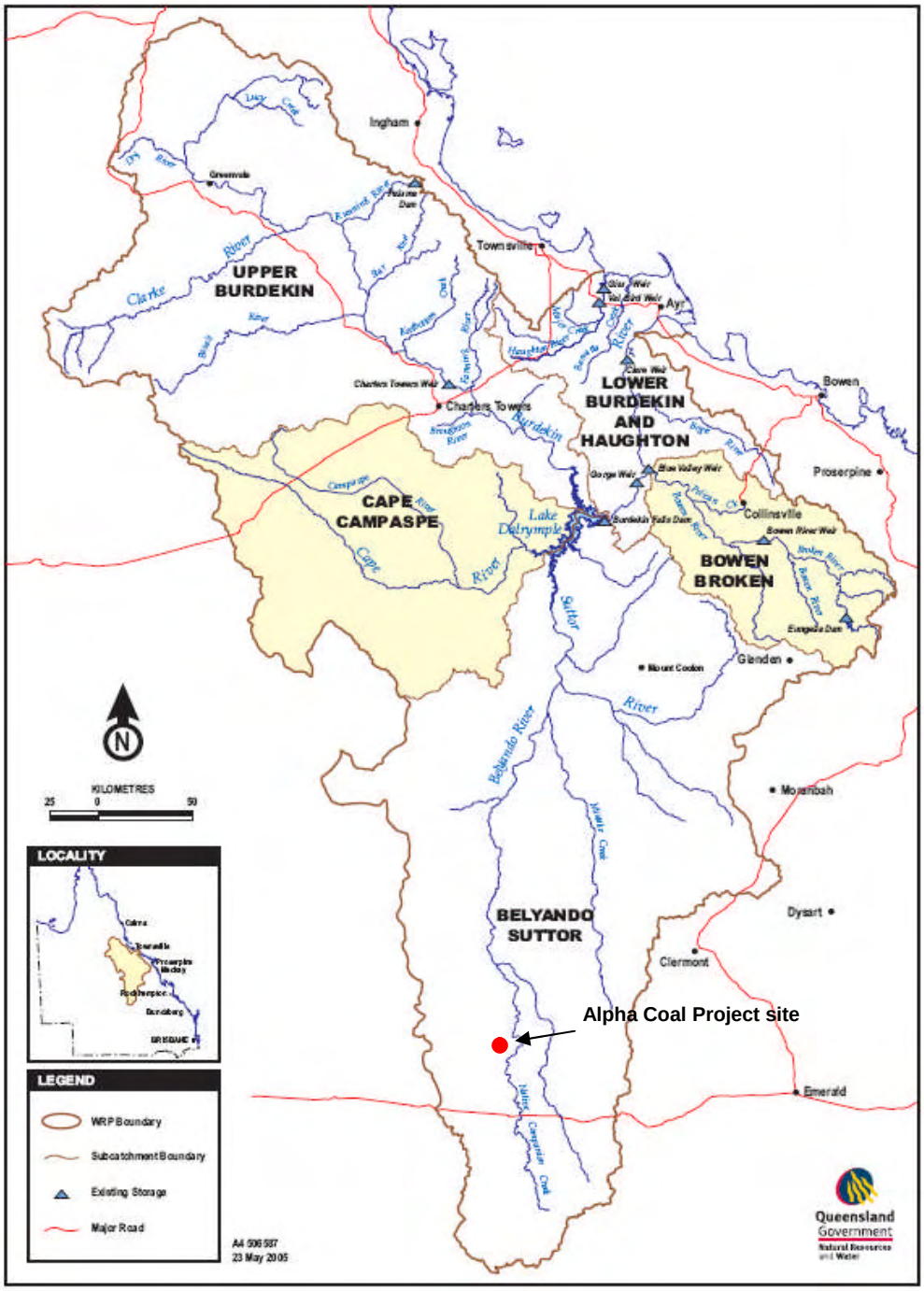


Figure 3: Regional Waterways[2], and location of the Alpha Coal Project site

[2] Sourced from the Burdekin Basin Water Resource Plan (DERM, 2007)

The Project site is traversed by numerous ephemeral drainage lines and creeks, shown in Figure 4. Lagoon Creek flows in a northerly direction the entire length of the Project site, with the tributaries Sandy Creek, Rocky Creek and Well Creek entering it to the north of the Project site. There is a permanent lagoon, pastoral dams, and numerous wetland areas situated within the Project area. Surface water within the Project site is used for stock drinking water.

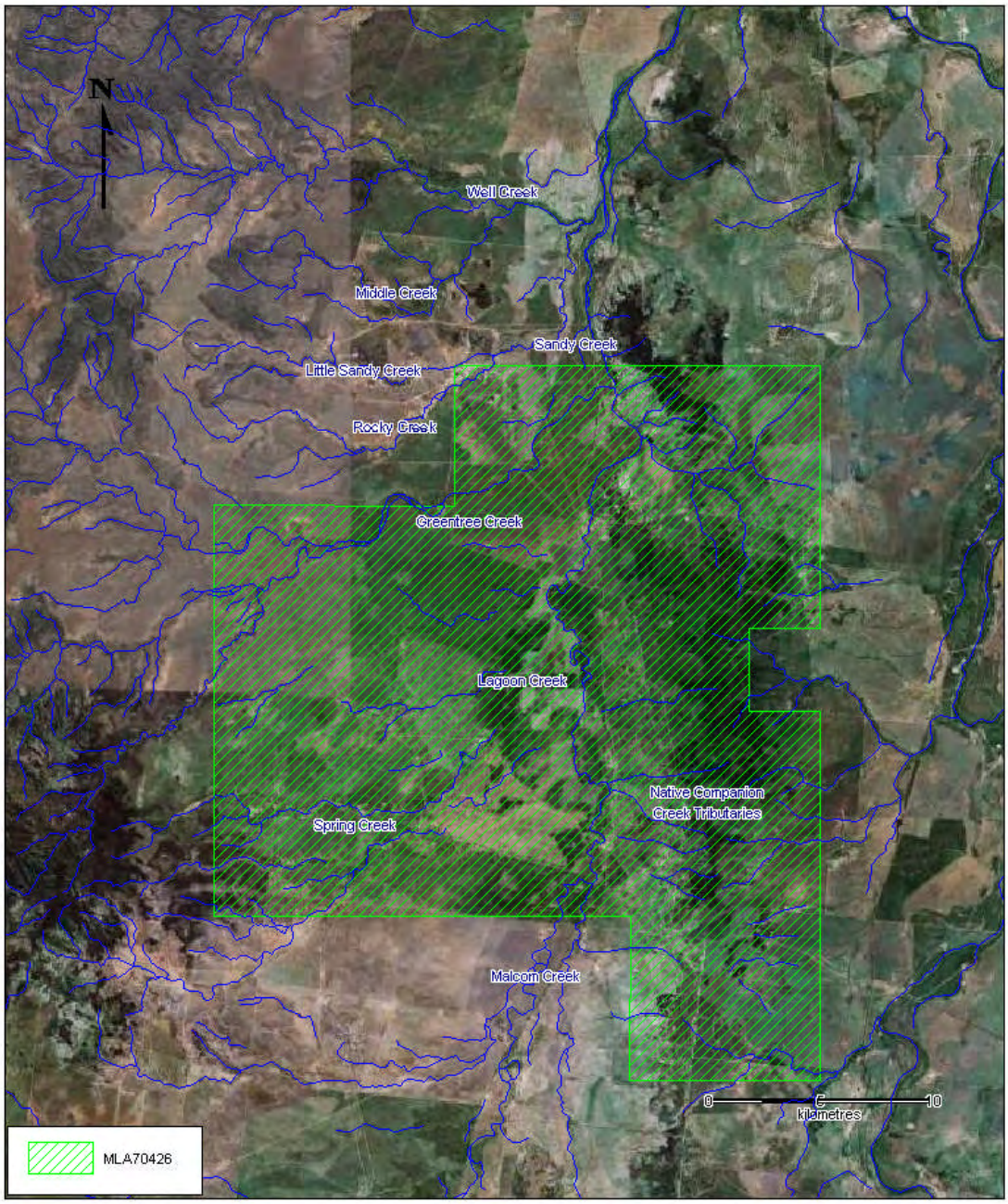


Figure 4: Local Waterways

The planned diversion of Lagoon Creek is 300 m wide, and extends for 9.6 km. This is depicted in Figure 5. Flood protection levees will be installed upstream and along the length of the diversion.

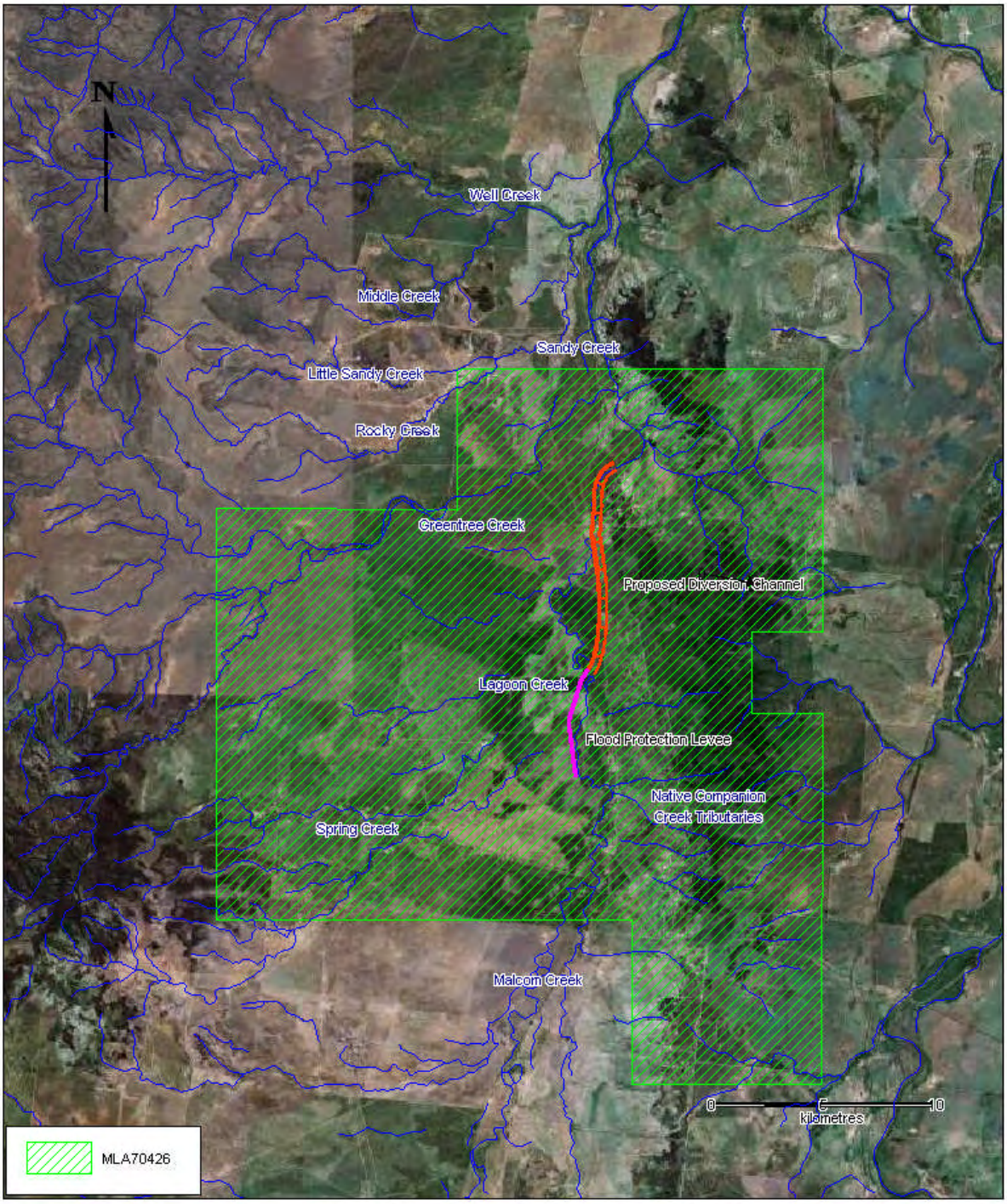


Figure 5: Proposed Diversion of Lagoon Creek

2.3 REGIONAL CLIMATE

This climatic description of the region in which the Project site is located has been compiled using the regional data collected by Australian Bureau of Meteorology (http://www.bom.gov.au). The data has been sourced from weather stations located in Clermont (Station 035019), Alpha (Station 035000), and Barcaldine (Station 036007).

Monthly rainfall data has been captured consistently since 1887 from the Alpha Post Office, representing the closest reliable rainfall gauge to the Project site (refer to Figure 6 for details). Rainfall data from the weather station at Alpha indicates that January and February exhibit the highest mean monthly rainfall, averaging 117.5 millimetres (mm) and 115 mm respectively. The driest months of the year are August and September, recording an average of 19.1 mm and 20.4 mm respectively.

The Project region experiences distinct wet and dry seasons. The wet season typically falls between the months of December and February, sometimes extending into March. The remaining months make up the dry period, averaging around 30 mm per month. The average annual rainfall for the region is 664.3 mm per year.

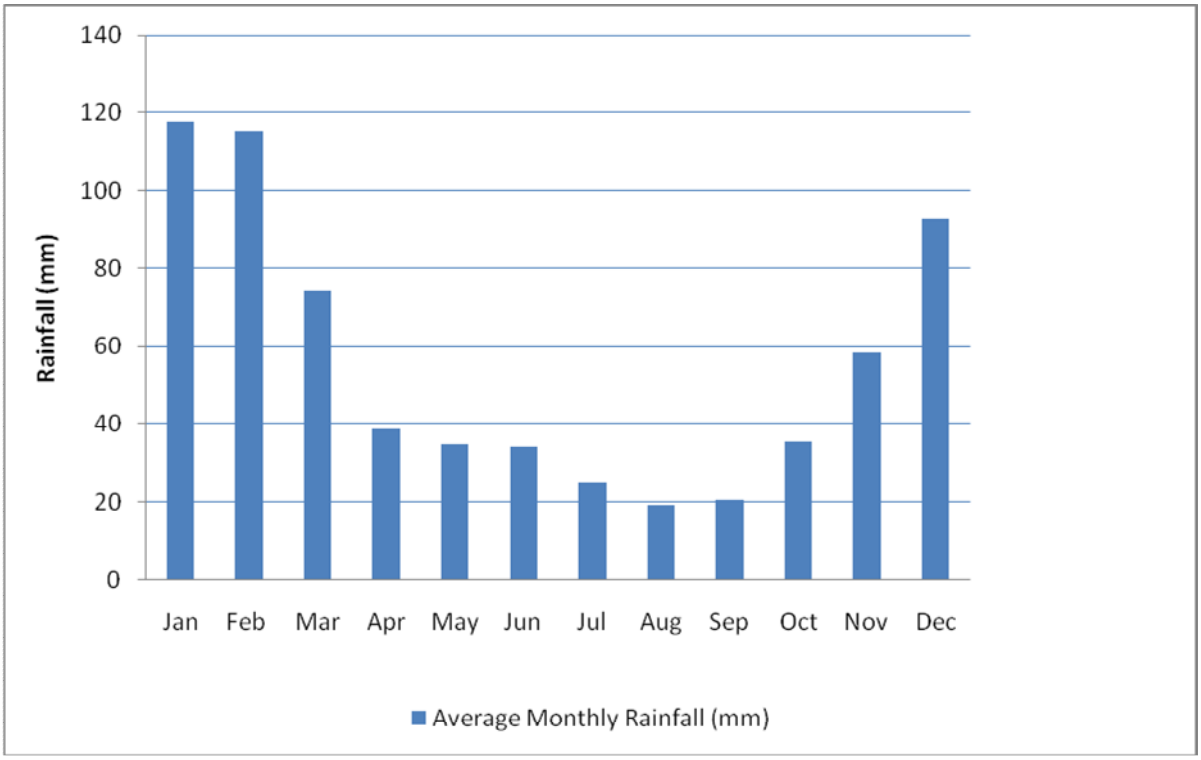


Figure 6: Mean Monthly Rainfall For Alpha

Temperature data is sourced from the Clermont Station, and has been compiled since 1971.

The coldest mean daily temperatures occur in July (8 degrees Celsius (ºC)), with November to January having a mean maximum temperature of 34ºC (shown in Figure 7).

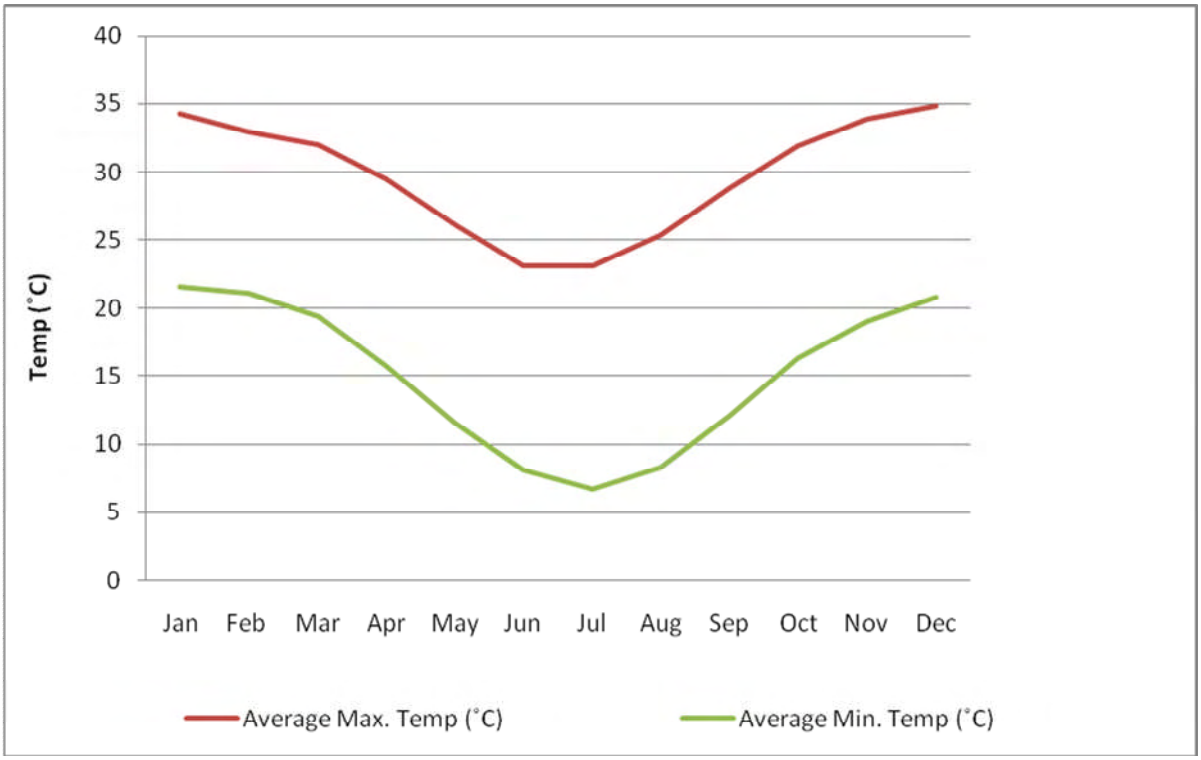


Figure 7: Average Maximum and Minimum Monthly Temperatures for the Alpha Region

Recorded humidity levels at the Barcaldine Station show a mean monthly level of 54 percent (%) at 9:00 am and 34% at 3:00 pm, with the highest monthly humidity reaching 64% in June at 9:00 am and the lowest humidity reaching 26% in September at 3:00 pm. Humidity levels recorded at the Clermont weather station display the highest monthly humidity reaching an average of 71% in February and the lowest humidity reaching 29% in September.

2.4 CONDITIONS PRIOR TO AND DURING THE SURVEY

The timing of each survey was selected to target the appropriate seasonality on site, namely; wet season surveys between February and March and the dry season survey (which was undertaken at the request of DERM) was undertaken in June. The dates of each survey and local climatic conditions have been summarised as follows:

March 2009 – Wet Season

A total of 26.2 mm of rain fell in the Alpha region (as measured at the Alpha Station) in the month of March 2009. 148.4 mm of rainfall fell in February 2009. Temperatures (as measured at Clermont) ranged from 18.1ºC to 35.4ºC.

March 2010 – Wet Season

A total of 94.8 mm of rain fell in the Alpha region (as measured at the Alpha Station) in the month of March 2010. 212.8 mm of rainfall fell in February 2010. Temperatures (as measured at Clermont) ranged from 19.7ºC to 30.1ºC.

June 2011 – Dry Season

A total of 23.8 mm of rain fell in the Alpha region (as measured at the Alpha Station) in the month of June 2011. 26.8 mm of rainfall fell in May 2011 (as measured at the Clermont Station). Temperatures (as measured at Clermont) ranged from 1.4ºC to 28.2ºC for the two months.

2.5 CURRENT LAND USE

Low intensity cattle grazing and mineral exploration are the predominant land use activities on the Project site.

3.0 RELEVANT LEGISLATION

Legislation relevant to the assessment of aquatic flora, fauna and biodiversity on the Project site is discussed below.

3.1 QUEENSLAND NATURE CONSERVATION ACT 1992

The most relevant portions of the *Nature Conservation Act 1992* (NC Act) to the Project are the sections which pertain to Wildlife and Habitat Conservation. The classes of wildlife[3] to which the NC Act applies includes protected wildlife, which is defined as:

- Extinct wildlife;
- Endangered wildlife;
- Vulnerable wildlife;
- Near Threatened; and
- Least Concern wildlife.

Species listed under the above classes are published in the associated *Nature Conservation (Wildlife) Regulation 2006* (NCWR).

The NC Act defines 'threatening processes' as:

a) Threatening the survival of any protected area, area of major interest, protected wildlife, community of native wildlife or native wildlife habitat; or

b) Affecting the capacity of any protected area, area of major interest, protected wildlife, community of native wildlife or native wildlife habitat to sustain natural processes.

The NC Act is relevant to the Project should any flora or fauna species of conservation significance (as detailed in the NCWR) be found on the Project site.

3.2 COMMONWEALTH ENVIRONMENT PROTECTION AND BIODIVERSITY CONSERVATION ACT 1999

Under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), an action will require approval from the Federal Environment Minister if the action has, will have, or is likely to have a significant impact on a matter of National Environmental Significance. Matters of National Environmental Significance include:

- World Heritage properties;

[3] Under the *Nature Conservation Act 1992*, Wildlife is defined to be any taxon of an animal, plant, protista, procaryote or virus.

- National Heritage Places;
- RAMSAR wetlands of international importance;
- Nationally Threatened species and ecological communities;
- Migratory species protected under international agreements;
- Nuclear Actions;
- Great Barrier Reef Marine Park; and
- The Commonwealth marine environment.

Of the above matters of National Environmental Significance, only two are applicable to the Project site:

- Nationally Threatened species and ecological communities; and
- Migratory species protected under international agreements.

Consequently, should any species/communities listed as Threatened or Migratory be found on the Project site, the Project will be assessed under guidelines provided in the EPBC Act.

In addition, the EPBC Act provides for the identification and listing of key threatening processes.

3.3 QUEENSLAND LAND PROTECTION (PEST AND STOCK ROUTE MANAGEMENT) ACT 2002

The objectives of *the Land Protection (Pest and Stock Route Management) Act 2002* (LP Act) are to consolidate, amend and provide laws for the management, control, prohibition, and regulation of the introduction, spread and keeping of certain plants and animals declared under the Act. The LP Act is relevant to the Project with regard to the control and management of declared pest plant (weed) and animal species.

4.0 DATABASE SEARCH AND LITERATURE REVIEW

Database searches have collated information on flora and fauna species identified in the region from previous surveys, community records and other sources. A review of such databases facilitated the formulation of specific field survey techniques aimed at targeting certain flora and fauna species, vegetation communities and habitat types known from the region.

The following databases were searched for historical records of flora and fauna within the vicinity of the Project site that have habitat requirements intrinsically linked to aquatic habitats:

- EPBC Act Online Database: This database provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act for a nominated area; and

- Wildlife Online Database (Department of Environment and Resource Management (DERM): This database uses records collected from previous surveys, including the Queensland Museum surveys as well as records from the public.

The results of these database searches revealed that several flora and fauna species of conservation significance, that have habitat requirements intrinsically linked to aquatic systems, are known from the Alpha region, as discussed below. The 100 x 100km search area, referred to as "the Alpha Coal Project area" in the following tables, is defined by the points *22.75046 S, 145.989507 E, 22.753652 S, 146.963474 E, 23.656973 S, 146.963228 E and 23.653639 S, 145.982694 E.* Database search results are included in Appendix A.

4.1 FLORA

Review of the databases and previous surveys conducted in the region indicate a number of flora species of conservation significance, however none of these species were associated with aquatic ecosystems as indicated by the Queensland Herbarium.

4.2 FAUNA

Literature and database searches indicated that eight fauna species of conservation significance which require aquatic habitats and / or feed almost exclusively within aquatic habitats have been identified in the Alpha Coal Project area. These species are listed in Table 1 below.

Table 1 Rare and Threatened Fauna from the Alpha Coal Project area

Scientific Name	Common Name	Conservation Status	
		EPBC Act	NC Act
Birds			
Erythrotriorchis radiatus	Red Goshawk	Vulnerable*	Endangered
Geophaps scripta scripta	Squatter Pigeon (southern)	Vulnerable	Vulnerable
Lophoictinia isura	Square-tailed Kite		Near Threatened
Melithreptus gularis	Black-chinned Honey-eater		Near Threatened
Neochmia ruficauda ruficauda	Star Finch (eastern)	Endangered	
Poephila cincta cincta	Black-throated Finch (southern)	Endangered	
Rostratula australis	Australian Painted Snipe	Vulnerable	
Reptiles			
Denisonia maculata	Ornamental Snake	Vulnerable	

* Red Goshawk is not included in the EPBC Act Protected Matters Report, returned from a search using the area specified above, however it is included in the Wildlife Online Extract for the same search area (both Appendix A). The Red Goshawk is listed as Vulnerable under the EPBC Act.

A further 10 species, listed under the EPBC Act as Migratory or Marine Overfly, which have habitat requirements linked to aquatic areas were identified in the database searches. These are shown in Table 2 below.

Table 2 Migratory and Marine Fauna (Birds) potentially occurring in the Alpha Coal Project area

Scientific Name	Common Name	Migratory Species			Listed Marine Species
		Migratory Marine Birds	Migratory Terrestrial Species	Migratory Wetlands Species	
Apus pacificus	Fork-Tailed Swift	X		X	X
Ardea alba	Great Egret	X			X
Ardea ibis	Cattle Egret	X		X	X
Gallinago hardwickii	Latham's Snipe			X	X

Scientific Name	Common Name	Migratory Species			Listed Marine Species
		Migratory Marine Birds	Migratory Terrestrial Species	Migratory Wetlands Species	
Haliaeetus leucogaster	White-Bellied Sea-Eagle		X		X
Hirundapus caudacutus	White-throated Needletail		X		X
Merops ornatus	Rainbow Bee-eater		X		X
Myiagra cyanoleuca	Satin flycatcher		X		X
Nettapus coromandelianus albipennis	Australian Cotton Pygmy-goose			X	X
Rostratula benghalensis s. lat	Painted Snipe			X	X

4.3 WETLAND HABITATS

A review of the DERM interactive WetlandMaps (2009) database (http://www.epa.qld.gov.au/wetlandinfo/site/MappingFandD/WetlandMapsAndData.html) revealed the presence of lacustrine and palustrine water bodies within the Project site (Figure 8). These water bodies however, are not outlined within the Environmentally Sensitive Areas (ESAs) mapping for the Project area. ESAs mapping shows the Category A, B, and C areas of conservation significance, including those under international agreements (e.g. Ramsar wetlands).

Lacustrine wetlands are wetlands and deepwater habitats situated in topographic depressions, dammed river channels, or artificial waterbodies i.e. lakes. Palustrine wetlands are wetlands dominated by persistent emergent vegetation i.e. vegetated swamps. The locations of these wetlands are provided in Appendix A.

Further to wetland habitat mapping, ground-truthing of each wetland environment was conducted during the field survey component of the assessment to examine habitat value.

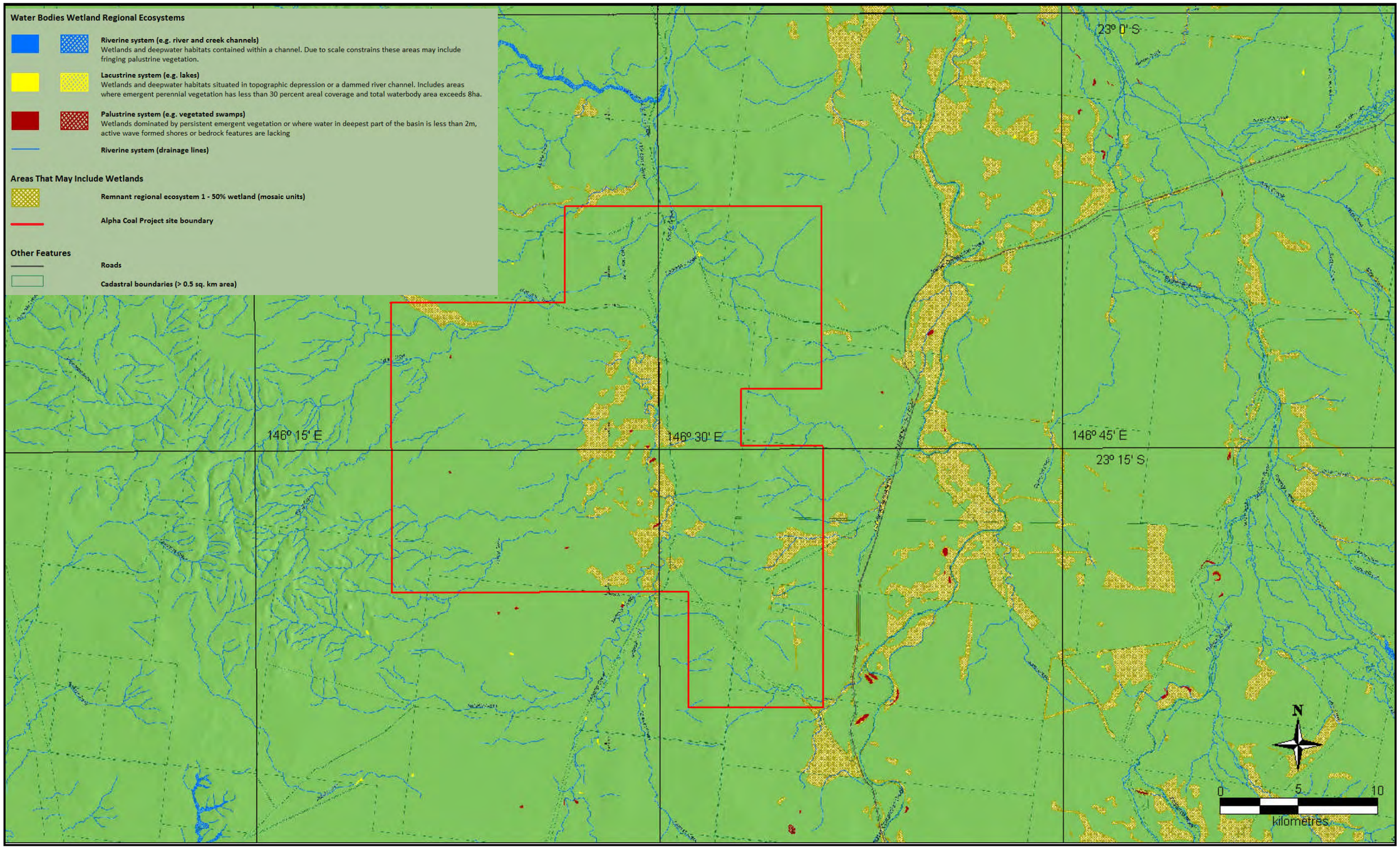


Figure 8: Mapped Wetlands of the Project Site

5.0 SURVEY METHODOLOGY

5.1 SURVEY TIMING

The initial aquatic survey was undertaken in the wet season between the 16th March 2009 and 21st of March 2009. Additional surveys were undertaken between the 15th March 2010 and 22nd of March 2010 (wet season – limited habitat assessment only for additional sampling locations AQ36 – AQ42), the 27th June 2010 and 29th June 2010 (dry season – limited habitat assessment only for additional sampling locations AQ43 – AQ48) and the 13th June 2011 and 22nd of June 2011 (dry season). The surveys were conducted at these times to represent both wet and dry seasons. In both March 2009 and March 2010 the Project Site was wet and the impact of rainfall upon the local aquatic community was fully expressed in terms of aquatic species diversity. For example, it takes a number of weeks for frog eggs (once hydrated) to develop into adults that are recognisable species.

The additional June 2011 dry season aquatic ecology survey was specifically requested by the Department of Environment and Resource Management in order to assess aquatic environmental values during dry periods.

The survey methods are discussed in Section 5.3. The sites that were surveyed are shown in Figure 9 below.

5.2 PERSONNEL

A team of at least two suitably qualified and experienced ecologists undertook each field survey described above. For each survey AARC deployed one senior ecologist with at least five years of experience, along with at least one other ecologist with a minimum of 2 years of experience.

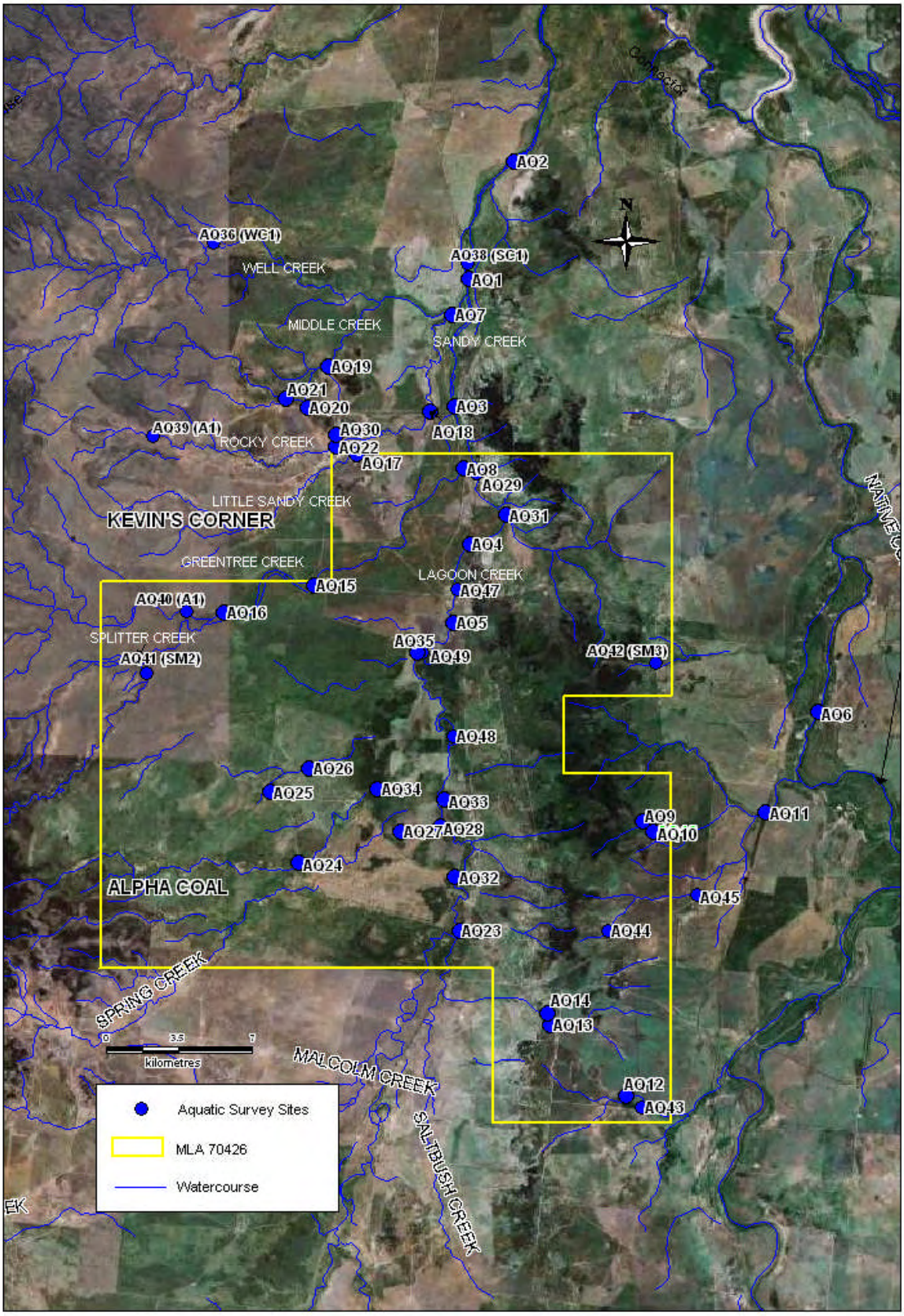


Figure 9: Aquatic Survey Locations

5.3 FIELD SURVEY METHODS

The location of each aquatic survey site was based upon database searches, location of Project site infrastructure (upstream / midstream / downstream of impacts), diversity in aquatics habitat (riffle / run / pools) and accessibility to the survey site. Site selection aimed to ensure that the sites sampled were representative of all habitat types present in the Alpha Coal Project site. The level of assessment undertaken at each site is described in Sections 5.3.1 to 5.3.6, and tabulated in Table 3.

5.3.1 Initial Site Scoping

Site scoping was conducted using two methods. Firstly, aerial photography and topographic maps of the Project site were reviewed to gain an overall perspective of the location of watercourses, and the direction of water flow.

Secondly, accessible areas of the Project site were broadly surveyed from a vehicle. This allowed for the targeting of upstream, midstream, and downstream locations, as well as habitats potentially occupied by species of conservation significance.

5.3.2 Surface Water Quality Sampling

At each site where surface water was available, in situ recordings of pH, Electrical Conductivity (EC), and temperature within the water body was taken. Surface water samples were collected from each site where sufficient water was available, immediately refrigerated and sent to a National Association of Testing Authorities (NATA) accredited lab for analysis of the following parameters:

- Total Dissolved Solids (TDS)
- Total Nitrogen
- Total Phosphorous
- Nitrate
- Sulphate
- Fluoride
- Turbidity
- Aluminium
- Uranium
- Arsenic
- Boron
- Cadmium
- Calcium
- Copper
- Lead
- Manganese
- Mercury
- Molybdenum
- Antimony
- Nickel
- Selenium
- Zinc
- Chromium

Care was taken when obtaining samples that the sediment within the water body was not disturbed.

A total of 23 sites contained sufficient surface water for samples to be obtained and analysed.

5.3.3 Aquatic and Riparian Vegetation Identification

At each of the sites surveyed, a brief description of the riparian vegetation was recorded. This is captured more fully in the Terrestrial Flora and Fauna Report produced by AARC. Where in-stream flora was observed, it was also identified, and dominance recorded.

5.3.4 Macro-invertebrate Sampling

The shallows of the waterbodies at 19 sites were kick-sampled (disturbing the stream bed and passing a D-frame net with a 100 micrometre mesh-size through the resulting plume, along 5-10 m sections of the water body). Various microhabitats within the stream were targeted. All macro-invertebrates sampled over a 20 minute period were placed in a preservative solution and identified to family or sub-family level. Samples collected during the March 2009 survey were identified at the Australian Centre for Tropical Freshwater Research, samples collected in March 2010 were identified at FRC Environmental and samples collected in 2011 were identified at ALS Environmental.

5.3.5 Aquatic Vertebrate Fauna Sampling

The aquatic vertebrate composition of each survey site was tested using four methods: drag netting, baited traps, spotlighting and call recording, as explained below. Electro-fishing was considered as an additional aquatic sampling technique for the dry season survey, but was not employed, because any electro-fishing data produced during the dry season, could not be compared with the non-electro-fishing, trapping data that was generated during the wet season.

5.3.5.1 Drag Netting

The water body at each survey site in which vertebrate fauna sampling was undertaken was swept using a 25 mm mesh-size drag net strung between two people as they walked slowly up sections of the water body. This method allows large sections of the watercourse to be sampled; however snags and benthic debris can allow fish to avoid the net. Watercourses too narrow / shallow to allow the net to extend were excluded from drag netting. A total of 12 sites were drag netted over the course of the field survey.

5.3.5.2 Baited Traps

Opera-house and box traps were used at each site where trapping was to be undertaken to target carnivorous species. Traps were baited with either dry dog biscuits or bones to lure fish and other vertebrates into the traps. At each site where trapping was undertaken, four traps were left out for three nights each, and emptied at first light. All animals captured were identified, their abundances recorded, and then released back into the water. As 14 sites were trapped, a total of 168 trap nights were conducted on the Project site and the neighbouring Kevin's Corner site.

5.3.5.3 Spotlighting

Spotlighting was carried out at night along various sections of the waterbodies in an attempt to observe nocturnal wildlife that are less likely to be detected by other survey methods, such as frogs and reptiles.

5.3.5.4 Call Recording

A Song Meter SM2 Digital Field Recorder was deployed overnight at each site where trapping was undertaken. It was programmed to record amphibian calls from 5:30pm to 6:30am the next morning. Any calls were analysed using Wildlife Acoustics Song Scope V4 software.

5.3.6 Habitat Assessment

A habitat assessment was performed at selected sites using a modified version of the Australian River Assessment System (AUSRIVAS) protocols developed by the Department of Natural Resources and Mines in 2002. AUSRIVAS is a nationally standardised method for giving an assessment of the biological health of inland rivers within Australia. Each surveyed site was given a score out of 135, with higher numbers indicating favourable habitats normally associated with healthy waterways. Habitat Assessment was conducted at a total of 18 sites. Refer to Table 3 on following page and Section 6.7 for further details.

5.3.7 Impact Risk Assessment

An environmental risk assessment was conducted to identify potential risks associated with the Project. A risk is defined as the chance of something occurring that will have an impact on the objectives of the Project. An environmental incident is defined as any occurrence that can have an adverse impact (or impacts) upon the environmental values of the Project site. Potential risks were assessed using the AS/NZS ISO 31000:2009 Risk Management – Principles and Guidelines (originally AS/NZS 4360:2004) and the HB 203:2006 Environmental Risk Management – Principles and Process. Refer to Section 7.0 for further details

.

Table 3 Assessment Level per Survey Location for all surveys

Legend: ✳ = March 2009 (wet season)

⊙ = March 2010 (wet season)

○ = June 2010 (dry season)

◆ = June 2011 (dry season)

Site	Water Sample Taken	In Situ Water Reading	Sediment Sample Taken	Macro-Invertebrate Sample Taken	Drag Netting Conducted	Trapping Conducted	Habitat Assessment
AQ1	✳	✳		✳	✳	✳	✳
AQ2	✳	✳		✳	✳	✳	
AQ3	✳	✳		✳	✳	✳	✳
AQ4	✳◆	✳◆	◆	✳◆	✳◆	✳◆	✳◆
AQ5	✳◆	✳◆	◆	✳◆	✳◆	✳◆	✳◆
AQ6	◆	✳◆	◆	✳◆	✳	✳	✳◆
AQ7							✳
AQ8			◆				✳◆
AQ9	◆	✳◆	◆	✳◆	✳		◆
AQ10			◆				✳◆
AQ11			◆				✳◆
AQ12			◆				✳◆
AQ13			◆				✳◆
AQ14			◆				✳◆
AQ15			◆				✳◆
AQ16			◆				✳◆
AQ17	✳◆	✳◆	◆	✳		✳	✳◆
AQ18	✳	✳		✳		✳	✳
AQ19	✳	✳		✳		✳	✳
AQ20							✳
AQ21							✳

Site	Water Sample Taken	In Situ Water Reading	Sediment Sample Taken	Macro-Invertebrate Sample Taken	Drag Netting Conducted	Trapping Conducted	Habitat Assessment
AQ22							✳
AQ23	✳◆	✳◆	◆	✳	✳	✳	✳◆
AQ24			◆				✳◆
AQ25	✳	✳	◆				◆
AQ25A	◆	◆	◆	◆	◆	◆	◆
AQ26		✳	◆				◆
AQ27	✳	✳	◆				◆
AQ28	✳◆	✳◆	◆	✳◆	✳◆	✳◆	✳◆
AQ29	✳	✳	◆	✳			◆
AQ30		✳					
AQ31	✳◆	✳◆	◆	✳◆	✳◆	◆	✳◆
AQ32			◆				✳◆
AQ33			◆				✳◆
AQ34			◆				✳◆
AQ35			◆				✳◆
AQ36	⭘	⭘		⭘	⭘	⭘	⭘
AQ37	⭘	⭘		⭘		⭘	⭘
AQ38	⭘	⭘		⭘	⭘	⭘	⭘
AQ39	⭘	⭘		⭘	⭘	⭘	⭘
AQ40			◆				⭘◆
AQ41	⭘	⭘	◆	⭘			⭘◆
AQ42			◆				⭘◆
AQ43			◆				○◆
AQ44			◆				○◆
AQ45			◆				○◆
AQ46			◆				○◆
AQ47			◆				○◆
AQ48	◆	◆	◆				○◆
AQ49	◆	◆	◆	◆	◆	◆	◆

5.4 DATA ANALYSIS

5.4.1 Surface Water Quality

Data from the DERM (2007) watershed website for Native Companion Creek (measured at Violet Grove) was compiled and compared to the survey data. Various parameters of this data have been collected between 1968 and 2006.

Results of the analysis conducted on the surface water samples obtained in the field were compared to ANZECC (2000) Guidelines for both Aquatic Ecosystems for 95% species protection levels and Livestock Drinking Water, where triggers exist for the analysed parameters.

5.4.2 Macro-invertebrate Sampling

The resultant species list was analysed for the presence / absence of 'EPT' taxa. The EPT group of macro-invertebrates; Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddis flies) are three orders of insects that are especially sensitive to disturbance. Generally there are more EPT species in areas of higher water quality and available habitat than in degraded water bodies. When this information is looked at in conjunction with other data such as Stream Invertebrate Grade Number – Average Level (SIGNAL) Scores, water quality, etc, a basic estimate of river health can be determined.

The SIGNAL Index was developed by the National River Health Program as a tool for the bioassessment of water pollution and looks at the taxonomic composition of the invertebrate assemblage to determine river 'health'. Each macro-invertebrate is given a grade number between 1 and 10 based on their sensitivity to various pollutants (Chessman, 2003), with a lower number indicating a higher tolerance to a range of conditions. The SIGNAL Index value is calculated by averaging the pollution sensitivity grade numbers of the families present at each site, and plotting them. Crustaceans captured in the baited traps do not contributed to the SIGNAL scoring process, as due to the catch-release nature of the trapping methodology accurate catch numbers over a given timeframe cannot be calculated, and the potential for recaptures exists.

Once plotted on a bi-plot, the SIGNAL Index and the number of invertebrate families found in a stream used together can provide an indication of the types of pollution and other physical and chemical factors that affect macro-invertebrate communities (Chessman, 2003), depending on their position within the graph (refer to Figure 10 below for bi-plot interpretation).

Quadrant 3 Often indicating toxic pollution or harsh physical environments	**Quadrant 1** Indicates favourable habitat or chemically dilute water
Quadrant 4 Usually indicating urban, industrial, or agricultural pollution	**Quadrant 2** Often indicating high salinity or nutrient levels (may be natural)

Figure 10: SIGNAL 2 Bi-Plot Interpretation

The results of the macro-invertebrate identification were reviewed to determine the Functional Feeding Groups (FFGs) present within each water body. The term Functional Feeding Group refers to the method by which each species of invertebrate obtains food, and the relative abundance of macro-invertebrate FFGs may reflect the in-stream processes of the habitat. The ideal 'healthy' aquatic habitat has representatives of each FFG. Dominance or loss of a particular FFG may indicate a change in the ecological status of the stream or pool. In the absence of degradation of habitat or water quality, there will always be a natural dominance in relation to natural food sources e.g. an abundance of leaf litter will be reflected by an abundance of shredders.

5.4.3 Habitat Assessment

Table 4 below provides a framework for interpreting habitat assessment scores.

Table 4 Key to AUSRIVAS Habitat Assessment Scores (possible given score meanings)

Habitat Assessment Score	Interpretation
0 – 35	Habitat is poor. There is limited habitat availability for in-stream fauna. There is little variation in velocity and depth of water, and the creek bed consists of a single sediment type. The water body typically consists of a small, shallow pool. Streamside vegetation, if present, consists of grasses and sedges. There is moderate to significant erosion on the banks.
36 – 70	Habitat variety is moderate. This could be due to leaf litter and other vegetation or detritus in the water, or the presence of boulders and rocks. The streamside vegetation consists mainly of grasses and sedges. There is moderate evidence of bank erosion, and the percentage of vegetative cover on the banks is less than 50%.
71 – 100	Habitat is relatively good. The bank is stable, there is variety in depth and velocity within the water body and substrate type is variable and tending towards boulders and rocks. Streamside vegetation is of trees and shrubs, adding to the bank stability. The percentage of streamside cover by vegetation is relatively high.
101 – 135	Indicates a pristine and favourable habitat. There is no bank erosion and the dominant vegetation is trees. There is great variety in depth and velocity, and the habitat is quite complex, offering many types of protection for infauna. This is usually afforded by logs and branches, leaf litter, variety in substrate type, variety in water depth, and presence of vegetation living within the water body.

6.0 RESULTS AND DISCUSSION

A total of 50 sites were assessed for various elements of the aquatic survey. The results of each analysis type are provided below, in Sections 6.1 to 6.6. Descriptions of each site are summarised in Appendix B.

6.1 STREAM MORPHOLOGY

A range of morphologies in creeks, drainage lines, palustrine, and lacustrine areas were assessed during the course of the study. Photographs of each aquatic type are shown below in Photo Plate 1 to Photo Plate 7.

Photo Plate 1 Anabranch of 3rd Order Creek (AQ1)

Photo Plate 2 Dammed Section of 2nd Order Creek (AQ4)

Photo Plate 3 Pastoral Dam (AQ9)

Photo Plate 4 1st Order Drainage Line (AQ20)

Photo Plate 5 Lagoon / Palustrine Wetland (AQ28)

Photo Plate 6 Lacustrine Wetland (AQ31)

Photo Plate 7 Confluence of Two 1st Order Drainage Lines (AQ21)

6.2 SURFACE WATER

Surface water results from all three surface water surveys are provided in Table 5 and Table 6 below, and have been compared to both the ANZECC (2000) Aquatic Ecosystems Guidelines for 95% species protection for lowland river systems in south-east Queensland, and the ANZECC (2000) Livestock Drinking Water Guidelines for beef cattle. During the dry season survey, replicate samples were taken at two sites (31 and 49) as a quality assurance measure. Sites 1, 2, 3, 7, 18, 19, 20, 21, 22, 30, 36 (WC1), 37 (WC2), 38(SC1), and 39 (A1) are located within MLA 70425 to the north of the Project site, and were not sampled during the June 2011 dry season survey.

Laboratory results are provided in Appendix C.

Table 5 Surface Water Physico-Chemical Analysis Results

	Field pH			Field EC (microSiemens / centimetre (µS/cm))			Field Temperature (°C)			TDS (milligrams / Litre (mg/L))			Total Nitrogen (mg/L)			Total Phosphorous (mg/L)			Nitrate (mg/L)			Sulphate (mg/L)			Fluoride (mg/L)			Turbidity (Nephelometric Turbidity Units (NTU))		
ANZECC Aquatic Ecosystems Values	6.5 – 8.0			125 – 2200			n/a			n/a			0.5			0.05			0.7			n/a			n/a			Jun-50		
ANZECC Livestock Drinking Water Values	n/a			n/a			n/a			4000			n/a			n/a			400			1000			2			n/a		
Season	**Wet 2009**	**Wet 2010**	**Dry 2011**	**Wet 2009**	**Wet 2010**	**Dry 2011**	**Wet 2009**	**Wet 2010**	**Dry 2011**	**Wet 2009**	**Wet 2010**	**Dry 2011**	**Wet 2009**	**Wet 2010**	**Dry 2011**	**Wet 2009**	**Wet 2010**	**Dry 2011**	**Wet 2009**	**Wet 2010**	**Dry 2011**	**Wet 2009**	**Wet 2010**	**Dry 2011**	**Wet 2009**	**Wet 2010**	**Dry 2011**	**Wet 2009**	**Wet 2010**	**Dry 2011**
AQ01	6.88	ND	ND	28.7	ND	ND	28.2	ND	ND	236	ND	ND	1.42	ND	ND	0.76	ND	ND	1.29	ND	ND	<0.01	ND	ND	0.34	ND	ND	47.9	ND	ND
AQ02	7.11	ND	ND	26.7	ND	ND	26	ND	ND	194	ND	ND	1.9	ND	ND	1.95	ND	ND	1.19	ND	ND	<0.01	ND	ND	0.3	ND	ND	106	ND	ND
AQ03	7.25	ND	ND	158	ND	ND	31.4	ND	ND	112	ND	ND	1.22	ND	ND	0.94	ND	ND	1.19	ND	ND	<0.01	ND	ND	0.33	ND	ND	37.8	ND	ND
AQ04	7.27	ND	8.4	98.4	ND	216	29.6	ND	13.8	68	ND	98	10.83	ND	1.3	4.11	ND	0.13	10.56	ND	0.03	<0.01	ND	<1	0.22	ND	<0.1	230	ND	ND
AQ05	7.15	ND	7.8	98.8	ND	353	26	ND	16.6	76	ND	91	10.53	ND	1.3	1.28	ND	0.16	10.26	ND	0.02	1	ND	<1	0.11	ND	<0.1	97.6	ND	ND
AQ06	7.17	ND	8.18	181.9	ND	510	28	ND	13.5	ND	ND	225	ND	ND	0.3	ND	ND	0.01	ND	ND	0.03	ND	ND	2	ND	ND	0.2	ND	ND	ND
AQ09	8.14	ND	8.66	114.3	ND	61	30	ND	20.3	82	ND	106	2.51	ND	0.9	0.78	ND	0.07	2.38	ND	0.03	<0.01	ND	<1	0.37	ND	<0.1	36	ND	ND
AQ17	7.32	ND	8.37	265	ND	68	25.4	ND	13.5	152	ND	479	4.45	ND	2.4	7.68	ND	0.35	3.38	ND	0.52	1	ND	7	0.41	ND	<0.1	638	ND	ND
AQ18	7.24	ND	ND	144.4	ND	ND	27.5	ND	ND	92	ND	ND	4.13	ND	ND	3.16	ND	ND	3.91	ND	ND	<0.01	ND	ND	0.46	ND	ND	220	ND	ND
AQ19	7.55	ND	ND	171.3	ND	ND	28.9	ND	ND	114	ND	ND	3.36	ND	ND	11.17	ND	ND	1.96	ND	ND	<0.01	ND	ND	0.35	ND	ND	765	ND	ND
AQ23	7.69	ND	8.16	125.7	ND	283	26.3	ND	11.4	106	ND	514	4.18	ND	3	1.4	ND	0.7	4.08	ND	0.08	<0.01	ND	2	0.26	ND	<0.1	51.6	ND	ND
AQ25	8.22	ND	ND	215.7	ND	ND	27.7	ND	ND	172	ND	ND	291.2	ND	ND	5.22	ND	ND	289.73	ND	ND	<0.01	ND	ND	0.52	ND	ND	>1000	ND	ND
AQ25A	ND	ND	7.94	ND	ND	343	ND	ND	15.8	ND	ND	473	ND	ND	1.3	ND	ND	0.18	ND	ND	0.06	-	ND	3	ND	ND	0.2	ND	ND	ND
AQ26	7.89	ND	ND	615	ND	ND	29.8	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
AQ27	7.05	ND	ND	89.8	ND	ND	30.1	ND	ND	96	ND	ND	1.18	ND	ND	0.72	ND	ND	1.1	ND	ND	1	ND	ND	0.28	ND	ND	7.65	ND	ND
AQ28	-	ND	7.64	-	ND	361	-	ND	15.5	96	ND	ND	1.75	ND	0.8	0.68	ND	0.07	1.69	ND	0.02	<0.01	ND	ND	0.16	ND	ND	12.78	ND	ND
AQ29	6.73	ND	ND	104.9	ND	ND	24.7	ND	ND	122	ND	ND	2.87	ND	ND	1.01	ND	ND	2.6	ND	ND	<0.01	ND	ND	0.22	ND	ND	34.2	ND	ND
AQ30	8.61	ND	ND	315	ND	ND	32.2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
AQ31	8.8	ND	8.5	229	ND	215	30	ND	14.1	212	ND	162	54.48	ND	1.2	5.21	ND	0.08	53.76	ND	0.05	1	ND	<1	0.25	ND	<0.1	500	ND	ND
AQ31_R	ND	ND	8.5	ND	ND	215	ND	ND	14.1	ND	ND	126	ND	ND	1.2	ND	ND	0.08	ND	ND	0.04	ND	ND	<1	ND	ND	<0.1	ND	ND	ND
AQ36 (WC1)	ND	6.52	ND	ND	200	ND	ND	26.5	ND	ND	102	ND	ND	<0.1	ND	ND	ND	ND	ND	ND	ND	ND	2	ND	ND	<0.1	ND	ND	ND	ND
AQ37 (WC2)	ND	6.91	ND	ND	240	ND	ND	23	ND	ND	141	ND	ND	0.1	ND	ND	ND	ND	ND	ND	ND	ND	18	ND	ND	<0.1	ND	ND	ND	ND
AQ38 (SC1)	ND	7.09	ND	ND	180	ND	ND	26	ND	ND	324	ND	ND	0.4	ND	ND	ND	ND	ND	ND	ND	ND	1000	ND	ND	<0.1	ND	ND	ND	ND
AQ39 (A1)	ND	7.37	ND	ND	150	ND	ND	26	ND	ND	106	ND	ND	0.4	ND	ND	ND	ND	ND	ND	ND	ND	3	ND	ND	0.2	ND	ND	ND	ND
AQ41 (SM2)	ND	5.64	ND	ND	70	ND	ND	26	ND	ND	122	ND	ND	<0.1	ND	ND	ND	ND	ND	ND	ND	ND	12	ND	ND	<0.1	ND	ND	ND	ND
AQ44	ND	ND	7.93	ND	ND	143	ND	ND	12	ND	ND	395	ND	ND	1.4	ND	ND	0.17	ND	ND	0.03	ND	ND	2	ND	ND	<0.1	ND	ND	ND
AQ48	ND	ND	8.56	ND	ND	278	ND	ND	13.2	ND	ND	182	ND	ND	0.8	ND	ND	0.05	ND	ND	<0.01	ND	ND	<1	ND	ND	<0.1	ND	ND	ND
AQ49	ND	ND	8.17	ND	ND	270	ND	ND	13.6	ND	ND	198	ND	ND	1.1	ND	ND	0.09	ND	ND	<0.01	ND	ND	<1	ND	ND	<0.1	ND	ND	ND
AQ49_R	ND	ND	8.17	ND	ND	270	ND	ND	13.6	ND	ND	198	ND	ND	1.1	ND	ND	0.09	ND	ND	<0.01	ND	ND	<1	ND	ND	<0.1	ND	ND	ND

	Field pH	Field EC (microSiemens / centimetre (µS/cm))	Field Temperature (ºC)	TDS (milligrams / Litre (mg/L))	Total Nitrogen (mg/L)	Total Phosphorous (mg/L)	Nitrate (mg/L)	Sulphate (mg/L)	Fluoride (mg/L)	Turbidity (Nephelometric Turbidity Units (NTU))
Native Companion Creek (Historical) range	6.5 – 8.8	52 - 392	10.8 – 34.1	32 - 224	0.85 – 1.53	0.026 – 0.54	0 – 9.1	0 - 17	0.06 – 0.6	1.2 - 2430

1.0 = value is greater than the trigger value proposed in the ANZECC (2000) Aquatic Ecosystems Guidelines
1.0 = value is greater than the trigger value proposed in the ANZECC (2000) Livestock Drinking Water Guidelines
ND = No Data - parameter not assessed, n/a = not applicable

Table 6 Surface Water Metals Analysis Results

	Al (mg/L)				U (mg/L)				As (mg/l)				Be (mg/L)				Cd (mg/L)				Cr (mg/L)				Ca (mg/L)			
ANZECC Aquatic Ecosystem Values	0.055				n/a				0.013				0.37				0.0002				0.001				n/a			
ANZECC Livestock Drinking Water Values	5				0.2				0.5				5				0.01				1				1000			
Season	**Wet**		**Dry**		**Wet**		**Dry**		**Wet**		**Dry**		**Wet**		**Dry**		**Wet**		**Dry**		**Wet**		**Dry**		**Wet**		**Dry**	
Metals	**T**	**D**	**T**	**D**	**T**	**D**	**T**	**D**	**T**	**D**	**T**	**D**	**T**	**D**	**T**	**D**	**T**	**D**	**T**	**D**	**T**	**D**	**T**	**D**	**T**	**D**	**T**	**D**
Year	**2009**	**2010**	**2011**	**2011**	**2009**	**2010**	**2011**	**2011**	**2009**	**2010**	**2011**	**2011**	**2009**	**2010**	**2011**	**2011**	**2009**	**2010**	**2011**	**2011**	**2009**	**2010**	**2011**	**2011**	**2009**	**2010**	**2011**	**2011**
AQ1	3.087	ND	ND	ND	0.034	ND	ND	ND	0.016	ND	ND	ND	0.065	ND	ND	ND	0.002	ND	ND	ND	0.009	ND	ND	ND	39.37	ND	ND	ND
AQ2	8.13	ND	ND	ND	0.035	ND	ND	ND	0.018	ND	ND	ND	0.075	ND	ND	ND	0.002	ND	ND	ND	0.011	ND	ND	ND	27.13	ND	ND	ND
AQ3	1.462	ND	ND	ND	0.023	ND	ND	ND	0.011	ND	ND	ND	0.073	ND	ND	ND	0.001	ND	ND	ND	0.004	ND	ND	ND	11.91	ND	ND	ND
AQ4	11	ND	1.78	0.11	0.035	ND	<0.001	<0.001	0.009	ND	<0.001	<0.001	0.072	ND	<0.001	<0.001	0.001	ND	<0.05	<0.05	0.011	ND	2	0.3	7.16	ND	11	10
AQ5	10.71	ND	1.56	0.08	0.024	ND	<0.001	<0.001	0.008	ND	0.002	0.001	0.055	ND	<0.001	<0.001	0.001	ND	<0.05	<0.05	0.008	ND	1.6	0.2	7.04	ND	13	11
AQ6	ND	ND	0.13	0.03	ND	ND	<0.001	<0.001	ND	ND	<0.001	<0.001	ND	ND	<0.001	<0.001	ND	ND	<0.05	<0.05	ND	ND	0.5	<0.2	ND	ND	33	31
AQ9	2.163	ND	0.22	0.26	0.012	ND	<0.001	<0.001	0.009	ND	<0.001	<0.001	0.089	ND	<0.001	<0.001	0.004	ND	<0.05	<0.05	0.01	ND	0.3	0.2	3.66	ND	4	3
AQ17	30.38	ND	8.79	0.42	0.131	ND	<0.001	<0.001	0.008	ND	0.002	<0.001	0.113	ND	<0.001	<0.001	0.001	ND	<0.05	<0.05	0.018	ND	8	0.5	11.49	ND	5	4
AQ18	19.21	ND	ND	ND	0.06	ND	ND	ND	0.011	ND	ND	ND	0.053	ND	ND	ND	0.001	ND	ND	ND	0.012	ND	ND	ND	8.58	ND	ND	ND
AQ19	0.075	ND	ND	ND	0.21	ND	ND	ND	0.006	ND	ND	ND	0.071	ND	ND	ND	0.001	ND	ND	ND	0.018	ND	ND	ND	15.88	ND	ND	ND
AQ23	3.979	ND	24	0.14	0.018	ND	<0.001	<0.001	0.011	ND	0.004	<0.001	0.081	ND	<0.001	<0.001	0.002	ND	<0.05	<0.05	0.007	ND	19.7	0.4	7.4	ND	12	9
AQ25	41.33	ND	21.8	0.04	0.0231	ND	<0.001	<0.001	0.011	ND	0.006	0.002	0.104	ND	<0.001	<0.001	0.001	ND	<0.05	<0.05	0.039	ND	16.8	0.5	29.66	ND	7	4
AQ25A	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
AQ26	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
AQ27	0.217	ND	ND	ND	0.009	ND	ND	ND	0.01	ND	ND	ND	0.066	ND	ND	ND	0.001	ND	ND	ND	0.003	ND	ND	ND	8.09	ND	ND	ND
AQ28	0.531	ND	0.12	0.02	0.008	ND	<0.001	<0.001	0.009	ND	<0.001	<0.001	0.06	ND	<0.001	<0.001	0.002	ND	<0.05	<0.05	0.004	ND	<0.2	<0.2	5.54	ND	15	14
AQ29	0.307	ND	ND	ND	0.063	ND	ND	ND	0.011	ND	ND	ND	0.052	ND	ND	ND	0.001	ND	ND	ND	0.004	ND	ND	ND	6.31	ND	ND	ND
AQ30	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
AQ31	15.14	ND	0.76	0.36	0.074	ND	<0.001	<0.001	0.007	ND	0.002	<0.001	0.112	ND	<0.001	<0.001	0.002	ND	<0.05	<0.05	0.022	ND	1.2	0.2	9.17	ND	8	8
AQ31_R	ND	ND	0.8	0.34	ND	ND	<0.001	<0.001	ND	ND	<0.001	<0.001	ND	ND	<0.001	<0.001	ND	ND	<0.05	<0.05	ND	ND	1.4	<0.2	ND	ND	9	8
AQ36 (WC1)	0.19	0.19	ND	ND	n/a	<0.001	ND	ND	<0.001	<0.001	ND	ND	<0.001	<0.001	ND	ND	<0.0001	<0.0001	ND	ND	<0.001	<0.001	ND	ND	5	5	ND	ND
AQ37 (WC2)	0.02	0.02	ND	ND	n/a	<0.001	ND	ND	0.002	0.002	ND	ND	<0.001	<0.001	ND	ND	<0.0001	<0.0001	ND	ND	<0.001	<0.001	ND	ND	15	15	ND	ND
AQ38 (SC1)	0.08	0.08	ND	ND	n/a	<0.001	ND	ND	0.002	0.002	ND	ND	<0.001	<0.001	ND	ND	<0.0001	<0.0001	ND	ND	<0.001	<0.001	ND	ND	12	12	ND	ND
AQ39 (A1)	0.32	0.32	ND	ND	n/a	<0.001	ND	ND	<0.001	<0.001	ND	ND	<0.001	<0.001	ND	ND	<0.0001	<0.0001	ND	ND	<0.001	<0.001	ND	ND	6	6	ND	ND
AQ41 (SM2)	0.18	0.18	ND	ND	n/a	<0.001	ND	ND	<0.001	<0.001	ND	ND	<0.001	<0.001	ND	ND	<0.0001	<0.0001	ND	ND	<0.001	<0.001	ND	ND	<1	<1	ND	ND
AQ44	ND	ND	9.58	0.17	ND	ND	<0.001	<0.001	ND	ND	0.001	<0.001	ND	ND	<0.001	<0.001	ND	ND	<0.05	<0.05	ND	ND	10.6	0.8	ND	ND	2	1
AQ48	ND	ND	1.4	0.08	ND	ND	<0.001	<0.001	ND	ND	<0.001	<0.001	ND	ND	<0.001	<0.001	ND	ND	<0.05	<0.05	ND	ND	1.8	0.2	ND	ND	14	14
AQ49	ND	ND	2.03	0.61	ND	ND	<0.001	<0.001	ND	ND	0.002	<0.001	ND	ND	<0.001	<0.001	ND	ND	<0.05	<0.05	ND	ND	2.6	0.4	ND	ND	13	12

	Al (mg/L)				U (mg/L)				As (mg/l)				Be (mg/L)				Cd (mg/L)				Cr (mg/L)				Ca (mg/L)			
ANZECC Aquatic Ecosystem Values	0.055				n/a				0.013				0.37				0.0002				0.001				n/a			
ANZECC Livestock Drinking Water Values	5				0.2				0.5				5				0.01				1				1000			
AQ49_R	ND	ND	2.33	0.55	ND	ND	<0.001	<0.001	ND	ND	0.002	<0.001	ND	ND	<0.001	<0.001	ND	ND	<0.05	<0.05	ND	ND	2.4	0.4	ND	ND	13	12
Native Companion Creek (Historical) range	0 – 1.9				n/a				n/a				0 – 0.1				n/a				n/a				4 – 28.1			

1.0 = value is greater than the trigger value proposed in the ANZECC (2000) Aquatic Ecosystems Guidelines
1.0 = value is greater than the trigger value proposed in the ANZECC (2000) Livestock Drinking Water Guidelines
ND = No Data - parameter not assessed, n/a = not applicable
T = total D= dissolved

Table 6 Surface Water Metals Analysis (cont)

	Cu (mg/L)		Pb (mg/L)		Mn (mg/L)		Hg (mg/L)		Mo (mg/L)		Sb (mg/L)	
ANZECC Aquatic Ecosystems Values	0.0014		0.0034		1.9		0.0006		n/a		n/a	
ANZECC Livestock Drinking Water Values	1		0.1		n/a		0.002		0.15		n/a	

Season	**Wet**		**Dry**		**Wet**		**Dry**		**Wet**		**Dry**		**Wet**		**Dry**		**Wet**		**Dry**		**Wet**		**Dry**	
Metals	**T**	**D**	**T**	**D**	**T**	**D**	**T**	**D**	**T**	**D**	**T**	**D**	**T**	**D**	**T**	**D**	**T**	**D**	**T**	**D**	**T**	**D**	**T**	**D**
Year	**2009**	**2010**	**2011**	**2011**	**2009**	**2010**	**2011**	**2011**	**2009**	**2010**	**2011**	**2011**	**2009**	**2010**	**2011**	**2011**	**2009**	**2010**	**2011**	**2011**	**2009**	**2010**	**2011**	**2011**
AQ1	0.003	ND	ND	ND	0.008	ND	ND	ND	6.057	ND	ND	ND	<0.0001	ND	ND	ND	0.008	ND	ND	ND	0.116	ND	ND	ND
AQ2	0.004	ND	ND	ND	0.011	ND	ND	ND	4.275	ND	ND	ND	<0.0001	ND	ND	ND	0.008	ND	ND	ND	0.041	ND	ND	ND
AQ3	0.004	ND	ND	ND	0.008	ND	ND	ND	0.376	ND	ND	ND	<0.0001	ND	ND	ND	0.005	ND	ND	ND	<0.005	ND	ND	ND
AQ4	0.005	ND	2.9	1.6	0.012	ND	0.002	<0.001	0.147	ND	0.084	0.003	<0.0001	ND	<0.0001	<0.0001	0.006	ND	<0.001	<0.001	<0.005	ND	<0.001	<0.001
AQ5	0.003	ND	2.2	1.4	0.006	ND	0.001	0.001	0.14	ND	0.093	0.004	<0.0001	ND	<0.0001	<0.0001	<0.005	ND	<0.001	<0.001	<0.005	ND	<0.001	<0.001
AQ6	ND	ND	1.6	0.5	ND	ND	<0.001	0.009	ND	ND	0.175	0.149	ND	ND	<0.0001	<0.0001	ND	ND	<0.001	<0.001	ND	ND	<0.001	<0.001
AQ9	0.003	ND	0.5	0.5	0.01	ND	<0.001	<0.001	0.066	ND	0.014	0.006	<0.0001	ND	<0.0001	<0.0001	<0.005	ND	<0.001	<0.001	<0.005	ND	<0.001	<0.001
AQ17	0.007	ND	4.9	1	0.016	ND	0.006	<0.001	0.695	ND	0.146	0.104	<0.0001	ND	<0.0001	<0.0001	0.005	ND	<0.001	<0.001	<0.005	ND	<0.001	<0.001
AQ18	0.005	ND	ND	ND	0.008	ND	ND	ND	0.481	ND	ND	ND	<0.0001	ND	ND	ND	<0.005	ND	ND	ND	<0.005	ND	ND	ND
AQ19	0.016	ND	ND	ND	0.023	ND	ND	ND	2.369	ND	ND	ND	<0.0001	ND	ND	ND	<0.005	ND	ND	ND	<0.005	ND	ND	ND
AQ23	0.004	ND	12.1	2.8	0.01	ND	0.015	0.005	0.234	ND	0.3	0.004	<0.0001	ND	<0.0001	<0.0001	0.013	ND	<0.001	<0.001	<0.005	ND	<0.001	<0.001
AQ25	0.042	ND	8.2	2.8	0.036	ND	0.005	0.003	2.728	ND	0.191	0.004	<0.0001	ND	<0.0001	<0.0001	0.006	ND	<0.001	<0.001	<0.005	ND	<0.001	<0.001
AQ25A	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

	Cu (mg/L)				Pb (mg/L)				Mn (mg/L)				Hg (mg/L)				Mo (mg/L)				Sb (mg/L)			
AQ26	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
AQ27	<0.002	ND	ND	ND	0.007	ND	ND	ND	0.04	ND	ND	ND	<0.0001	ND	ND	ND	0.005	ND	ND	ND	<0.005	ND	ND	ND
AQ28	0.002	ND	1.2	0.5	0.008	ND	<0.001	0.002	0.064	ND	0.028	0.011	<0.0001	ND	<0.0001	<0.0001	0.005	ND	<0.001	<0.001	<0.005	ND	<0.001	<0.001
AQ29	0.002	ND	ND	ND	0.009	ND	ND	ND	0.586	ND	ND	ND	<0.0001	ND	ND	ND	<0.005	ND	ND	ND	<0.005	ND	ND	ND
AQ30	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
AQ31	ND	ND	2.1	2	0.018	ND	<0.001	<0.001	0.199	ND	0.076	0.002	<0.0001	ND	<0.0001	<0.0001	0.008	ND	<0.001	<0.001	0.006	ND	<0.001	<0.001
AQ31_R	ND	ND	2.3	1.9	ND	ND	0.001	0.002	ND	ND	0.079	0.003	ND	ND	<0.0001	<0.0001	ND	ND	<0.001	<0.001	ND	ND	<0.001	<0.001
AQ36 (WC1)	0.002	0.002	ND	ND	<0.001	<0.001	ND	ND	0.028	0.028	ND	ND	<0.0001	<0.0001	ND	ND	<0.001	<0.001	ND	ND	<0.001	<0.001	ND	ND
AQ37 (WC2)	<0.001	<0.001	ND	ND	<0.001	<0.001	ND	ND	2.19	2.19	ND	ND	<0.0001	<0.0001	ND	ND	<0.001	<0.001	ND	ND	<0.001	<0.001	ND	ND
AQ38 (SC1)	0.001	0.001	ND	ND	<0.001	<0.001	ND	ND	0.642	0.642	ND	ND	<0.0001	<0.0001	ND	ND	<0.001	<0.001	ND	ND	<0.001	<0.001	ND	ND
AQ39 (A1)	0.002	0.002	ND	ND	<0.001	<0.001	ND	ND	0.014	0.014	ND	ND	<0.0001	<0.0001	ND	ND	<0.001	<0.001	ND	ND	<0.001	<0.001	ND	ND
AQ41 (SM2)	0.001	0.001	ND	ND	<0.001	<0.001	ND	ND	0.03	0.03	ND	ND	<0.0001	<0.0001	ND	ND	<0.001	<0.001	ND	ND	<0.001	<0.001	ND	ND
AQ44	ND	ND	3.8	0.9	ND	ND	0.006	<0.001	ND	ND	0.026	0.002	ND	ND	<0.0001	<0.0001	ND	ND	<0.001	<0.001	ND	ND	<0.001	<0.001
AQ48	ND	ND	3	2	ND	ND	0.003	0.002	ND	ND	0.054	0.002	ND	ND	<0.0001	<0.0001	ND	ND	<0.001	<0.001	ND	ND	<0.001	<0.001
AQ49	ND	ND	3.5	2	ND	ND	0.002	<0.001	ND	ND	0.061	0.002	ND	ND	<0.0001	<0.0001	ND	ND	<0.001	<0.001	ND	ND	<0.001	<0.001
AQ49_R	ND	ND	3.1	2	ND	ND	0.002	<0.001	ND	ND	0.071	0.002	ND	ND	<0.0001	<0.0001	ND	ND	<0.001	<0.001	ND	ND	<0.001	<0.001
Native Companion Creek (Historical) range	0 – 0.08				n/a				0 – 0.03				n/a				n/a				n/a			

1.0 = value is greater than the trigger value proposed in the ANZECC (2000) Aquatic Ecosystems Guidelines
1.0 = value is greater than the trigger value proposed in the ANZECC (2000) Livestock Drinking Water Guidelines
ND = No Data - parameter not assessed, n/a = not applicable
T = total D= dissolved

Table 6 Surface Water Metals Analysis (cont)

	Ni (mg/L)				Se (mg/L)				Zn (mg/L)			
ANZECC Aquatic Ecosystems Values	0.011				0.011				0.008			
ANZECC Livestock Drinking Water Values	1				0.02				20			
Season	**Wet**		**Dry**		**Wet**		**Dry**		**Wet**		**Dry**	
Metals	**T**	**D**	**T**	**D**	**T**	**D**	**T**	**D**	**T**	**D**	**T**	**D**
Year	**2009**	**2010**	**2011**	**2011**	**2009**	**2010**	**2011**	**2011**	**2009**	**2010**	**2011**	**2011**
AQ1	0.008	ND	ND	ND	0.01	ND	ND	ND	0.008	ND	ND	ND
AQ2	0.009	ND	ND	ND	0.02	ND	ND	ND	0.004	ND	ND	ND
AQ3	0.004	ND	ND	ND	0.01	ND	ND	ND	<0.002	ND	ND	ND
AQ4	0.007	ND	0.002	0.001	0.01	ND	0.2	0.2	0.005	ND	<0.005	0.008
AQ5	0.005	ND	0.002	0.001	0.01	ND	<0.2	<0.2	0.003	ND	0.006	<0.005
AQ6	ND	ND	0.002	0.001	ND	ND	<0.2	<0.2	ND	ND	0.005	0.006
AQ9	0.007	ND	<0.001	<0.001	0.01	ND	<0.2	<0.2	<0.004	ND	<0.005	0.007
AQ17	0.01	ND	0.004	0.001	0.01	ND	0.2	0.2	0.008	ND	0.005	<0.005
AQ18	0.009	ND	ND	ND	0.01	ND	ND	ND	0.003	ND	ND	ND
AQ19	0.018	ND	ND	ND	<0.01	ND	ND	ND	0.022	ND	ND	ND
AQ23	0.007	ND	0.011	0.001	0.01	ND	0.4	0.2	<0.002	ND	0.02	0.005
AQ25	0.026	ND	0.01	0.002	<0.01	ND	0.4	0.2	0.075	ND	0.028	0.009
AQ25A	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
AQ26	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
AQ27	<0.004	ND	ND	ND	0.01	ND	ND	ND	<0.002	ND	ND	ND
AQ28	<0.004	ND	<0.001	<0.001	0.01	ND	<0.2	<0.2	<0.002	ND	<0.005	<0.005
AQ29	0.005	ND	ND	ND	0.01	ND	ND	ND	<0.002	ND	ND	ND
AQ30	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
AQ31	0.017	ND	0.002	0.002	0.01	ND	<0.2	<0.2	0.011	ND	<0.005	<0.005
AQ31_R	ND	ND	0.003	0.002	ND	ND	<0.2	<0.2	ND	ND	<0.005	<0.005
AQ36 (WC1)	0.002	0.002	ND	ND	<0.01	<0.01	ND	ND	0.012	0.012	ND	ND
AQ37 (WC2)	0.005	0.005	ND	ND	<0.01	<0.01	ND	ND	<0.005	<0.005	ND	ND
AQ38 (SC1)	0.003	0.003	ND	ND	<0.01	<0.01	ND	ND	<0.005	<0.005	ND	ND
AQ39 (A1)	0.002	0.002	ND	ND	<0.01	<0.01	ND	ND	<0.005	<0.005	ND	ND
AQ41 (SM2)	0.001	0.001	ND	ND	<0.01	<0.01	ND	ND	0.086	0.086	ND	ND
AQ44	ND	ND	0.003	<0.001	ND	ND	0.4	0.2	ND	ND	<0.005	<0.005
AQ48	ND	ND	0.002	<0.001	ND	ND	<0.2	<0.2	ND	ND	0.019	0.006
AQ49	ND	ND	0.002	0.001	ND	ND	<0.2	<0.2	ND	ND	0.006	<0.005

	Ni (mg/L)				Se (mg/L)				Zn (mg/L)			
AQ49_R	ND	ND	0.002	0.001	ND	ND	<0.2	<0.2	ND	ND	0.008	<0.005
Native Companion Creek (Historical) range	n/a				n/a				0 – 0.1			

-- = value is greater than the trigger value proposed in the ANZECC (2000) Aquatic Ecosystems Guidelines
1.0 = value is greater than the trigger value proposed in the ANZECC (2000) Livestock Drinking Water Guidelines
ND = No Data - parameter not assessed
T = total D= dissolved

The results from the baseline surveying of water quality on and surrounding the Project site show that water exceeds the trigger values provided in the ANZECC (2000) Aquatic Ecosystems Guidelines at one or more sites for pH, EC, Total Nitrogen, Total Phosphorous, Nitrate, Turbidity, Sulphate, Aluminium, Arsenic, Cadmium, Chromium, Copper, Lead, Manganese, Selenium, Zinc, and Nickel. Further, Aluminium, Selenium, Copper, Chromium and Uranium levels exceeded the proposed trigger values provided in the ANZECC (2000) Livestock Drinking Water Guidelines.

The elevated (above ANZECC (2000) Aquatic Ecosystems Guideline trigger values) surface water heavy-metal concentrations that were recorded at specific aquatic sampling locations, are probably a result of elevated heavy metals present in the solid strata (rocks and sediment) over which the surface water flows.

6.2.1 Proposed Monitoring

It is proposed that water quality continue to be monitored prior to any Project activities occurring, throughout the life of the Project, and throughout decommissioning and rehabilitation. As background water quality exceeds parameters provided in the ANZECC Guidelines, it is necessary to set site-specific water quality targets.

The Queensland Water Quality Guidelines (2006) provide procedures for deriving local monitoring parameter values for aquatic ecosystem protection..

6.3 SEDIMENT

Analytical results produced for the sediment samples have been compared against ANZECC trigger values for stream sediment quality.

6.3.1 Metal Concentrations

The results of the sediment analysis were screened against both high and low interim sediment quality guidelines (ISQG) for stream sediments, a summary of which is presented in Table 7.

None of the results exceeded the low or high ISQG values. However, it should be noted that Silver exhibits a limit of detection of 2mg/kg (which is above the low ISQG values for this metal) and therefore an assessment of silver in sediments against the low ISQG value cannot be conducted.

Therefore, contaminated sediment does not appear to be present at the sediment sampling locations.

Table 7 Sediment Analysis Results: Total Metals

	Antimony (mg/kg)	Arsenic (mg/kg)	Barium (mg/kg)	Beryllium (mg/kg)	Cadmium (mg/kg)	Chromium (mg/kg)	Cobalt (mg/kg)	Copper (mg/kg)	Lead (mg/kg)	Manganese (mg/kg)	Nickel (mg/kg)	Selenium (mg/kg)	Silver (mg/kg)	Vanadium (mg/kg)	Zinc (mg/kg)	Uranium (mg/kg)	Mercury (mg/kg)
ISQG-Low	2	20			1.5	80		65	50		21		1		200		0.15
ISQG - High	25	70			10	370		270	220		52		3.7		410		1
AQ04	<5	<5	30	<1	<1	5	<2	<5	<5	27	<2	<5	<2	13	<5	0.3	<0.1
AQ05	<5	<5	70	<1	<1	11	6	7	8	86	5	<5	<2	30	8	0.4	<0.1
AQ06	<5	<5	70	<1	<1	11	6	6	7	304	6	<5	<2	22	11	0.4	<0.1
AQ08	<5	<5	<10	<1	<1	<2	<2	<5	<5	12	<2	<5	<2	<5	<5	<0.1	<0.1
AQ09	<5	7	50	<1	<1	39	4	<5	9	89	3	<5	<2	80	<5	0.3	<0.1
AQ10/46	<5	<5	20	<1	<1	4	<2	<5	<5	6	<2	<5	<2	12	<5	0.1	<0.1
AQ11	<5	<5	20	<1	<1	6	2	<5	<5	85	<2	<5	<2	12	<5	<0.1	<0.1
AQ12	<5	<5	150	<1	<1	8	2	<5	10	667	<2	<5	<2	25	<5	0.1	<0.1
AQ13A	<5	<5	70	<1	<1	17	4	<5	6	143	2	<5	<2	59	11	0.3	<0.1
AQ13B	<5	<5	60	<1	<1	9	3	<5	<5	110	2	<5	<2	29	10	0.2	<0.1
AQ14	<5	<5	40	<1	<1	12	<2	<5	<5	17	<2	<5	<2	32	<5	0.2	<0.1
AQ15	<5	<5	<10	<1	<1	<2	<2	<5	<5	5	<2	<5	<2	<5	<5	<0.1	<0.1
AQ16	<5	<5	40	<1	<1	4	<2	<5	<5	154	<2	<5	<2	7	<5	0.1	<0.1
AQ17	<5	7	140	<1	<1	38	3	8	10	179	4	<5	<2	133	8	0.5	<0.1
AQ23	<5	<5	100	<1	<1	10	6	5	7	439	4	<5	<2	24	7	0.4	<0.1
AQ24	<5	<5	170	<1	<1	12	12	<5	9	1370	6	<5	<2	31	<5	0.3	<0.1
AQ25	<5	<5	100	<1	<1	14	5	14	8	361	7	<5	<2	33	24	0.7	<0.1
AQ25-A	<5	<5	70	<1	<1	10	4	<5	<5	192	4	<5	<2	41	10	0.5	<0.1
AQ26	<5	<5	10	<1	<1	26	3	<5	7	137	2	<5	<2	37	<5	0.4	<0.1
AQ27	<5	<5	60	<1	<1	13	4	8	6	247	8	<5	<2	32	14	0.2	<0.1
AQ28	<5	<5	60	<1	<1	14	3	14	10	113	6	<5	<2	34	16	1	<0.1
AQ29	<5	<5	90	<1	<1	18	2	13	13	126	5	<5	<2	38	22	1.1	<0.1
AQ31	<5	<5	10	<1	<1	8	<2	<5	<5	67	2	<5	<2	13	<5	0.2	<0.1
AQ32	<5	<5	140	1	<1	22	10	15	14	455	12	<5	<2	54	27	1	<0.1
AQ33	<5	<5	60	<1	<1	16	8	13	12	552	6	<5	<2	35	15	0.7	<0.1
AQ34_A	<5	<5	60	<1	<1	13	5	<5	10	473	4	<5	<2	21	<5	0.2	<0.1
AQ34B	<5	<5	60	<1	<1	15	4	<5	10	389	2	<5	<2	18	<5	0.1	<0.1
AQ35	<5	<5	120	<1	<1	20	6	13	11	212	9	<5	<2	46	20	0.4	<0.1
AQ40	<5	<5	<10	<1	<1	2	<2	<5	<5	17	<2	<5	<2	<5	<5	<0.1	<0.1
AQ41	<5	<5	<10	<1	<1	<2	<2	<5	<5	9	<2	<5	<2	<5	<5	<0.1	<0.1
AQ42	<5	<5	<10	<1	<1	3	<2	<5	<5	<5	<2	<5	<2	13	<5	<0.1	<0.1
AQ43	<5	<5	20	<1	<1	11	4	<5	<5	45	<2	<5	<2	34	<5	0.1	<0.1
AQ44	<5	7	20	<1	<1	14	<2	<5	<5	11	<2	<5	<2	53	<5	0.2	<0.1
AQ45	<5	<5	10	<1	<1	6	<2	<5	<5	5	<2	<5	<2	11	<5	<0.1	<0.1
AQ47	<5	<5	10	<1	<1	13	<2	<5	<5	48	<2	<5	<2	35	<5	0.1	<0.1
AQ48	<5	<5	40	<1	<1	8	2	<5	<5	138	3	<5	<2	16	12	0.2	<0.1
AQ49	<5	<5	60	<1	<1	13	4	7	8	196	5	<5	<2	26	8	0.3	<0.1

6.3.2 Particle Size

The Project Site stream substrates are typically sands; which is depicted below in Table 8 and Figure 11. AQ25_A (the pastoral dam adjacent to AQ25), AQ28, AQ29, AQ32, AQ33 and AQ35 exhibited higher fine sediment percentages than other sites (clay particles <2 micrometre (µm) and silt of 2 - 60µm). These sites are described as either dams, lacustrine wetlands or palustrine wetlands, and the majority of these structures contained water at the time of this survey. The fine sediments (with a larger clay component) permit water to be retained for longer in these areas.

Table 8 Particle Size Distributions

Site	Unit	Fines (<75 µm)	Sand (>75 µm)	Gravel (>2mm)	Cobbles (>6cm)
AQ04	%	24	74	1	<1
AQ05	%	32	67	<1	<1
AQ06	%	32	65	3	<1
AQ08	%	1	97	2	<1
AQ09	%	27	71	2	<1
AQ10/46	%	7	90	2	<1
AQ11	%	3	97	<1	<1
AQ12	%	5	93	3	<1
AQ13A	%	14	82	4	<1
AQ13B	%	9	88	3	<1
AQ14	%	16	83	1	<1
AQ15	%	<1	96	4	<1
AQ16	%	<1	98	1	<1
AQ17	%	24	64	11	<1
AQ23	%	40	59	<1	<1
AQ24	%	4	86	9	<1
AQ25	%	77	23	<1	<1
AQ25-A	%	46	54	<1	<1
AQ26	%	20	78	2	<1
AQ27	%	47	51	2	<1

Site	Unit	Fines (<75 µm)	Sand (>75 µm)	Gravel (>2mm)	Cobbles (>6cm)
AQ28	%	68	31	1	<1
AQ29	%	80	20	<1	<1
AQ31	%	17	81	2	<1
AQ32	%	94	5	<1	<1
AQ33	%	74	25	1	<1
AQ34_A	%	11	87	2	<1
AQ34B	%	12	86	2	<1
AQ35	%	71	28	1	<1
AQ40	%	<1	96	3	<1
AQ41	%	<1	91	9	<1
AQ42	%	4	93	3	<1
AQ43	%	3	96	1	<1
AQ44	%	7	91	3	<1
AQ45	%	3	95	2	<1
AQ47	%	6	85	9	<1
AQ48	%	25	71	3	<1
AQ49	%	40	60	1	<1

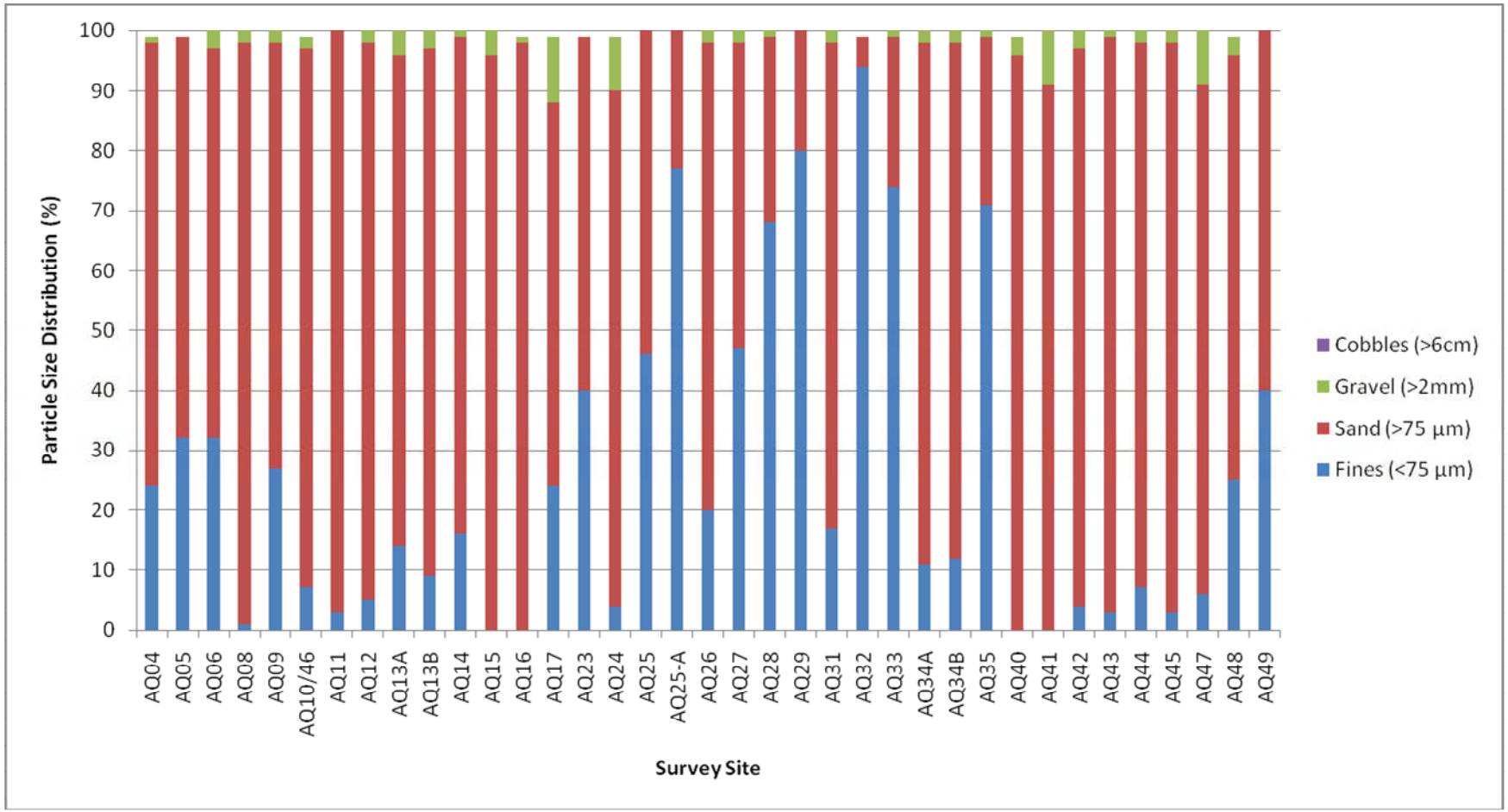


Figure 11: Stream Sediment Particle Size Distribution

6.4 AQUATIC AND RIPARIAN VEGETATION

The riparian vegetation is described more fully in the Terrestrial Flora and Fauna report. The larger creeks (e.g. Lagoon Creek and Sandy Creek) are vegetated with River Red Gum (*Eucalyptus camaldulensis*) riparian woodland (Regional Ecosystem 10.3.14). Smaller creeks and drainage lines are typically vegetated with the same Regional Ecosystem species as the surrounding areas (woodlands, grasslands, Brigalow community, etc).

6.4.1 Communities of Conservation Significance

The *Eucalyptus camaldulensis* woodland along drainage lines (Regional Ecosystem 10.3.14) is listed as Of Concern by the DERM Biodiversity Status. This listing is due to weed infestation and degradation. The Terrestrial Flora and Fauna Assessment by AARC mapped the extent of this Regional Ecosystem within the Project site.

6.4.2 Plants of Conservation Significance

No plants species listed under either the NC Act or EPBC Act were identified during the course of the survey. A full plant species list of species identified during the survey from riparian and aquatic sites is provided in Appendix D.

6.4.3 Introduced / Weed Species

Numerous introduced plant species were identified on the Project site within riparian habitat. These are listed below in Table 9. The Department of Employment, Economic Development and Innovation (DEEDI) website was searched for the status of each introduced species against the declared species list and Weed of National Significance (WONS) list.

Under the LP Act pest species can be listed as Class 1, 2, or 3 declared animals. Class 1 pest species are those that are not commonly present in Queensland, and, if introduced, would cause an adverse economic, environmental, or social impact. Land owners must take reasonable steps to keep land free of Class 1 pests. Class 2 pest species are established in Queensland and have, or could have, an adverse economic, environmental, or social impact. Land owners must take reasonable steps to keep land free of Class 2 pests, and often a coordinated approach by land owners, local government, and the community is required. Class 3 pest species are those that are established in Queensland and have, or could have, an adverse economic, environmental, or social impact. The primary objective of the Class 3 listing is to prevent the sale of the species, and therefore prevent their spread into new areas. Landholders are not required to keep land free of Class 3 pests, unless their land is adjacent to an environmentally significant area.

Table 9 Introduced Species of the Project Site

Botanical Name	Common Name	Status under the LP Act
Opuntia tomentosa	Velvety Tree Pear	Class 2
Parkinsonia aculeata	Parkinsonia	Class 2
Lantana camara	Lantana	Class 3
Echinochloa colona	Awnless Barnyard Grass	Not declared[4]
Scoparia dulcis	Scoparia	Not declared
Verbesina encelioides	-	Not declared
Verbena incompta	Purpletop	Not declared
Cucumis anguria var. anguria	West Indian Gherkin	Not declared
Digitaria ciliaris	Summer Grass	Not declared
Xanthium pungens	Noogoora Burr	Not declared
Ricinus communis	Castor Oil Plant	Not declared
Cenchrus ciliaris	Buffel Grass	Not declared
Melinus repens	Red Natal Grass	Not declared

Pest Fact Sheets sourced from DEEDI are provided in Appendix E for Noogoora Burr, Castor Oil Bush, Velvety Tree Pear, Lantana and Parkinsonia.

Site AQ06, situated on Native Companion Creek was noted as having prolific Castor Oil Plant along the banks of the watercourse (Photo Plate 8). Although this site is located outside of the Project areas, and was surveyed to provide reference site data, care should be taken that Castor Oil Plant does not spread to the Project site. A Pest Fact Sheet is provided in Appendix E.

[4] Plants listed as 'Not Declared' under the LP Act are not declared plants under Queensland legislation, however they are considered weeds and therefore, control is recommended.

Photo Plate 8 Castor Oil Plant at AQ6

Parthenium (*Parthenium hysterophorus*), whilst not observed during the survey, has become a weed of major concern within the Project site due to its recent propagation there, and is listed as a Class 2 declared weed. Survey site AQ35 is located adjacent to an area which had recently been sprayed for Parthenium. Lantana (*Lantana camara*), a Class 3 declared weed and a WONS, has also been observed by the landowners within the Project site. Pest Fact Sheets are provided in Appendix E.

6.5 MACRO-INVERTEBRATES

Macro-invertebrates are invertebrates that can be seen with the naked eye. The types and numbers of macro-invertebrates found in a river or creek can be used as biological indicators (bio-indicators) of the health of that environment for the following reasons:

1) They are generally sensitive to the cumulative impacts of a wide range of disturbances and pollutants;

2) They are abundant in freshwater systems;

3) They are relatively easy to identify; and

4) They are easy to collect (Chessman, 2003).

A total of 58 macro-invertebrate taxa were identified during the wet season surveys, and 47 were identified during the dry season. The complete taxa lists of the macro-invertebrates identified during the three surveys are presented in Appendix F. Some of the more commonly encountered macro-invertebrate families included Leptoceidae, Diptera: Chironominae, Trichoptera: Tanypodinae and Chironominae, Acarina: Acarina and Ephemeroptera: Baetidae.

Of these taxa, the abundances of 53 were used for the wet season SIGNAL scoring and 44 were used for the dry season analysis. SIGNAL scoring excluded Freshwater Crabs (*Holthuisana* spp), two species of freshwater crayfish (*Cherax* sp), and three species of shrimp due to the non-standardised method of capturing them (i.e. captures were not timed as for the live-picking method when dip-netting, and potential for re-captures exists due to the catch-release method utilised).

The SIGNAL 2 score method is commonly used to assess the health of a river, by looking at the taxonomic composition of the macro-invertebrate assemblage. The SIGNAL 2 Index value is calculated by averaging the pollution sensitivity grade numbers of the macro-invertebrate families present at each site, and plotting it against the number of families.

Figures 12 and 13 below shows the result of the SIGNAL 2 assessment of macro-invertebrate assemblages within and surrounding the Project site during the wet and dry seasons respectively. In the wet season no sites fell within the "pristine" category of Quadrant 1. Sites within Quadrant 2 included AQ3 (two pools of water in Lagoon Creek), AQ5 (situated in numerous small terrace pools in Lagoon Creek vegetated with lily pads (*Nymphoides* sp) and inundated grass), AQ6 (situated in Native Companion Creek), AQ23 (situated downstream of the confluence of Saltbush and Lagoon Creeks in an area with trailing vegetation), AQ28 (situated within the Lagoon) AQ29 (lacustrine area in the Exploration Permit – Coal Application (EPCA), sector densely vegetated with water plants and grass species), AQ37(situated in an ephemeral creek) and AQ39 (situated in an ephemeral creek). All other sites fell within Quadrant 4. Whilst this would normally indicate some form of industrial pollution, it should be noted that the Queensland AUSRIVAS Sampling and Processing Manual (Conrick and Cockayne, 2001) dictates that sampling should occur during the early wet season (when flow has been established for at least four weeks), and four to six weeks after any flooding has subsided. Due to rainfall events prior to the wet season surveys, the sample period was not entirely optimal.

In the dry season, most sites fell within Quadrant 2, with only AQ06 occurring in the 'pristine' category of Quadrant 1 and AQ04 falling in Quadrant 4. A site's position in Quadrant 4 normally indicates toxic pollution or a harsh physical environment, however the surface water results for this site do not indicate high levels of pollution or a particularly harsh aquatic environment, so the relatively low number of macroinvertebrate families present may instead be a result of the timing of the survey, coupled with the fact that the site consists of a single, non-flowing pool.

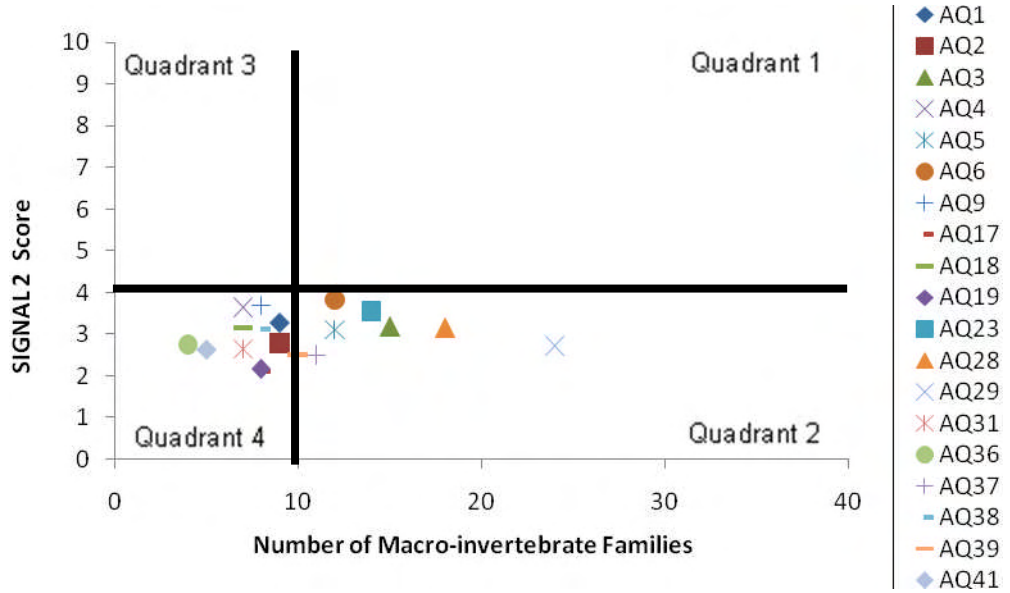


Figure 12: SIGNAL 2 Score Bi-Plot – March 2009 and 2010 (Wet Season)

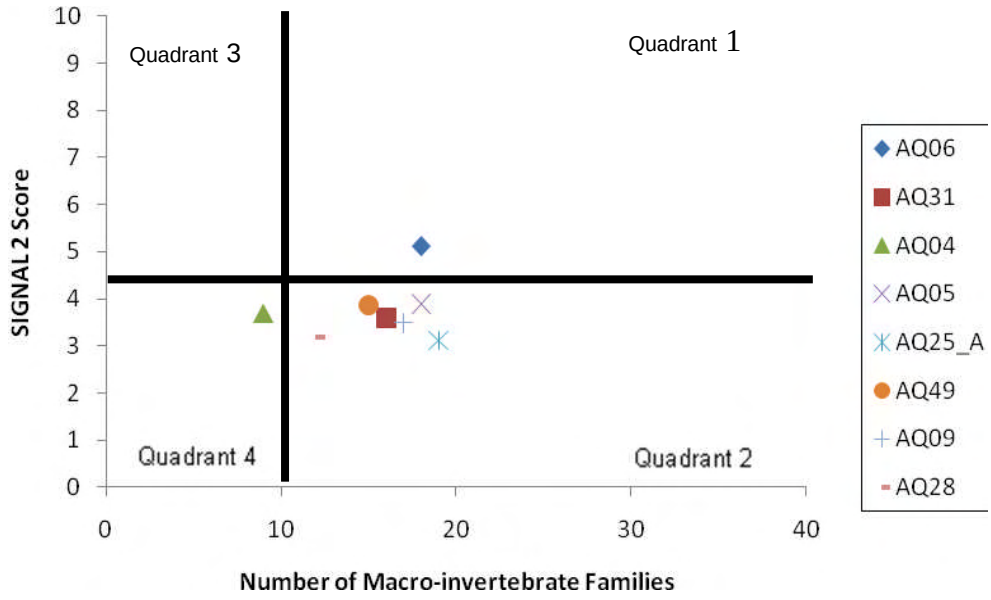


Figure 13: SIGNAL 2 Score Bi-Plot – June 2011 (Dry Season)

Figures 14 and 15 show a comparison of the macro-invertebrate family richness across all sites surveyed during the wet and dry seasons respectively. It can be seen that in the wet season, AQ28 and AQ29 had the highest family richness, followed by AQ05 and AQ06. In the dry season AQ25_A had the highest family richness, followed by AQ05 and AQ06. These sites fell within Quadrant 1 and 2 of the bi-plots (refer to Figures 12 and 13 above), indicating a healthy and diverse habitat for macro-invertebrate fauna.

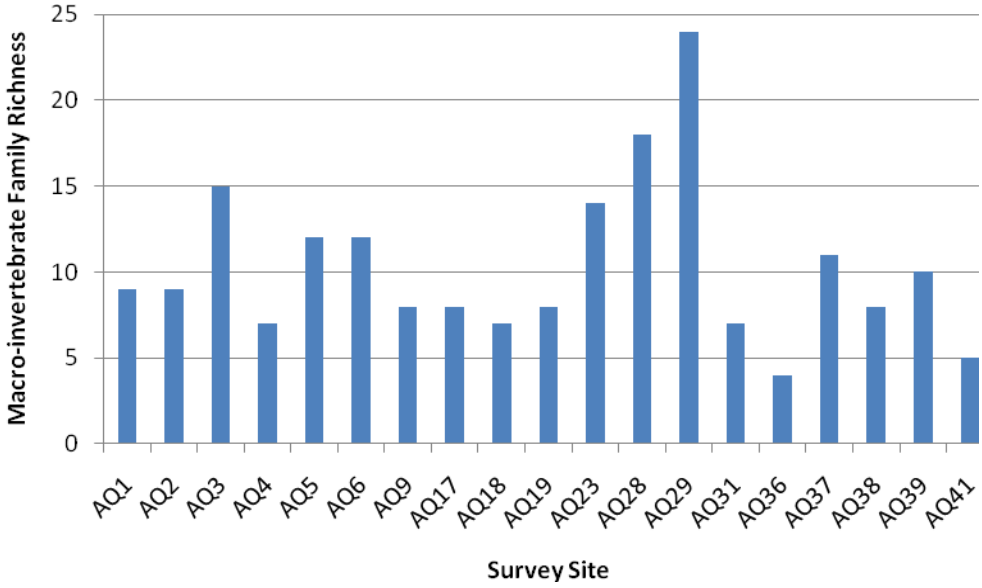


Figure 14: Macro-invertebrate Family Richness (Wet Season)

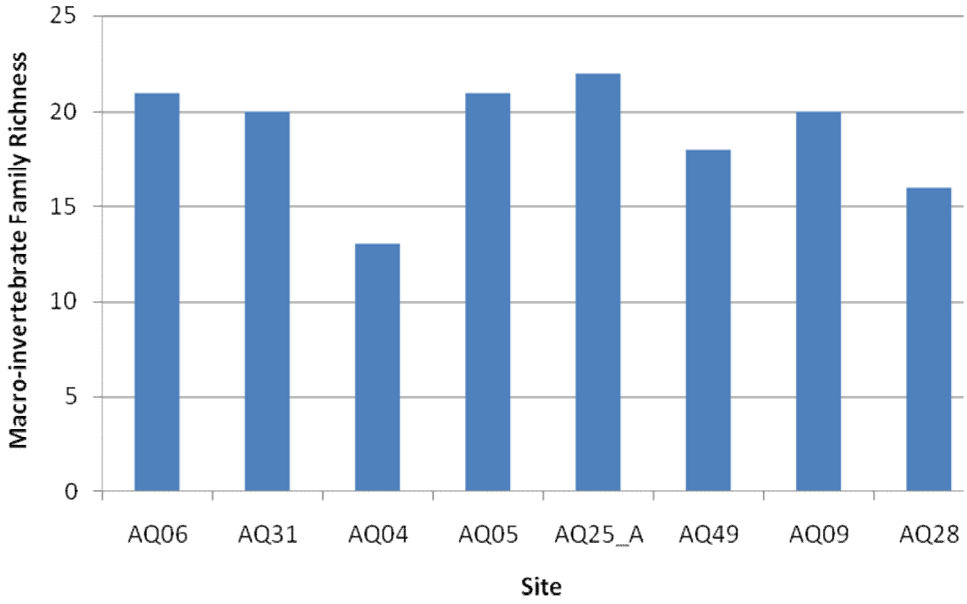


Figure 15: Macro-invertebrate Family Richness (Dry Season)

There are numerous factors that affect the distribution and density of macro-invertebrates. Oldmeadow *et al* (1997) claim algal cover to be a significant variable in the distribution of macro-invertebrates. Fritz and Dodds (2005) state that flooding in intermittent streams is an important factor in macro-invertebrate density and richness, with their study showing that a greater than 50 year flood can reduce site richness by up to 97% immediately following the flood event. Bunn *et al.* (1999) found the accumulation of leaf litter and benthic debris within a stream channel to be an important factor for macro-invertebrate richness, as it forms the basis of the aquatic food web. Growns and Davis (1991) found that cattle grazing can lead to the reduction in some of the functional feeding roles (shredders, grazers, collectors, and predators) within a stream.

In line with the graphed results, sites such as AQ04, which fell into Quadrant 3 of the SIGNAL bi-plot in the wet season and Quadrant 4 in the dry season, and had a relatively low macro-invertebrate family diversity were noted to have higher cattle grazing density and more extensive evidence of disturbance on the banks.

The FFGs most commonly encountered were predators followed by scrapers and gathering collectors (Figures 16 and 17 below). This was reflected in the FFGs represented at individual sites, with 16 of the 19 sites surveyed for macro-invertebrates having a larger composition of predatory taxa than any other FFG, and all sites having at least one predatory group of macro-invertebrates present in the faunal composition. Shredders and macrophyte piercers were the least encountered, being present at only four survey sites. When the FFGs per site were compared also with the position within the SIGNAL bi-plot, it can be seen that those sites falling within Quadrant 4 typically had a larger component of gathering collectors such as Diptera Chironominae larvae, Decapoda crustaceans, and Annelida Oligochaete worms. All sites within Quadrant 2 had a scraper (e.g. Gastropoda) component to their macro-invertebrate assemblage.

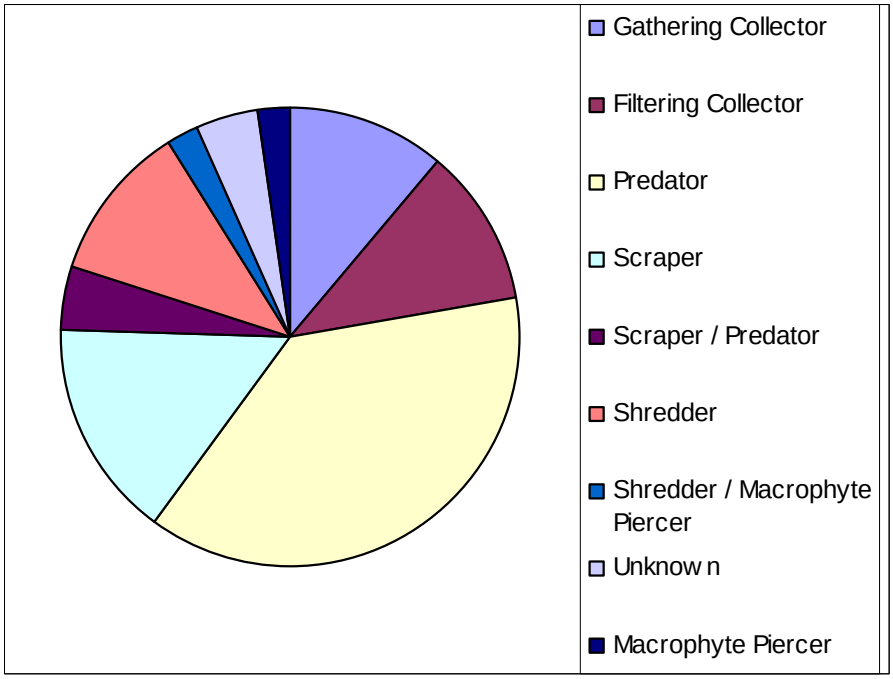


Figure 16: Functional Feeding Groups (Wet Season)

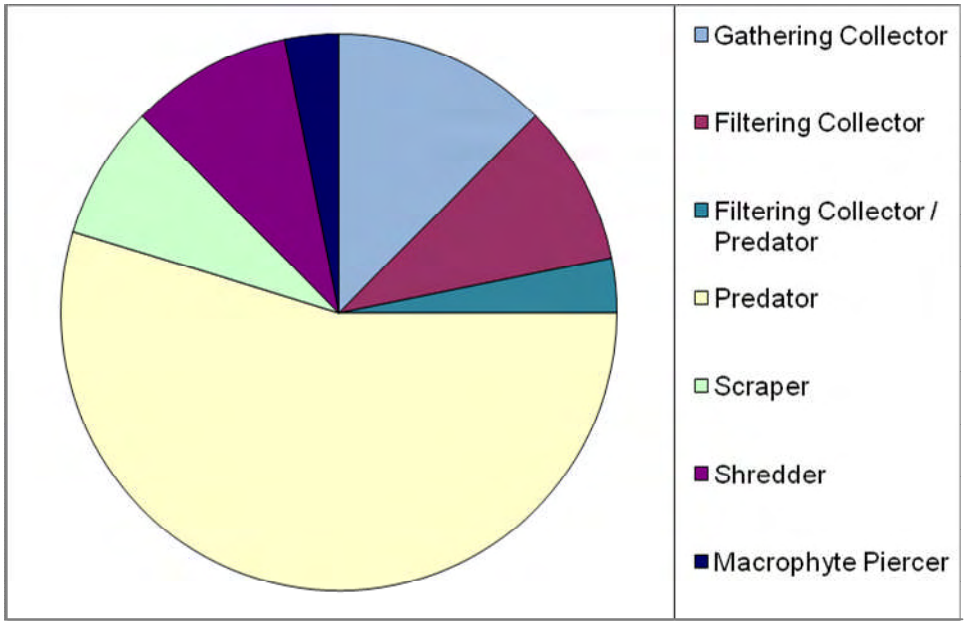


Figure 17: Functional Feeding Groups (Dry Season)

Figures 18 and 19 show that EPT taxa were identified at the majority of the survey sites where macro-invertebrate dip-netting was conducted. No taxa belonging to the Plecoptera order were identified at any of the sites during either the wet or dry season surveys. During the wet season, Ephemeropteran individuals were the most commonly encountered. In the dry season there was an almost equal incidence of Ephemeropteran and Trichopteran families. This may be due in some part to the difference in the picking experience of the personnel involved in each survey, as some families are easier to recognise than others.

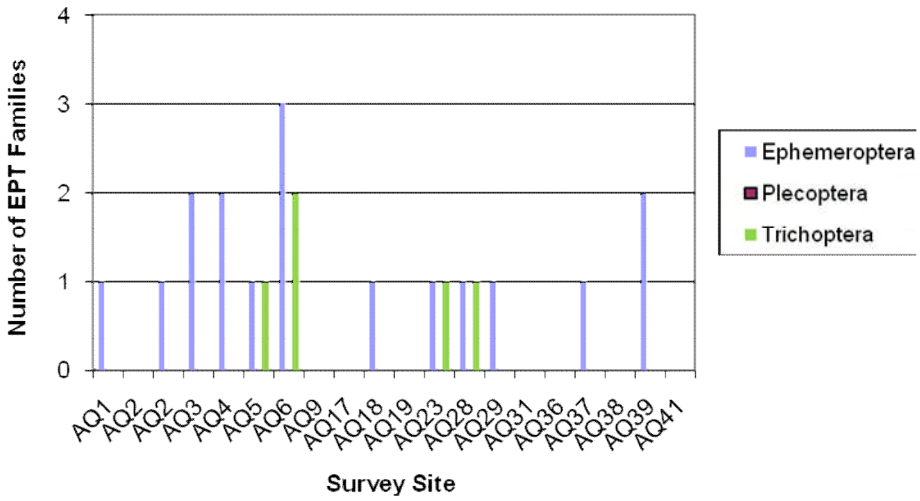


Figure 18: EPT Richness Across Survey Sites (Wet Season)

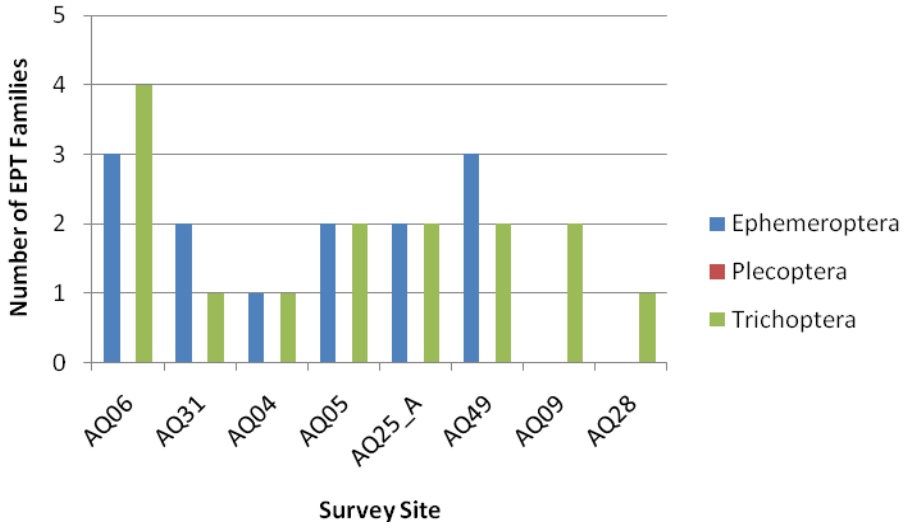


Figure 19: EPT Richness Across Survey Sites (Dry Season)

EPT taxa are considered sensitive to environmental degradation, so the presence of such species can indicate broad-scale health of the waterway.

Whilst trapping within the Project site, numerous crustacean species that are not included in the SIGNAL scoring catalogue were encountered. These included two species of freshwater yabby (*Cherax destructor* (Common Yabby) and *Cherax quadricarinatus* (Redclaw Yabby), shown below in Photo Plate 9, and two species of freshwater shrimp (*Macrobrachium* sp, and *Paratya australiensis*, and the freshwater crab (*Holthuisana* sp).

Photo Plate 9 Common Yabby (*Cherax destructor*) and Redclaw Yabby (*Cherax quadricarinatus*)

The species richness for each site of these crustaceans is provided below in Figures 20 and 21. Figures 22 and 23 show the relative abundance of each species trapped per site. It must be noted that as this study did not involve a mark-recapture element, there is a possibility that numerous individuals were captured more than once throughout the survey. The complete tally of crustaceans captured during the survey is given in Appendix F.

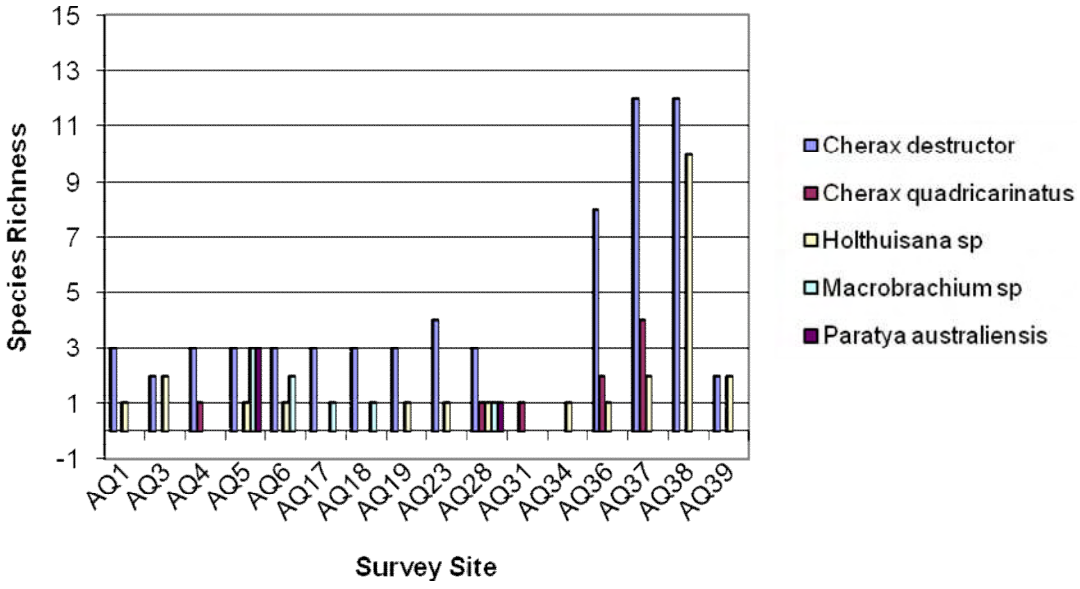


Figure 20: Crustacean Species Richness per Survey Site (Wet Season)

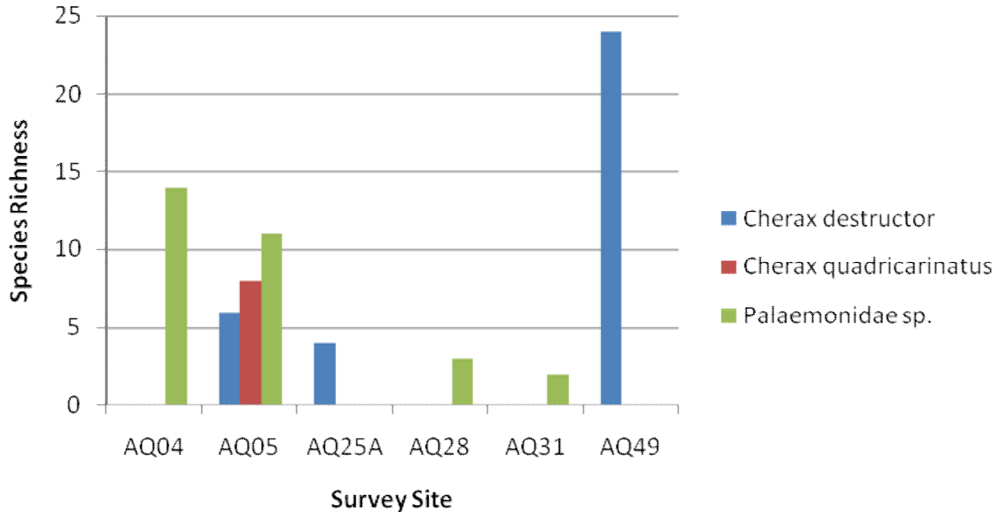


Figure 21: Crustacean Species Richness per Survey Site (Dry Season)

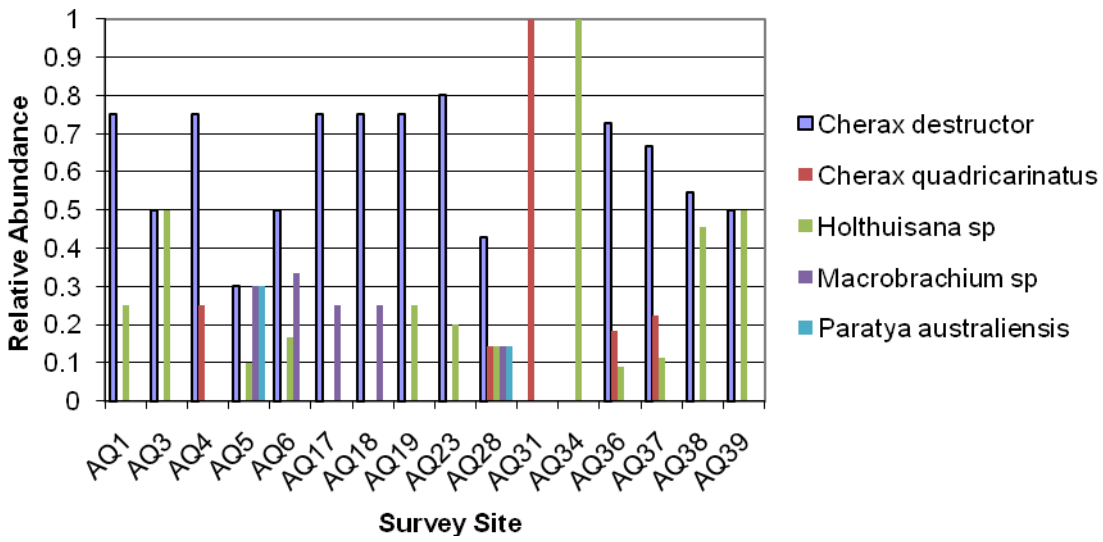


Figure 22: Crustacean Relative Abundance per Survey Site (Wet Season)

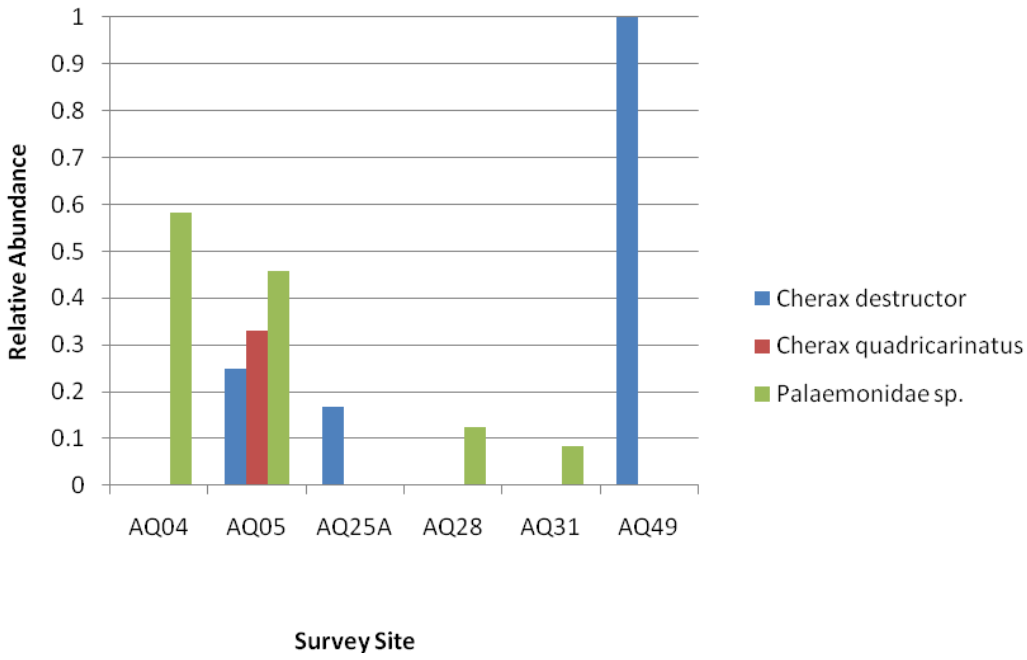


Figure 23: Crustacean Relative Abundance per Survey Site (Dry Season)

6.6 AQUATIC VERTEBRATES

A total of two mammal species, eight fish, five amphibians, two reptiles and 25 aquatic bird species were observed during the field surveys. The Terrestrial Flora and Fauna surveys have identified a further five amphibians and one mammal which have habitat requirements intrinsically linked to aquatic areas. Each vertebrate group is discussed below.

6.6.1 Fish

Ephemeral streams are subject to wide physico-chemical fluctuations. This is reflected in the species composition of fish found in these types of waterways, and notably their tolerance to a wide range of water physico-chemical qualities (McNeil, 2005).

The fish species identified during the aquatic study included Spangled Perch (*Leiopotherapon unicolour*) (Photo Plate 10), Purple-spotted Gudgeon (*Mogurnda adspersa*) (Photo Plate 10), Bony Bream (*Nematalosa erebi*), Glass Perch (*Ambassis agassizi*), Rainbowfish (*Melanotaenia splendida*), Hyrtl's Tandan (*Neosilurus hyrtlii*), Carp Gudgeon (*Hypseleotris compressa*) and the Barred Grunter (*Amniataba percoides*).

Photo Plate 10 Spangled Perch and Purple-spotted Gudgeon

The expected water quality tolerances of fish are provided in Table 10 below.

Table 10 Expected Water Quality Tolerances of the Identified Fish Species

Species	pH Tolerance	Thermal Tolerance (ºC)	Dissolved Oxygen Tolerance (mg/L)
Range during the survey	**6.88 – 8.8**	**24.7 – 32.2**	**Not assessed**
Spangled Perch	4 – 10.2[1]	5 – 44[1]	n/a
Bony Bream	4.8 – 8.6[1]	9 – 38[1]	Intolerant of hypoxia[1]
Glass Perch	6.3 – 9.9[3]	11 – 33.6[3]	0.3 – 19.5levels[3]
Purple-spotted Gudgeon		5 - 32[2]	Can withstand short periods of low oxygen levels[2]
Rainbowfish	5 – 9.2[5]	12 – 36[5]	n/a
Hyrtl's Tandan	<9.1[4]	>8, and up to ~35[4]	Can withstand mildly hypoxic conditions (>1.5 mg/L)[4]
Carp Gudgeon	5 – 9.1[1]	<35[1]	n/a
Barred Grunter	7-8.2[2]	22-24[2]	n/a[2]

[1] = obtained from Allen *et al*. (2003)
[2] = obtained from Native Fish Australia (2008)
[3] = obtained from Pusey *et al*. (2004)
[4] = obtained from BMA (2008)
[5] = obtained from Tappin (2009)

From the water quality results, it would be expected that Bony Bream would be excluded from some of the sample sites due to water pH being above their tolerance, and Purple-spotted Gudgeons due to temperature. These exceedances were seen at sites AQ30 and AQ31. No sampling of fauna was undertaken at sites where water availability and therefore aquatic condition was deemed unsuitable. Drag netting was conducted at AQ31, a lacustrine wetland in the northern Mineral Development Lease (MDL). Bony Bream were caught at this site, despite the water quality. Fish will actively avoid areas of adverse water conditions, however, due to the shallow (<1.2 m), contained nature of AQ31, coupled with regular cattle access, it is likely that the site would not remain a viable Bony Bream habitat for long.

Figure 24 shows the species richness of fish at each site during the wet season. Highest species diversity was recorded at AQ4, AQ5 and AQ28, while AQ19 and AQ37 recorded no captures or observations.

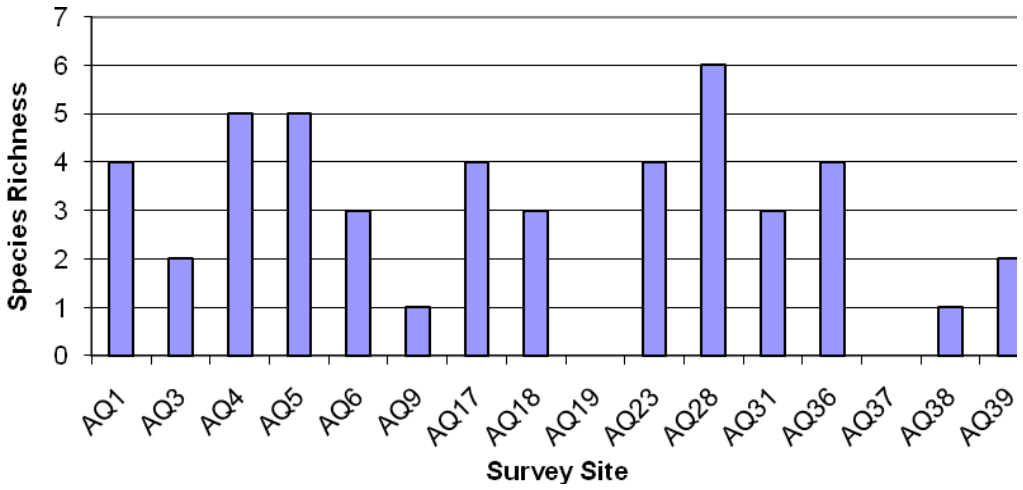


Figure 24: Fish Species Richness per Site (Wet Season)

Figure 25 shows the species richness of fish at each site during the dry season. Highest species diversity was recorded at AQ5 and AQ28, while AQ25A and AQ49 recorded the least captures or observations.

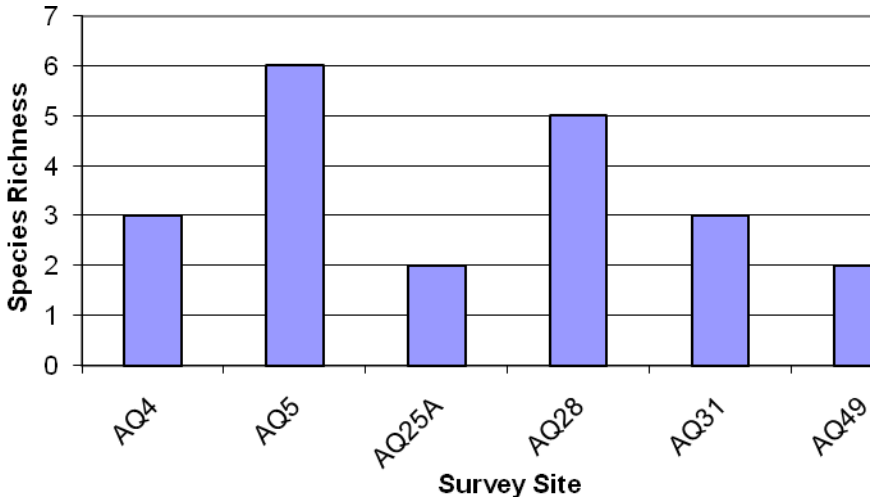


Figure 25: Fish Species Richness per Site (Dry Season)

The relative abundance of fish species present at each site during the wet and dry seasons has been calculated, and is provided below in Figures 26 and 27.

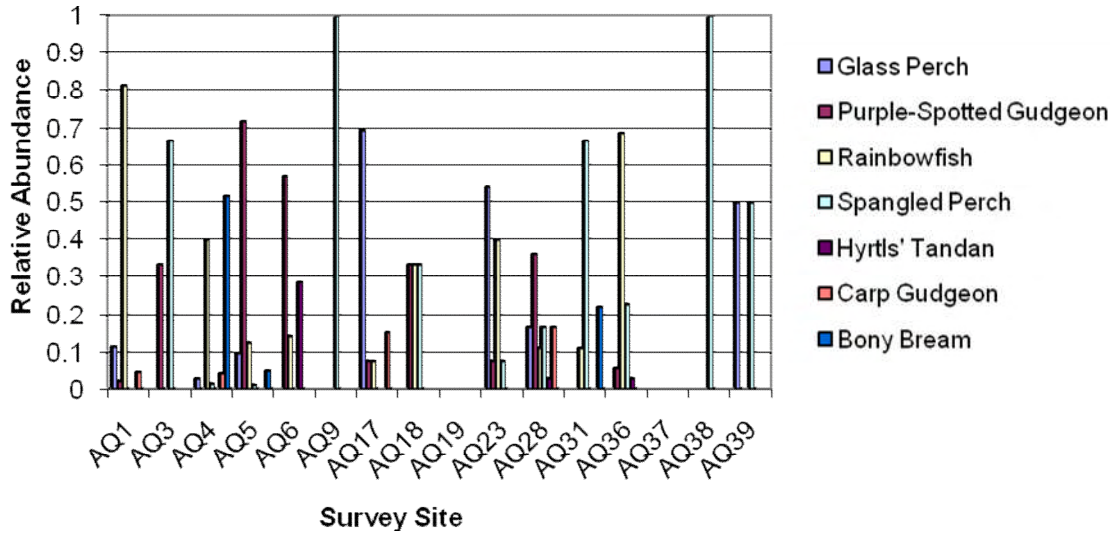


Figure 26: Relative Abundance of Fish Species at each Site (Wet Season)

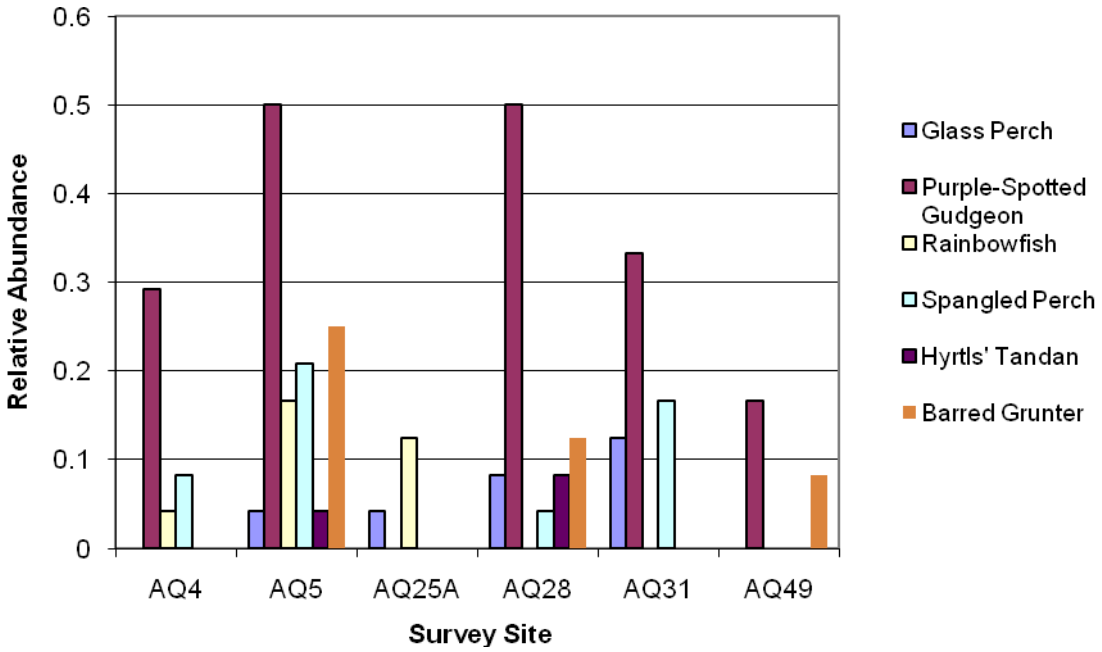


Figure 27: Relative Abundance of Fish Species at each Site (Dry Season)

All species identified are native, and are considered common throughout their ranges. The number of each fish species recorded at each site is provided in Appendix G.

6.6.2 Terrestrial Vertebrates

The full list of terrestrial vertebrate fauna species recorded during the Aquatic Fauna surveys is provided in Appendix H.

6.6.2.1 Birds

Wet Season

Twelve bird species with habitat requirements linked to aquatic areas were observed in the Project site during the course of the wet season surveys. These are shown in Figure 28 below. The Pacific Black Duck (*Anas superciliosa*) was the most commonly observed species, being seen at three sites, and in larger numbers. The Masked Lapwing (*Vanellus miles*) was also observed at three sites. AQ28 had the richest bird species richness, as can be seen in below. AQ28 was the palustrine lagoon site, which had abundant in-stream vegetation, roosting sites, and a stable water level. This site was considered to be relatively good-quality aquatic species habitat, barring the high level of cattle disturbance on the banks.

Of the 12 bird species identified within the Project site during the surveys, nine are listed as either Migratory or Marine under the EPBC Act (as shown in below in Table 11).

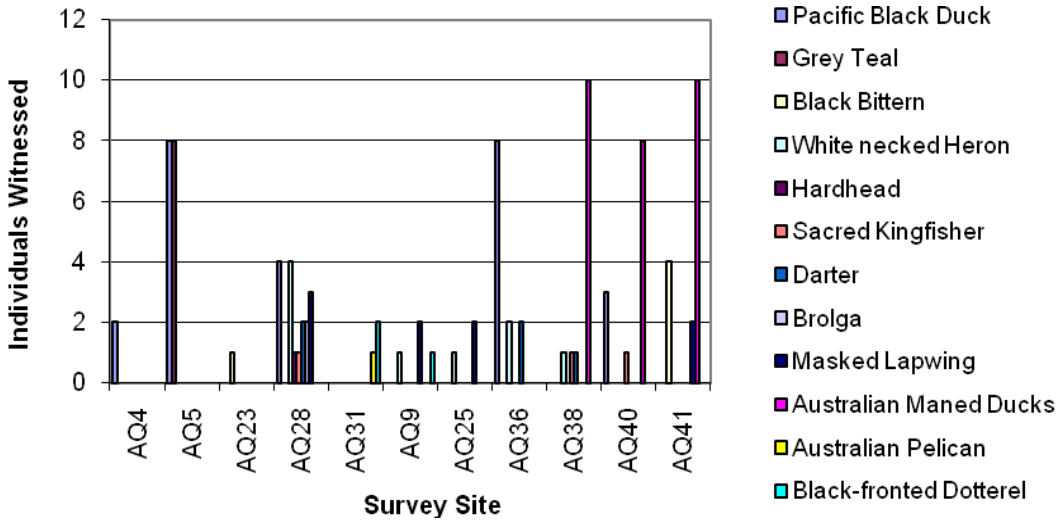


Figure 28: Bird Species Observed on the Project Site (Wet Season)

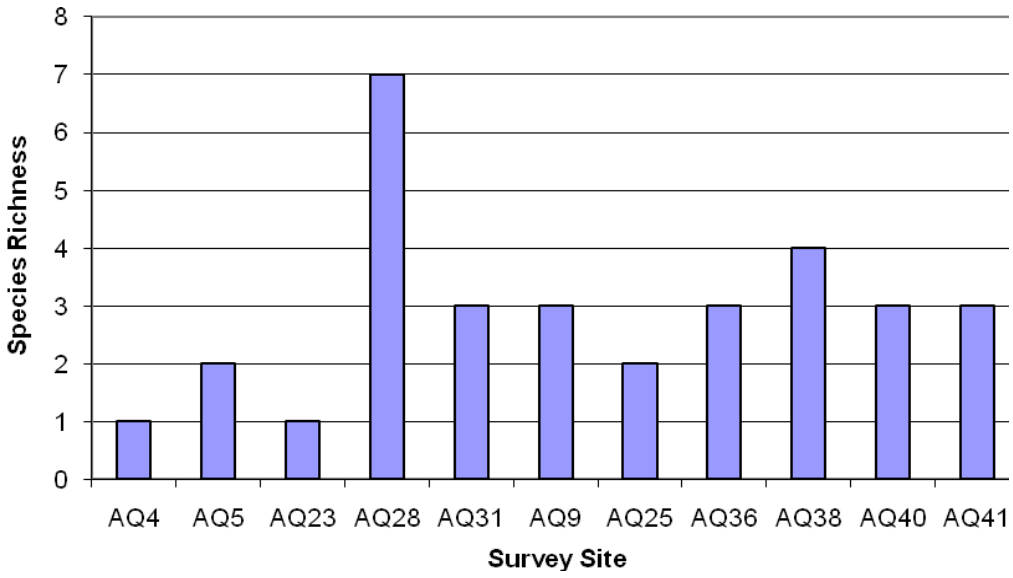


Figure 29: Bird Species Richness per Site (Wet Season)

Dry Season

A total of 21 bird species with habitat requirements linked to aquatic areas were observed in the Project site during the course of the dry season survey. These are shown in Figure 30 below. The White-eyed Duck (*Aythya australis*) occurred in the largest numbers, but only at AQ31. The Australian Maned Duck (*Chenonetta jubata*) was the next most abundant species, being found in moderate numbers at three sites.

The Masked Lapwing (*Vanellus miles*) was also observed at four sites. AQ31 had the richest bird species richness, as can be seen in Figure 31 below. AQ31 was the lacustrine wetland site, which had abundant in-stream vegetation, moderate roosting sites, and a stable water level. This site was considered to be relatively good-quality aquatic species habitat, barring the high level of cattle disturbance on the banks.

Of the 25 bird species identified within the Project site during both the wet and dry season surveys, 13 are listed as either Migratory or Marine under the EPBC Act (as shown below in Table 11).

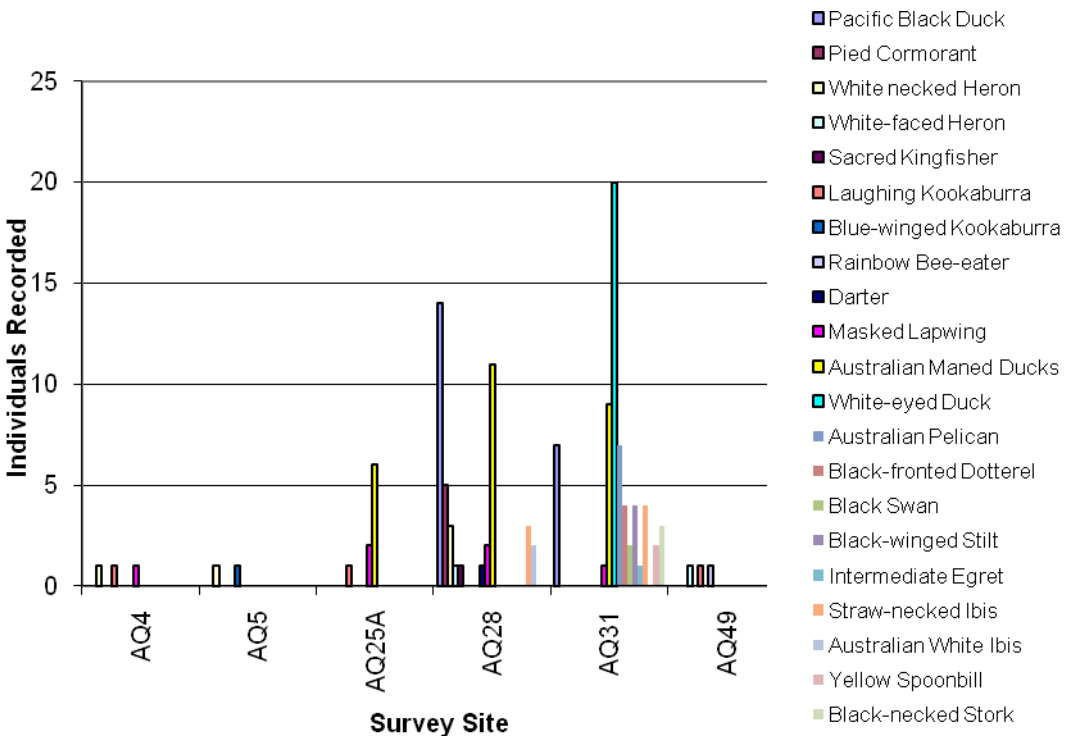


Figure 30: Bird Species Observed on the Project Site (Dry Season)

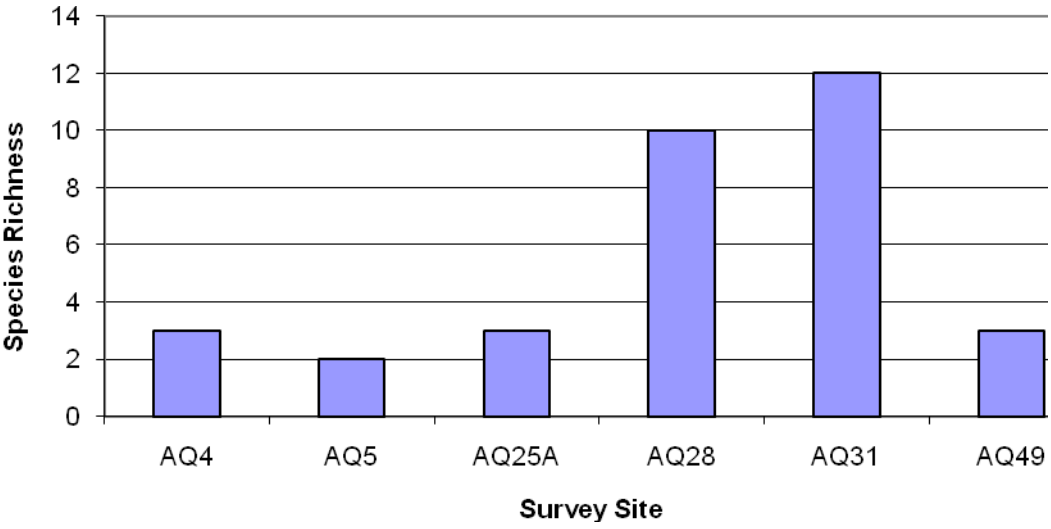


Figure 31: Bird Species Richness per Site (Dry Season)

Table 11 Migratory and Marine Birds Identified Within the Project Site

Species	Migratory	Marine
Pacific black Duck – *Anas superciliosa*	X	-
Grey Teal – *Anas gracilis*	X	-
Hardhead – *Aythya australis*	X	-
Australian Maned Duck – *Chenonetta jubata*	X	-
Sacred Kingfisher – *Todiramphus sanctus*	-	X
Masked Lapwing – *Vanellus miles*	X	-
Australian Pelican – *Pelecanus conspicillatus*	-	X
Black-fronted Dotterel – *Charadrius melanops*	X	-
Brolga – *Grus rubicunda*	X	-
Australian White Ibis - *Threskiornis molucca*	-	X
Straw-necked Ibis - *Threskiornis spinicollis*	-	X
Black-winged Stilt - *Himantopus himantopus*	-	X
Rainbow Bee-eater – *Merops ornatus*	X	X

A further five aquatic bird species were identified during the Terrestrial Flora and Fauna surveys, including five species listed under the EPBC Act as Marine. These included the Little Black Cormorant (not listed), Whistling Kite (*Haliastur sphrenus*), the Great Egret (*Ardea alba*), the Intermediate Egret (*Ardea intermedia*) and the Nankeen Night Heron (*Nycticorax caledonicus*). The Whistling Kite is further listed as Migratory under the EPBC Act. The distribution of these species is widespread throughout eastern Queensland, and the local populations on the Project site are unlikely to constitute an 'ecologically significant proportion' of the total population of the species.

Furthermore, the Project site is not at the limit of these species' range, nor are these species considered to be declining within the region. Therefore, it is unlikely the Project will have a significant impact on the regional populations of these species.

6.6.2.2 Mammals

The Feral Pig (*Sus scrofa*) was observed at AQ3 and AQ4. The feral pig is a Class 2 declared animal under the LP Act. The feral pig is one of the most widespread and damaging pest animals in Queensland. They favour environments with permanent water bodies and have the potential to cause widespread ecological damage by spreading weeds and disease and spoiling riparian areas.

Evidence indicating the presence of the european rabbit (*Oryctolagus cuniculus*) was recorded during the wet season surveys. Competition and land degradation by rabbits is listed as a key threatening process under Commonwealth legislation, and the species is listed as a Class 2 declared animal under the LP Act. Rabbits are widely distributed throughout Australia and occur across a diverse variety of habitats. Rabbits directly compete with native wildlife for food and shelter and can impact on native plants by ringbarking, grazing and browsing, and preventing regeneration of seedlings. Their digging and browsing leads to a loss of vegetation cover, which in turn can result in slope instability and soil erosion.

During the June 2008 survey, the Little Pied Bat (*Chalinolobus picatus*) was recorded within riparian habitat using an ANABAT detector. The Little Pied Bat is listed as Rare under the NC Act. Little is known about the species, except that it roosts in caves, mineshafts, and tree hollows (Menkhorst and Knight, 2001) and it requires access to free-standing water (Department of Natural Resources (DNR), 2003).

During the June 2011 survey, the Water Rat (*Hydromys chrysogaster*) was recorded at AQ28 during the spotlighting component of the survey. This species is widely distributed throughout Australia and nearby islands, occupying a wide range of habitats in proximity to permanent water. It not listed as a species of conservation significance under either the NC Act or the EPBC Act.

6.6.2.3 Amphibians

Many amphibian species that occur in Australia's drier regions are burrowing species capable of spending several years underground awaiting heavy rain, after which they come to the soil surface to feed and breed. This behaviour is referred to as aestivation and assists in water preservation and survival during prolonged drought (Withers, 1995). Consequently, the vast majority of amphibians from seasonally dry regions only occur in areas where the ground is soft enough to allow digging during wet periods.

Non-burrowing frog species also inhabit drier regions where they adopt different survival strategies, such as sheltering deep in tree hollows or cool rock crevices. However, these species are still typically associated with water sources.

Many of the creeks on the Project site were sandy and appeared soft enough for burrowing frogs. During the dry season some areas of standing water remained viable amphibian habitat, in the form of pastoral dams and billabongs. During the wet season the creeks hold water after rainfall events, and low lying areas within grasslands become boggy.

Five amphibian species were observed during the surveys. These included the Ornate Burrowing Frog (*Platyplectrum ornatum*), the Little Red Tree Frog (*Litoria rubella*), the Broad-palmed Frog (*Litoria latopalmata*), the Striped Burrowing Frog (*Litoria alboguttata*) (Photo Plate 11), and the Cane Toad (*Rhinella marina*) (Photo Plate 11).

Photo Plate 11 Striped Burrowing Frog and Cane Toad

The introduced Cane Toad was observed in large numbers during the wet season at both AQ5 and AQ8, as can be seen below in Figure 32.

The Cane Toad is a non-declared pest animal under the LP Act, so there is no legal requirement to control their numbers within the Project site, however they can cause serious environmental harm, and it is recommended that the Project take steps to minimise their population growth. They were introduced in 1935 to control agricultural pests, but proved ineffective. They produce a highly toxic venom, which can cause death if ingested by domestic and most native animals (DEEDI, 2008). They are voracious feeders, and will eat a wide variety of insects, frogs, small reptiles, mammals, and birds (DEEDI, 2008). A Pest Fact Sheet for the species is provided in Appendix E.

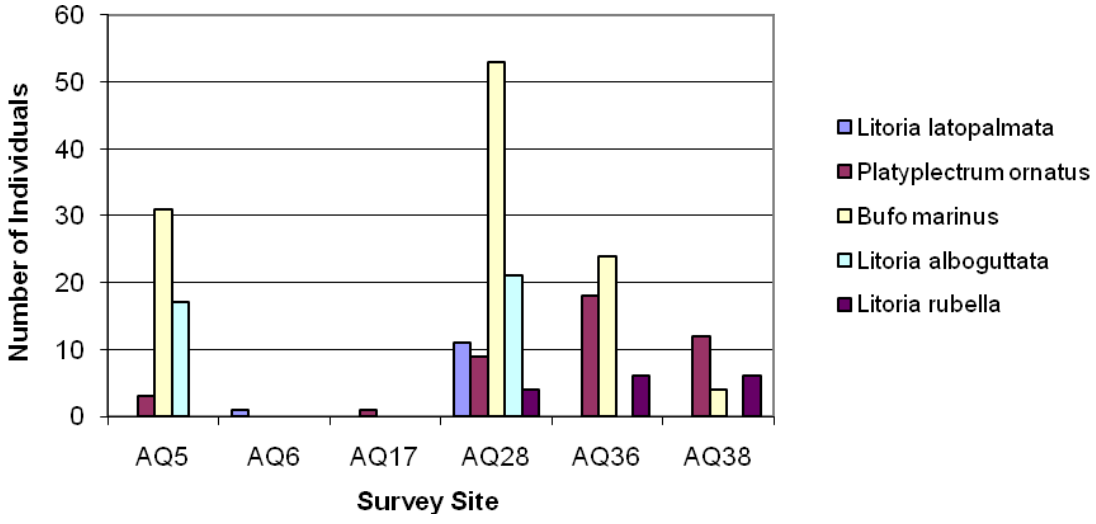


Figure 32: Amphibian Species Observed per Site (Wet Season)

In addition to the species listed above, the Terrestrial Flora and Fauna Surveys identified the following amphibian species: *Litoria caerulea* (Green Tree Frog), *Litoria fallax* (Dwarf Tree Frog), *Litoria inermis* (Floodplain Frog), *Lymndynastes tasmaniensis* (Spotted Marsh Frog), and *Uperoleia rugosa* (Eastern Burrowing Toadlet). All of the species identified to date are considered common throughout their range.

No native amphibian species were recorded from their calls during the dry season survey. The Cane Toad was observed in low numbers at Sites AQ23 and AQ31.

6.6.2.4 Reptiles

A single aquatic reptile species, Eastern Snake-necked Turtle (*Chelodina longicollis*) was observed on the Project site during the wet season. The Eastern Snake-necked Turtle (Photo Plate 12) was observed at the lagoon (AQ28). This species is common to the area, and inhabits swamps, lakes, billabongs, and slow-moving rivers (Cogger, 2000).

No reptiles were recorded during the dry season.

Photo Plate 12 Eastern Snake-necked Turtle (*Chelodina longicollis*)

6.6.3 Other Threatened Species from the Region

This section discusses aquatic and riparian species of conservation significance that are known from the broad region near Alpha but were not observed on the Project site by AARC. These species have been identified from wildlife database searches (Appendix A) and scientific literature searches. Table 12 provides an assessment of the likelihood of these species utilising the Project site.

Table 12 Species of Conservation Significance from the Region Not Identified Within the Site

Scientific Name Species Name	Conservation Status		Habitat	Notes
	EPBC Act	NCWR		
Erythrotriorchis radiatus Red Goshawk	V	E	Found over wooded and forested land with a mosaic of vegetation types in tropical and warm temperate climates in coastal and sub coastal areas (Marchant and Higgins 1993)	While the Project site offers a mosaic of vegetation types, this species is generally found closer to the coast in areas with permanent water. The Project will not disturb its favoured habitat and is unlikely have any adverse impacts on this species.
Melithreptus gularis Black-chinned Honeyeater	-	NT	Often found in the upper levels of open forest and woodland dominated by box and ironbark eucalypts, also in riparian areas (Higgins *et al*., 2001).	Some suitable habitat may occur on the Project site however given the species range and the availability of similar habitat in the region it is unlikely the Project will adversely affect it.
Gallinago hardwickii Latham's Snipe, Japanese Snipe	M L	-	Inhabits low vegetation around wetlands in shallows, sedges, and reeds (Morcombe 2002).	Due to the abundance of similar habitat type surrounding the Project Site, if the species was present in the region, the Project is unlikely to impact on the species.
Haliaeetus leucogaster White-bellied Sea-Eagle	M L	-	Usually coastal, the White-bellied Sea-Eagle will seasonally occur along flooded inland swamps and major rivers (Morcombe 2002).	The nearby creek system is ephemeral and as such it is unlikely the species would occur within the Project Site.
Hirundapus caudacutus White-throated Needletail	M L	-	Inhabits high open spaces, above almost any habitat (Morcombe 2002).	Grassy woodland and riparian habitats similar to those occurring on the Project Site are commonly represented in the wider area. It is considered unlikely that mining activities will result in adverse impacts on this species if it were to occur in local region.
Poephila cincta cincta Black-throated Finch (southern)	E	E	Inhabits open woodland, scrubby plains, Pandanus flats with deep cover of grasses, never far from water.	Some suitable habitat may be available during the wet season.
Neochmia ruficauda ruficauda Star Finch (Southern, Eastern)	E	-	Near water; grassy flats with bushes, low trees; reeds, rushes; irrigated crops, sugar cane (Pizzey & Knight 2006).	Due to the abundance of similar habitat type surrounding the Project Site, if the species was present in the region, the Project is unlikely to impact on the species.

Scientific Name Species Name	Conservation Status		Habitat	Notes
	EPBC Act	NCWR		
Ardea alba Great Egret	M		Shallows of rivers, estuaries; tidal mudflats, freshwater wetlands; sewage ponds, irrigation areas, larger dams etc (Pizzey & Knight 2006).	Due to the abundance of similar habitat type within the area, the Project is unlikely to have an impact on this species.
Ardea ibis Cattle Egret	M L	-	Inhabits stock paddocks, pastures, croplands, garbage tips, mudflats and drains (Pizzey & Knight 2006).	Due to the abundance of similar habitat type within the area, the Project is unlikely to impact on the species
Numenius minutus Little Curlew	M L	-	Inhabits dry grasslands of clay and blacksoil plains, river floodplains and grassy woodlands (Morcombe 2002).	It is considered unlikely that mining activities will result in adverse impacts on this species if it were to occur in the local region.
Rostratula australis Australian Painted Snipe	V	-	This species inhabits shallow inland wetlands, either permanent or temporary	Due to the abundance of similar habitat type surrounding the Project Site, if the species was present in the region, the Project is unlikely to impact on the species.
Rostratula benghalensis s. lat. Painted Snipe	M L	-	Inhabits the surrounds and shallows of wetlands that are well vegetated with low cover (Pizzey & Knight 2006).	Due to the abundance of similar habitat type surrounding the Project Site, if the species was present in the region, the Project is unlikely to impact on the species.

Legend: E = Endangered
V = Vulnerable
NT = Near Threatened
M L = Listed as Migratory and / or Marine

6.7 HABITAT ASSESSMENT

Table 13 below shows the Habitat Assessment scores for each of the survey sites. All sites assessed fell within the 'moderate' to 'good' category, whilst AQ06 was close to the 'pristine / favourable' category (refer to Table 4 for interpretation of Habitat Assessment scores). Many of these sites have low Habitat Assessment scores due to high erosion potential, lack of stable in-stream habitat and / or limited riparian vegetation. AQ06 (relatively good Habitat Assessment score) was seen to fall within Quadrant 2 of the SIGNAL bi-plot, and to have three out of the seven identified fish present during the survey.

Table 13 Habitat Assessment Results and Site Descriptions

Site	Description	Habitat Assessment Score / 135
AQ01	AQ01 had a moderate amount of in-stream stable habitat (undercut banks, submerged logs).The banks exhibited instability, with a large percentage of the bank showing evidence of recent erosion, and the dominant vegetation being grasses and sedges. In-stream habitat was limited by the creek bed having a large percentage of fine sediment, evidence of bottom scouring and sediment deposition, and only occasional bends providing habitat.	57
AQ03	AQ03 had a large proportion of in-stream available cover in the form of mid-channel vegetation and submerged logs. The dominant riparian vegetation was of tree form. The site habitat assessment score was lowered by it having a large portion of fine sediment, evidence of channel alteration and scouring, and high levels of bank erosion.	62
AQ04	AQ04 had favourable habitat scores relating to variables such as channel alteration (as the site is located within a dammed section of the creek there was very little evidence of channelization, bottom scouring, or deposition), had variety in depth, and moderately stable banks. The score was lowered by the site having fine sediments, being a single pool, and having minimal vegetative cover on its banks.	50
AQ05	AQ05 was characterised by numerous small terrace pools and one large pool. The stream bed was dominated by fine sediments, with evidence of channel alteration, and limited in-stream stable habitat. The large pool of water provided adequate depth, and the smaller pools provided habitat for fauna in the bends. There was little evidence of erosion along the vegetated banks during the wet season; however, a reduction in water levels during the dry season exposed the bare, steep banks to erosion processes.	54
AQ06	AQ6 had a stable, predominantly gravel substrate, with submerged logs and in-stream Melaleuca's adding to the stability. The site also received high scores with having a variety of habitats ranging from riffle zones to deep pools. The banks were moderately unstable, however, and there was a moderate amount	99

Site	Description	Habitat Assessment Score / 135
	of deposition within the pools.	
AQ10	AQ10 was a large, heavily disturbed river bed on the eastern boundary of the Project site. The river was dry at the time of the surveys; however the channel showed moderate potential for in-stream fauna. The banks were unstable with high, steep sides, extensive erosion and exposed roots.	52
AQ15	AQ15 was located along Greentree Creek within a River Red Gum riparian community. The wide, sandy creek bed was dry during survey periods and was limited in stable habitat for in-stream fauna as a result of the fine grained sediments, lack of gravel or cobbles (riffle habitat) and absence of bends or contours. However the banks were stable and well vegetated, whilst the streamside cover was dominated by trees.	56
AQ16	AQ16 was located further downstream from AQ15 along Greentree Creek. The site was also located within a mature River Red Gum community and was a dry, sandy creek bed at the time of the surveys. Similar characteristics between these sites in regards to bank stability and surrounding vegetation (good – excellent) as well as in-stream habitat availability (fair - poor) resulted in similar Habitat Assessment scores.	59
AQ17	AQ17 had limited stable in-stream habitat, with the sediment being predominantly fine-grained, and evidence of channel alteration present. The site consisted of a single pool. The banks were stable, with little evidence of erosion, and the majority of the bank vegetated with grasses and sedges to add to the stability.	48
AQ18	AQ18 had limited in-stream stable habitat. The non-flowing pool was intersected by a road. The stream sediment was mud, and there was only an occasional bend and bottom contour. The banks were highly unstable, with steep slopes and evidence of recent erosion. The dominant streamside vegetation was grasses and sedges.	42
AQ19	AQ19 was a small pool of water within a drainage line. The site had limited stable in-stream habitat, fine-grained stream sediments, obvious new deposition of sediments and channelisation, no riffle zones, and the banks were highly unstable. The banks were moderately vegetated with predominantly grasses and sedges to give some stability.	37
AQ23	AQ23 was a sub-optimal habitat for in-stream fauna. There was limited stable habitat, fine sediments, heavy deposition of fine materials, scouring, only an occasional bend to provide habitat, and moderate instability on the banks. The banks did have a moderate amount of vegetative cover, which were predominantly shrubs.	40

Site	Description	Habitat Assessment Score / 135
AQ28	AQ28 had in-stream adequately stable habitat for in-stream fauna, however the stream sediments were predominantly fine-grained. The single, large pool of water did not have any evidence of channel alteration, or sediment deposition, and the banks were moderately stable and vegetated with grasses and sedges	75
AQ31	AQ31 was located in a partially dried lacustrine wetland. The site had a lack of stable in-stream habitat, with fine-grained sediments, limited bottom contouring, and less than 50% of the stream bank was vegetated. The site had limited erosion, and relatively minor amounts of channelisation, scouring, and deposition.	52
AQ36 (WC1)	AQ36 – this 3rd order site was located in a rocky pool situated on Well Creek, in the western flank of the Project site. The site had steep rocky banks and was >2m deep in sections. The site was noted to have high fish assemblage and the overall aquatic health was considered good. Given the volume of water at the pool, it is believed the site holds water during both the wet and dry seasons.	87
AQ37 (WC2)	AQ37 - this site was located on Wells Creek, upstream of a road crossing. Small isolated pools were present at the time of survey. Stream sediments consisted of moderately coarse sands. Black Tea Trees and Moreton Bay Ashes (*Eucalyptus tessellaris*) were present both in-stream and within the riparian zone. Noogoora Burr was noted at the site.	54
AQ38 (SC1)	AQ38 – was located in a sandy stretch of Lagoon Creek in the northern section of the Project site. The site was not flowing at the time of survey; however pools were significant, indicating recent flow events. Pools were <1m and contained a sand/vegetation detritus mixed benthic substrate.	80
AQ39 (A1)	AQ39 – this site was located within a drainage line on the western boundary of the Project site. Although not flowing at the time of survey, the drainage held significant water, and was >1m deep at the study location. The vegetation surrounding the drainage line included River Red Gum. The sediment at the site ranged from fine sand to small pebbles. Some erosion was evident, however the site was considered to hold moderate ecological value.	78
AQ40 (SM1)	AQ40 - located within a dry sandy creek bed in the western flank of the Project site along a tributary of Greentree Creek. The site had well vegetated banks whilst riparian vegetation was dominated by a mature community of River Red Gum and Bloodwoods. The majority of the sediment was fine grained however, limiting the availability of stable habitat. The channel also showed signs of alteration as a result of past flow events via bar deposition, note that the steep banks will increase erosion	58

Site	Description	Habitat Assessment Score / 135
	potential during future flows.	
AQ41 (SM2)	AQ41 – located within a dry sandy creek bed in a tributary of Greentree Creek close to AQ40. This site also housed a mature community of River Red Gum, Bloodwoods, and a diverse shrub and ground layer along the creek banks. Stable in-stream habitat was lacking as a result of the fine-grained sandy substrate, and the straight, flat watercourse limited the diversity of habitat available.	56
AQ42 (SM3)	AQ42 (SM3) - located within a rocky creek bed in the eastern flank of the Project site. Although the site was dry at time of survey, the rocky substrate provided moderately stable in-stream habitat, whilst rubble found along bed would allow for favourable riffle / pool habitats during flow periods. The bed showed evidence of alteration and scouring however, and the bank was highly unstable, sparsely vegetated and exposed to erosion during previous flow events.	59
AQ43	AQ43 – located within a sandy creek bed in the south-eastern corner of the Project site. The site had well vegetated banks with riparian vegetation dominated by a mature community of River Red Gum and Poplar Box. The majority of the sediment was fine grained providing limited stable habitat. The channel also showed signs of alteration and erosion due to past flow events.	34
AQ44	AQ44 – located within a rocky stream bed in the south-eastern portion of the Project site. The gently sloping banks were stable with a moderate cover of riparian vegetation dominated by lancewood and ironbark. The stream bed contained a range of habitats from small stony pools to sandy runs.	84
AQ45	AQ45 – flat sandy creek bed outside the south-eastern boundary of the Project site. The low banks supported a dense riparian community dominated by Buffel grass and River Red Gum. The majority of the sediment was fine grained providing limited stable habitat.	68
AQ46	AQ 46 - a large, heavily disturbed river bed on the eastern boundary of the Project site. The river was dry at the time of the surveys; however the channel showed moderate potential for in-stream fauna. The banks were unstable with high, steep sides, extensive erosion and exposed roots.	52
AQ47	AQ47 – a sandy channel situated close to Degulla Rd in the northern section of the Project site. Low banks and dense vegetation provide moderate bank stability, however there is some evidence of erosion in places. The dominant vegetation includes River Red Gum and Poplar Box.	43

Site	Description	Habitat Assessment Score / 135
AQ48	AQ48 – located within the bulk sample project in the centre of the Project site, adjacent to an access road and its associated culvert. Moderate habitat for in-stream fauna was present, with some bends and stream bed contours. Some evidence of erosion was present where the banks were highest, however dense riparian vegetation, dominated by Rive Red Gum and Silver-Leaved Ironbark, provide moderate bank stabilisation.	66
AQ49	AQ49 – situated south of the mine camp in the central portion of the Project site. Heavily disturbed and eroded banks present, however channel variations provide good in-stream habitat. Banks are predominantly devoid of vegetation, with only scattered River Red Gum, Brigalow and Poplar Box.	67

7.0 IMPACT RISK ASSESSMENT

Due to the complexity of natural ecosystems, the consequences of an environmental incident or event can be far-reaching and varied. Complex food webs exist in natural ecosystems and when one component, such as a river, is affected, the consequences can be linked through to a number of species, both terrestrial and aquatic, both flora and fauna. It is therefore important that adequate management strategies are implemented to prevent such occurrences or minimise their impacts.

7.1 LEGISLATION AND GUIDELINES

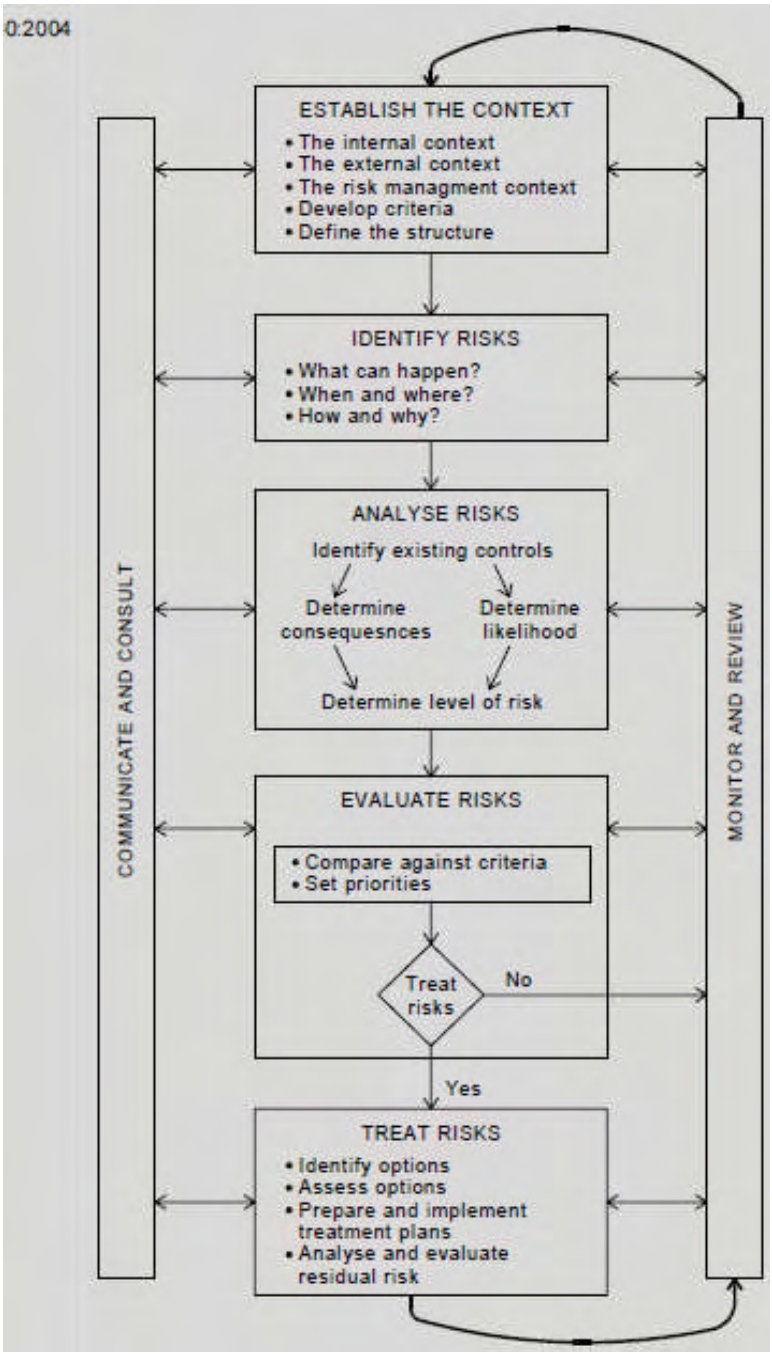
The *Environmental Protection Act (1994)* governs the environmental aspects associated with mining activities in Queensland. Under this Act, mining projects are granted an environmental authority (EA) which details conditions to be achieved by the mine to minimise environmental harm caused, or likely to be caused, by the mining activities. The *Australian Standard for Risk Management (AS/NZ ISO 31000:2009 (originally AS/NZS 4360:1995, but converted to an international standard in 2009))* and *HB203:2006 Environmental Risk Management Principals and Processes* are the current standards which guide risk and environmental risk management in Australia.

7.2 RISK MANAGEMENT FRAMEWORK

The methodology for risk management is illustrated below in Figure 33, and has been sourced from HB 203:2006 *Environmental Risk Management – Principles and Process*. The risk assessment was applied to the Project based on background information as provided by HPPL. For each potential environmental risk and associated identified impact, a consequence value (Table 14), likelihood factor (Table 15) and risk rating (Table 16) was assigned, assuming no control / mitigation strategies in place.

Proposed control and mitigation measures were then developed and applied, and the process of assigning a consequence value, likelihood factor and risk rating was repeated.

For any risks remaining with a high or extreme residual risk, further control mitigation strategies were applied, as this was deemed an unacceptable level of risk for the Project.



Source: Environmental Risk Management – Principles and Process. HB 203:2006. (Standards Australia / Standards New Zealand, 2006)

Figure 33: Risk Management Process

Table 14 Qualitative Measure of Consequence

Level	Descriptor	Environmental/Social Impacts	Legal	Public/ Media Attention	Financial Impact
1	Catastrophic	Significant extensive detrimental long term impacts on the environment, community or public health. Catastrophic and/or extensive chronic discharge or persistent hazardous pollutant. Damage to an extensive portion of aquatic ecosystem. Long term impact on water resource.	Licence to operate likely to be revoked or not granted.	Probable public or media outcry with national/international coverage. Significant green NGO campaign.	>$1million
2	Major	Off-site release contained with outside assistance. Short to medium term detrimental environmental or social impact off-site or long term environmental damage on-site.	May involve significant litigation and fines. Specific focus from regulator.	May attract attention of local and state media and local community groups.	$500,000 - $1 million
3	Moderate	Onsite release contained with outside assistance. Significant discharge of pollutant, a possible source of community annoyance. Non persistent, but possible widespread damage to land. Damage that can be remediated without long term loss or very localised, long persistent damage.	Probably serious breach of regulation. Possible prosecution and/or fine. Significant difficulties or delays experienced in gaining future approvals.	May attract attention from local media, heightened concern by local community.	$50,000 – $500,000
4	Minor	On site release immediately contained without outside assistance. Ongoing or repeat exceedances of odour, dust or noise/vibration limits.	Minor on the spot fines or formal written correspondence from regulator.	Local community attention or repeated complaints.	$5,000 – $50,000
5	Insignificant	Negligible environmental impact. Minor transient release of pollutant including odour, dust and noise/vibration. Minor social impact.	No serious breach of regulation. Minor licence non-compliances.	Local landholder verbal discussion/complaint.	Less than $5,000

Table 15 Qualitative Measures of Likelihood

Level	Descriptor	Example	Frequency
A	Almost certain	Is expected to occur in most circumstances	> once per year
B	Likely	Will probably occur in most circumstances	Once per year
C	Possible	Could occur	Once every 5 years
D	Unlikely	Could occur but not expected	May happen within Project life
E	Rare	Occurs in only exceptional circumstances	Not likely to happen with Project life

Source: modified from: Environmental Risk Management – Principles and Process. HB 203:2006. (Standards Australia / Standards New Zealand, 2006).

Table 16 Qualitative Risk Analysis Matrix – Level of Risk

Likelihood	Consequences				
	1 Catastrophic	2 Major	3 Moderate	4 Minor	5 Insignificant
A - Almost certain	E	E	E	H	H
B - Likely	E	E	H	H	M
C - Possible	E	E	H	M	L
D - Unlikely	E	H	M	L	L
E - Rare	H	H	M	L	L

Source: Environmental Risk Management – Principles and Process. HB 203:2006. (Standards Australia / Standards New Zealand, 2006).

Table 17 Qualitative Risk Analysis Matrix Legend

E = Extreme Risk: Immediate Action Required
H = High Risk: Senior Management Attention Required
M = Moderate Risk: Management Responsibility Must Be Specified
L = Low Risk: Manage By Routine Procedures

The complete list of identified environmental risks for the Project is provided in Table 18 below.

In summary, 60 risks to aquatic values where identified for the Project. Prior to applying management strategies, the following risk ranking frequencies were identified:

- 15 Extreme Risks;
- 27 High Risks;
- 9 Moderate Risks; and
- 1 Low Risk.

Once mitigation strategies were applied the following residual risk frequencies were found:

- 0 Extreme Risk
- 3 High Risk;
- 16 Moderate Risks; and
- 32 Low Risks.

The following incidents were found to have a high level of inherent risk:

- Loss of aquatic habitat as a result of the diversion of Lagoon and Sandy Creeks;
- Failure of fines dam resulting in contamination of soil and surface water; and
- Generation of Acid Rock Drainage (ARD) and Neutral Mine Drainage (NMD) as a result of the creation of the final void.

The introduction of a combination of behavioural controls, system controls and engineering controls generally reduced the consequence and / or likelihood rating of an impact. This in turn, reduced the overall risk rating of each potential impact. Of the high inherent risks, all were reduced to a lower residual risk following the implementation of proposed control measures.

While most of these impacts were assessed as having a rare likelihood of occurrence, their “major” consequence value ensured that their high residual risk rating persisted, following the implementation of several control measures. These control measures included:

- Extensive testing and identification of ARD generation potential and appropriate monitoring and management of any ARD issues;
- Bunding and diversions to prevent the release of pit water;
- Original design and annual inspection of referable dams conducted by a qualified engineer; and
- DERM approvals sought for fines dam designs.

The loss of aquatic habitat and degradation of downstream watercourses due to the proposed creek diversions still retains a Likelihood rating of ‘Possible’ owing to the high level of disturbance inherent in such works. There is potential however, to mitigate this risk using the following control measures:

- Flora and fauna management measures that are implemented during construction, in order to prevent disturbance of species of conservation significance;
- Erosion and sediment control measures; and
- Rehabilitation and monitoring, once the construction works are complete.

Table 18 Risk Assessment Results

Process/ Functional Area	Activity	Aspect/ Hazard	Scenario	Impact	Inherent Risk: Consequence	Inherent Risk: Likelihood	Inherent Risk: Risk	Behavioural Controls: People-based controls that rely on skills, knowledge and experience of individuals and groups.	System Controls: Executed by individuals within the bounds of a management system.	Engineering Controls: Execute automatically and do not require human intervention.	Residual Risk: Consequence	Residual Risk: Likelihood	Residual Risk: Risk
Mineral Exploration	Drilling	Emissions - dust	Drilling will be conducted over the Project area. Fugitive dust emissions from these activities may impact upon surface water quality, riparian vegetation and consequently, habitat utilization by aquatic fauna.	Increased turbidity and/or sedimentation of water courses may decrease their habitat value for fauna, particularly in the dry season when non-burrowing species are more restricted and at higher risk of disturbance. Taxa impacted directly may include macro-invertebrates (particularly more sensitive groups, e.g. EPT), and vertebrates that feed in / inhabit aquatic environments including frogs, fish, reptiles (e.g. ornamental snake and snake-necked turtle), mammals (e.g. water rat) and birds (e.g. Black-winged Stilt).	Minor	Possible	Moderate	Nil	Dust suppression by water trucks on unsealed roads and disturbance areas.	Nil	Minor	Unlikely	Low

Process/ Functional Area	Activity	Aspect/ Hazard	Scenario	Impact	Inherent Risk			Behavioural Controls	System Controls	Engineering Controls	Residual Risk		
					Consequence	Likelihood	Risk	People-based controls that rely on skills, knowledge and experience of individuals and groups.	Executed by individuals within the bounds of a management system.	Execute automatically and do not require human intervention.	Consequence	Likelihood	Risk
Mineral Exploration	Drilling	Generation – hazardous solid waste	Oxidation of drill cuttings containing sulphides could lead to the generation of minor volumes of acidic run-off and consequently contaminate soil and surface water.	Increased pH of watercourses could render the affected areas unsuitable for some aquatic fauna. Taxa directly affected may include macro-invertebrates (particularly more sensitive groups, e.g. EPT), and vertebrates that feed in / inhabit aquatic environments including frogs, fish (especially those with low acidity tolerance, such as the Glass Perch and Barred Grunter), reptiles (e.g. ornamental snake and snake-necked turtle), mammals (e.g. water rat) and birds (e.g. Black-winged Stilt).	Minor	Possible	Moderate	Nil	Drill sites will be cleaned up and rehabilitated as soon as possible.	Nil	Minor	Unlikely	Low

Process/ Functional Area	Activity	Aspect/ Hazard	Scenario	Impact	Inherent Risk			Behavioural Controls	System Controls	Engineering Controls	Residual Risk		
					Consequence	Likelihood	Risk	People-based controls that rely on skills, knowledge and experience of individuals and groups.	Executed by individuals within the bounds of a management system.	Execute automatically and do not require human intervention.	Consequence	Likelihood	Risk
Mineral Exploration	Drilling	Release – contaminated water	Release of water from drill holes.	Increased turbidity, sedimentation and/or contamination of water courses may decrease their habitat value for fauna, particularly in the dry season when non-burrowing species are more restricted and at higher risk of disturbance. Taxa impacted directly may include macro-invertebrates (particularly more sensitive groups, e.g. EPT), and vertebrates that feed in / inhabit aquatic environments including frogs, fish, reptiles (e.g. ornamental snake and snake-necked turtle), mammals (e.g. water rat) and birds (e.g. Black-winged Stilt).	Minor	Likely	High	Nil	Nil	Drill sumps will be constructed for all exploration drill holes.	Minor	Unlikely	Low

Process/ Functional Area	Activity	Aspect/ Hazard	Scenario	Impact	Inherent Risk			Behavioural Controls	System Controls	Engineering Controls	Residual Risk		
					Consequence	Likelihood	Risk	People-based controls that rely on skills, knowledge and experience of individuals and groups.	Executed by individuals within the bounds of a management system.	Execute automatically and do not require human intervention.	Consequence	Likelihood	Risk
Mineral Exploration	Bulk hydrocarbon storage, field re-fuelling	Spill – hazmat bulk	Hydrocarbons stored for drilling activities may be spilled, resulting in soil and surface water contamination.	Contamination of surface water with hydrocarbons would reduce the diversity and density of taxa that feed in / inhabit aquatic environments, including macro-invertebrates (particularly more sensitive groups, e.g. EPT), and vertebrates that feed in / inhabit aquatic environments including frogs, fish, reptiles (e.g. ornamental snake and snake-necked turtle), mammals (e.g. water rat) and birds (e.g. Black-winged Stilt). Such an event would also impact directly upon any flora and fauna reliant on the water course for hydration.	Moderate	Likely	High	Operators are trained in spill management and reporting procedures.	Spill cleanup kits are located throughout the site; staff are trained in the use of spill containment kits.	All hydrocarbons will be stored according to AS 1940.	Moderate	Unlikely	Moderate

Process/ Functional Area	Activity	Aspect/ Hazard	Scenario	Impact	Inherent Risk			Behavioural Controls	System Controls	Engineering Controls	Residual Risk		
					Consequence	Likelihood	Risk	People-based controls that rely on skills, knowledge and experience of individuals and groups.	Executed by individuals within the bounds of a management system.	Execute automatically and do not require human intervention.	Consequence	Likelihood	Risk
Mineral Exploration	Vegetation clearance	Clearance - vegetation	The clearing of vegetation for drilling activities may remove habitat that supports native aquatic flora and fauna.	The loss of riparian vegetation may result in the direct removal of habitat as well as the degradation of aquatic habitat resulting in reduction of water quality, loss of aquatic flora and fauna biodiversity and reduction of stream health. Taxa impacted directly may include macro-invertebrates (particularly more sensitive groups, e.g. EPT), and vertebrates that feed in / inhabit aquatic environments including frogs, fish, reptiles (e.g. ornamental snake and snake-necked turtle), mammals (e.g. water rat) and birds (e.g. Black-winged Stilt). Any taxa that utilise riparian habitat may also be directly affected.	Moderate	Possible	High	Nil	Vegetation clearing approval processes are in place and all clearing approved by the relevant regulatory body. Vegetation clearing will be kept to the minimum footprint possible and land will be returned to accepted uses and suitability.	Nil.	Minor	Unlikely	Low

Process/ Functional Area	Activity	Aspect/ Hazard	Scenario	Impact	Consequence	Likelihood	Risk	Behavioural Controls	System Controls	Engineering Controls	Consequence	Likelihood	Risk
					Inherent Risk			People-based controls that rely on skills, knowledge and experience of individuals and groups.	Executed by individuals within the bounds of a management system.	Execute automatically and do not require human intervention.	Residual Risk		
Project Construction	Bulk earthworks and mine development	Emissions – dust	Bulk earthworks conducted during mine development could result in fugitive dust emissions. These emissions may impact upon surface water quality, riparian vegetation and consequently, habitat utilization by aquatic fauna.	Increased turbidity and/or sedimentation of water courses may decrease their habitat value for fauna, particularly in the dry season when non-burrowing species are more restricted and at higher risk of disturbance. Taxa impacted directly may include macro-invertebrates (particularly more sensitive groups, e.g. EPT), and vertebrates that feed in / inhabit aquatic environments including frogs, fish, reptiles (e.g. ornamental snake and snake-necked turtle), mammals (e.g. water rat) and birds (e.g. Black-winged Stilt).	Moderate	Possible	High	Nil	Dust suppression by water trucks on unsealed roads and disturbance areas.	Nil	Minor	Unlikely	Low

Process/ Functional Area	Activity	Aspect/ Hazard	Scenario	Impact	Consequence	Likelihood	Risk	Behavioural Controls	System Controls	Engineering Controls	Consequence	Likelihood	Risk
					Inherent Risk			People-based controls that rely on skills, knowledge and experience of individuals and groups.	Executed by individuals within the bounds of a management system.	Execute automatically and do not require human intervention.	Residual Risk		
Project Construction	Bulk earthworks and mine development	Modification - landform	The creation of an open cut operation and associated waste rock dumps could result in significant modification of the pre-existing landscape, impacting upon the overland flow of surface water.	Increased turbidity and/or sedimentation of water courses may decrease their habitat value for fauna, particularly in the dry season when non-burrowing species are more restricted and at higher risk of disturbance. Increased flood levels could negatively impact on fringing riparian vegetation, degrading the micro habitat associated with stream banks. Taxa impacted directly may include macro-invertebrates (particularly more sensitive groups, e.g. EPT), and vertebrates that feed in / inhabit aquatic environments including frogs, fish, reptiles (e.g. ornamental snake and snake-necked turtle), mammals (e.g. water rat) and birds (e.g. Black-winged Stilt).	Moderate	Unlikely	Moderate	Nil	DERM will approve the final landform as part of the EIS approval.	Nil	Minor	Unlikely	Low

Process/ Functional Area	Activity	Aspect/ Hazard	Scenario	Impact	Inherent Risk			Behavioural Controls	System Controls	Engineering Controls	Residual Risk		
					Consequence	Likelihood	Risk	People-based controls that rely on skills, knowledge and experience of individuals and groups.	Executed by individuals within the bounds of a management system.	Execute automatically and do not require human intervention.	Consequence	Likelihood	Risk
Project Construction	Bulk earthworks and mine development	Modification – creek crossings	Access tracks, diversion drains and dams are planned to intersect with watercourses throughout the Project site. Construction works may mobilise sediment and/or modify water flow, impacting upon aquatic in-stream habitat and associated riparian vegetation.	Increased turbidity and/or sedimentation of water courses may decrease their habitat value for fauna, particularly in the dry season when non-burrowing species are more restricted and at higher risk of disturbance. Taxa impacted directly may include macro-invertebrates (particularly more sensitive groups, e.g. EPT), and vertebrates that feed in / inhabit aquatic environments including frogs, fish, reptiles (e.g. ornamental snake and snake-necked turtle), mammals (e.g. water rat) and birds (e.g. Black-winged Stilt). In-stream fauna such as fish and amphibians may be impacted if creek crossings are not designed to facilitate their movement downstream.	Moderate	Possible	High	Nil	Appropriate erosion and sediment control measures implemented to prevent mobilisation of sediment into watercourses.	All creek crossings designed to withstand projected flood events and allow for the movement of in-stream fauna.	Minor	Unlikely	Low

Process/ Functional Area	Activity	Aspect/ Hazard	Scenario	Impact	Inherent Risk			Behavioural Controls	System Controls	Engineering Controls	Residual Risk		
					Consequence	Likelihood	Risk	People-based controls that rely on skills, knowledge and experience of individuals and groups.	Executed by individuals within the bounds of a management system.	Execute automatically and do not require human intervention.	Consequence	Likelihood	Risk
Project Construction	Bulk earthworks and mine development	Modification – creek diversions	The proposed diversions of Lagoon Creek and Sandy Creek will remove vegetation and riparian and aquatic habitat, and may mobilise sediment and/or modify water flow.	Increased turbidity and/or sedimentation of water courses may decrease their habitat value for fauna, particularly in the dry season when non-burrowing species are more restricted and at higher risk of disturbance. Taxa impacted directly may include macro-invertebrates (particularly more sensitive groups, e.g. EPT), and vertebrates that feed in / inhabit aquatic environments including frogs, fish, reptiles (e.g. ornamental snake and snake-necked turtle), mammals (e.g. water rat) and birds (e.g. Black-winged Stilt). The removal of the riparian vegetation may impact upon the River Red Gum communities known to occur on the Project site, as well as the full suite of potentially occurring and recorded aquatic fauna.	Major	Likely	Extreme	Nil	Appropriate erosion and sediment control measures implemented to prevent mobilisation of sediment downstream. Rehabilitation of modified section of the creeks implemented as soon as possible, and designed to replicate the pre-existing ecosystem.	The creek diversion designed to withstand projected flood events, provide suitable habitat for riparian flora and aquatic fauna and allow for the movement of in-stream fauna.	Moderate	Moderate	High

Process/ Functional Area	Activity	Aspect/ Hazard	Scenario	Impact	Inherent Risk			Behavioural Controls	System Controls	Engineering Controls	Residual Risk		
					Consequence	Likelihood	Risk	People-based controls that rely on skills, knowledge and experience of individuals and groups.	Executed by individuals within the bounds of a management system.	Execute automatically and do not require human intervention.	Consequence	Likelihood	Risk
Project Construction	Vegetation Clearance	Emissions - dust	The clearing of vegetation may cause increased dust emissions during construction.	Increased turbidity and/or sedimentation of water courses may decrease their habitat value for fauna, particularly in the dry season when non-burrowing species are more restricted and at higher risk of disturbance. Taxa impacted directly may include macro-invertebrates (particularly more sensitive groups, e.g. EPT), and vertebrates that feed in / inhabit aquatic environments including frogs, fish, reptiles (e.g. ornamental snake and snake-necked turtle), mammals (e.g. water rat) and birds (e.g. Black-winged Stilt).	Moderate	Possible	High	Nil	Dust suppression by water trucks on unsealed roads and disturbance areas..	Nil	Minor	Unlikely	Low

Process/ Functional Area	Activity	Aspect/ Hazard	Scenario	Impact	Consequence	Likelihood	Risk	Behavioural Controls	System Controls	Engineering Controls	Consequence	Likelihood	Risk
					Inherent Risk			People-based controls that rely on skills, knowledge and experience of individuals and groups.	Executed by individuals within the bounds of a management system.	Execute automatically and do not require human intervention.	Residual Risk		
Project Construction	Vegetation Clearance	Release - sediment	The clearing of vegetation may cause sediment to be mobilised which could cause degradation of any adjacent aquatic habitat through sediment build-up.	Increased turbidity and/or sedimentation of water courses may decrease their habitat value for fauna, particularly in the dry season when non-burrowing species are more restricted and at higher risk of disturbance. Taxa impacted directly may include macro-invertebrates (particularly more sensitive groups, e.g. EPT), and vertebrates that feed in / inhabit aquatic environments including frogs, fish, reptiles (e.g. ornamental snake and snake-necked turtle), mammals (e.g. water rat) and birds (e.g. Black-winged Stilt).	Moderate	Possible	High	Nil	Appropriate erosion and sediment control measures implemented to prevent mobilisation of sediment into watercourses.	Run-off from all disturbed areas will pass through sediment dams, and bunds will be installed downstream of disturbance areas to prevent the release of sediment.	Minor	Unlikely	Low

Process/ Functional Area	Activity	Aspect/ Hazard	Scenario	Impact	Consequence	Likelihood	Risk	Behavioural Controls	System Controls	Engineering Controls	Consequence	Likelihood	Risk
					Inherent Risk			People-based controls that rely on skills, knowledge and experience of individuals and groups.	Executed by individuals within the bounds of a management system.	Execute automatically and do not require human intervention.	Residual Risk		
Project Construction	Vegetation Clearance	Clearance - vegetation	The clearing of vegetation will remove habitat that supports native aquatic flora and fauna.	The loss of riparian vegetation may result in the direct removal of habitat as well as the degradation of aquatic habitat through increased turbidity, sedimentation or contamination. Increased turbidity and/or sedimentation of water courses may decrease their habitat value for fauna, particularly in the dry season when non-burrowing species are more restricted and at higher risk of disturbance. Taxa impacted directly may include macro-invertebrates (particularly more sensitive groups, e.g. EPT), and vertebrates that feed in / inhabit aquatic environments including frogs, fish, reptiles (e.g. ornamental snake and snake-necked turtle), mammals (e.g. water rat) and birds (e.g. Black-winged Stilt). Any taxa that utilise riparian habitat may also be directly affected.	Moderate	Possible	High	Nil	Vegetation clearing approval processes in place, and all clearing approved by the relevant regulatory body. Vegetation clearing will be kept to the minimum footprint possible and land will be returned to accepted uses and suitability.	Nil	Minor	Unlikely	Low

Process/ Functional Area	Activity	Aspect/ Hazard	Scenario	Impact	Inherent Risk			Behavioural Controls	System Controls	Engineering Controls	Residual Risk		
					Consequence	Likelihood	Risk	People-based controls that rely on skills, knowledge and experience of individuals and groups.	Executed by individuals within the bounds of a management system.	Execute automatically and do not require human intervention.	Consequence	Likelihood	Risk
Project Construction	Vegetation Clearance	Clearance - vegetation	The clearing of vegetation will remove species and/or communities of conservation significance, or cause a reduction in habitat for these species.	Species of conservation significance known to occur, such as the numerous bird species listed as either Marine or Migratory under the EPBC, and vegetation communities such as the River Red Gum community, will be potentially impacted by the removal of any riparian vegetation. No aquatic species of conservation significance were recorded within the water courses themselves, and none are considered likely to occur.	Major	Unlikely	High	Environmental inductions to make all personnel and contractors aware of vegetation clearing approval processes and the potential presence of any species/communities of conservation significance.	Vegetation clearing approval processes in place, and all clearing approved by the relevant regulatory body. Vegetation clearing will be kept to the minimum footprint possible. Rehabilitation of the project area to create habitat similar to that present prior to disturbance.	Nil	Minor	Unlikely	Low

Process/ Functional Area	Activity	Aspect/ Hazard	Scenario	Impact	Inherent Risk			Behavioural Controls	System Controls	Engineering Controls	Residual Risk		
					Consequence	Likelihood	Risk	People-based controls that rely on skills, knowledge and experience of individuals and groups.	Executed by individuals within the bounds of a management system.	Execute automatically and do not require human intervention.	Consequence	Likelihood	Risk
Project Construction	Bulk hydrocarbon storage, field re-fuelling	Spill – hazmat bulk	Hydrocarbons stored for construction activities may be spilled, resulting in soil and surface water contamination.	Contamination of surface water with hydrocarbons would reduce the diversity and density of aquatic fauna. Taxa impacted directly may include macro-invertebrates (particularly more sensitive groups, e.g. EPT), and vertebrates that feed in / inhabit aquatic environments including frogs, fish, reptiles (e.g. ornamental snake and snake-necked turtle), mammals (e.g. water rat) and birds (e.g. Black-winged Stilt). Any taxa that utilise riparian habitat may also be directly affected. Such an event would also impact upon any flora and fauna reliant on the water course for hydration.	Moderate	Likely	High	Operators are trained in spill management and reporting procedures.	Spill cleanup kits are located throughout the site; staff are trained in the use of spill containment kits.	All hydrocarbons will be stored according to AS 1940.	Moderate	unlikely	Moderate

Process/ Functional Area	Activity	Aspect/ Hazard	Scenario	Impact	Inherent Risk			Behavioural Controls	System Controls	Engineering Controls	Residual Risk		
					Consequence	Likelihood	Risk	People-based controls that rely on skills, knowledge and experience of individuals and groups.	Executed by individuals within the bounds of a management system.	Execute automatically and do not require human intervention.	Consequence	Likelihood	Risk
Project Construction	Hazardous waste storage	Spill – hazmat minor	Hazardous waste will be generated during construction activities. These products will need to be stored prior to disposal or removal from site. The potential exists for these waste products to contaminate land and water resources during storage.	Contamination of surface water with hazardous waste would reduce the diversity and density of aquatic flora and fauna. Taxa impacted directly may include macro-invertebrates (particularly more sensitive groups, e.g. EPT), and vertebrates that feed in / inhabit aquatic environments including frogs, fish, reptiles (e.g. ornamental snake and snake-necked turtle), mammals (e.g. water rat) and birds (e.g. Black-winged Stilt). Any taxa that utilise riparian habitat may also be directly affected. Such an event would also impact upon any flora and fauna reliant on the water course for hydration.	Moderate	Possible	High	Operators are trained in spill management and reporting procedures	Spill cleanup kits are located throughout the site; staff are trained in the use of spill containment kits.	Hazardous waste will be stored in a bunded area.	Minor	Unlikely	Low

Process/ Functional Area	Activity	Aspect/ Hazard	Scenario	Impact	Inherent Risk			Behavioural Controls	System Controls	Engineering Controls	Residual Risk		
					Consequence	Likelihood	Risk	People-based controls that rely on skills, knowledge and experience of individuals and groups.	Executed by individuals within the bounds of a management system.	Execute automatically and do not require human intervention.	Consequence	Likelihood	Risk
Project Construction	Infrastructure Construction	Emissions – dust	Construction works during mine development could result in fugitive dust emissions. These emissions may impact upon surface water quality, riparian vegetation and consequently, habitat utilization by aquatic fauna.	Increased turbidity and/or sedimentation of water courses may decrease their habitat value for fauna, particularly in the dry season when non-burrowing species are more restricted and at higher risk of disturbance. Taxa impacted directly may include macro-invertebrates (particularly more sensitive groups, e.g. EPT), and vertebrates that feed in / inhabit aquatic environments including frogs, fish, reptiles (e.g. ornamental snake and snake-necked turtle), mammals (e.g. water rat) and birds (e.g. Black-winged Stilt).	Moderate	Possible	High	Nil	Dust suppression by water trucks on unsealed roads and disturbance areas.	Nil	Minor	Unlikely	Low

Process/ Functional Area	Activity	Aspect/ Hazard	Scenario	Impact	Inherent Risk			Behavioural Controls	System Controls	Engineering Controls	Residual Risk		
					Consequence	Likelihood	Risk	People-based controls that rely on skills, knowledge and experience of individuals and groups.	Executed by individuals within the bounds of a management system.	Execute automatically and do not require human intervention.	Consequence	Likelihood	Risk
Project Construction	Vehicle washdown	Generation - wastewater	Wash down pads will be used during construction activities. These systems may overflow resulting in contamination to both surface water and soil.	Contamination of surface water with excess sediment and/or chemical contaminants may decrease their habitat value for fauna, particularly in the dry season when non-burrowing species are more restricted and at higher risk of disturbance. Taxa impacted directly may include macro-invertebrates (particularly more sensitive groups, e.g. EPT), and vertebrates that feed in / inhabit aquatic environments including frogs, fish, reptiles (e.g. ornamental snake and snake-necked turtle), mammals (e.g. water rat) and birds (e.g. Black-winged Stilt).	Moderate	Almost Certain	Extreme	Nil	Washdown pads and oil/water separators will be inspected and cleaned out regularly. The washdown systems are designed by a qualified engineer with due consideration to required capacities.	All washdown pads will have oil/water separators installed as part of the system.	Minor	Unlikely	Low

Process/ Functional Area	Activity	Aspect/ Hazard	Scenario	Impact	Inherent Risk			Behavioural Controls	System Controls	Engineering Controls	Residual Risk		
					Consequence	Likelihood	Risk	People-based controls that rely on skills, knowledge and experience of individuals and groups.	Executed by individuals within the bounds of a management system.	Execute automatically and do not require human intervention.	Consequence	Likelihood	Risk
Mining: Drill and Blast	Drill and blast	Emissions - dust	Drill and blast mining activities will result in fugitive dust emissions. These emissions may impact upon surface water quality, riparian vegetation and consequently, habitat utilization by aquatic fauna.	Increased turbidity and/or sedimentation of water courses may decrease their habitat value for fauna, particularly in the dry season when non-burrowing species are more restricted and at higher risk of disturbance. Taxa impacted directly may include macro-invertebrates (particularly more sensitive groups, e.g. EPT), and vertebrates that feed in / inhabit aquatic environments including frogs, fish, reptiles (e.g. ornamental snake and snake-necked turtle), mammals (e.g. water rat) and birds (e.g. Black-winged Stilt).	Moderate	Possible	High	Nil	Dust suppression by water trucks on unsealed roads and disturbance areas.	Nil	Minor	Unlikely	Low

Process/ Functional Area	Activity	Aspect/ Hazard	Scenario	Impact	Inherent Risk			Behavioural Controls	System Controls	Engineering Controls	Residual Risk		
					Consequence	Likelihood	Risk	People-based controls that rely on skills, knowledge and experience of individuals and groups.	Executed by individuals within the bounds of a management system.	Execute automatically and do not require human intervention.	Consequence	Likelihood	Risk
Mining: Drill and Blast	Explosives mixing	Spill – hazmat bulk	The potential exists for spills of hydrocarbons and explosives during explosives mixing.	Contamination of surface water with hydrocarbons and explosives would decrease their habitat value for fauna, particularly in the dry season when non-burrowing species are more restricted and at higher risk of disturbance. Taxa impacted directly may include macro-invertebrates (particularly more sensitive groups, e.g. EPT), and vertebrates that feed in / inhabit aquatic environments including frogs, fish, reptiles (e.g. ornamental snake and snake-necked turtle), mammals (e.g. water rat) and birds (e.g. Black-winged Stilt). Such an event would also impact upon any flora and fauna reliant on the water course for hydration.	Minor	Likely	High	Operators are trained in spill management and reporting procedures.	Spill cleanup kits are located throughout the site; staff are trained in the use of spill containment kits.	All hydrocarbons will be stored according to AS 1940.	Minor	Possible	Moderate

Process/ Functional Area	Activity	Aspect/ Hazard	Scenario	Impact	Inherent Risk			Behavioural Controls	System Controls	Engineering Controls	Residual Risk		
					Consequence	Likelihood	Risk	People-based controls that rely on skills, knowledge and experience of individuals and groups.	Executed by individuals within the bounds of a management system.	Execute automatically and do not require human intervention.	Consequence	Likelihood	Risk
Mining: Drill and Blast	Bulk hydrocarbon storage, field re-fuelling	Spill – hazmat bulk	Hydrocarbons stored for drilling and blasting activities may be spilled, resulting in soil and surface water contamination.	Contamination of surface water with hydrocarbons would decrease their habitat value for fauna, particularly in the dry season when non-burrowing species are more restricted and at higher risk of disturbance. Taxa impacted directly may include macro-invertebrates (particularly more sensitive groups, e.g. EPT), and vertebrates that feed in / inhabit aquatic environments including frogs, fish, reptiles (e.g. ornamental snake and snake-necked turtle), mammals (e.g. water rat) and birds (e.g. Black-winged Stilt). Such an event would also impact upon any flora and fauna reliant on the water course for hydration.	Moderate	Likely	High	Operators are trained in spill management and reporting procedures.	Spill cleanup kits are located throughout the site; staff are trained in the use of spill containment kits.	All hydrocarbons will be stored according to AS 1940.	Moderate	unlikely	Moderate

Process/ Functional Area	Activity	Aspect/ Hazard	Scenario	Impact	Inherent Risk			Behavioural Controls	System Controls	Engineering Controls	Residual Risk		
					Consequence	Likelihood	Risk	People-based controls that rely on skills, knowledge and experience of individuals and groups.	Executed by individuals within the bounds of a management system.	Execute automatically and do not require human intervention.	Consequence	Likelihood	Risk
Mining: Production	Dump Construction	Emissions - dust	Waste rock dumps will be constructed over the life of the project. These dumps could result in fugitive dust emissions which may impact upon surface water quality, riparian vegetation and consequently, habitat utilization by aquatic fauna.	Increased turbidity and/or sedimentation of water courses may decrease their habitat value for fauna, particularly in the dry season when non-burrowing species are more restricted and at higher risk of disturbance. Taxa impacted directly may include macro-invertebrates (particularly more sensitive groups, e.g. EPT), and vertebrates that feed in / inhabit aquatic environments including frogs, fish, reptiles (e.g. ornamental snake and snake-necked turtle), mammals (e.g. water rat) and birds (e.g. Black-winged Stilt)	Moderate	Likely	High	Nil	Dust suppression by water trucks on unsealed roads and disturbance areas. Rehabilitation and stabilisation of disturbed areas will be completed as soon as possible.	Nil	Minor	Unlikely	Low

Process/ Functional Area	Activity	Aspect/ Hazard	Scenario	Impact	Inherent Risk			Behavioural Controls	System Controls	Engineering Controls	Residual Risk		
					Consequence	Likelihood	Risk	People-based controls that rely on skills, knowledge and experience of individuals and groups.	Executed by individuals within the bounds of a management system.	Execute automatically and do not require human intervention.	Consequence	Likelihood	Risk
Mining: Production	Dump Construction	Generation - ARD	The creation of waste rock dumps could result in the generation of ARD from sulphide minerals contained within.	Increased acidity and heavy metal concentration in water courses may decrease their habitat value for fauna, particularly in the dry season when non-burrowing species are more restricted and at higher risk of disturbance. Taxa impacted directly may include macro-invertebrates (particularly more sensitive groups, e.g. EPT), and vertebrates that feed in / inhabit aquatic environments including frogs, fish (especially species with low acidity tolerance, such as the Glass Perch and Barred Grunter), reptiles (e.g. ornamental snake and snake-necked turtle), mammals (e.g. water rat) and birds (e.g. Black-winged Stilt). If the water becomes highly contaminated with ARD it could be toxic to all flora and fauna.	Major	Possible	Extreme	Nil	Nil	Rock dumps will be situated so to avoid interference with overland flows of surface water. Groundwater monitoring downstream of the waste rock dumps will be undertaken. Run-off and seepage interception and divert and retention structures will be utilised.	Moderate	Unlikely	Moderate

Process/ Functional Area	Activity	Aspect/ Hazard	Scenario	Impact	Inherent Risk			Behavioural Controls	System Controls	Engineering Controls	Residual Risk		
					Consequence	Likelihood	Risk	People-based controls that rely on skills, knowledge and experience of individuals and groups.	Executed by individuals within the bounds of a management system.	Execute automatically and do not require human intervention.	Consequence	Likelihood	Risk
Mining: Production	Dump construction	Generation - NMD	The creation of waste rock dumps could result in the generation of NMD from saline elements contained within.	Increased salinity of water courses may decrease their habitat value for fauna, particularly in the dry season when non-burrowing species are more restricted and at higher risk of disturbance. Taxa impacted directly may include macro-invertebrates (particularly more sensitive groups, e.g. EPT), and vertebrates that feed in / inhabit aquatic environments including frogs, fish (especially rainbow fish), reptiles (e.g. ornamental snake and snake-necked turtle), mammals (e.g. water rat) and birds (e.g. Black-winged Stilt) . If the water becomes highly contaminated with NMD it could become toxic to all flora and fauna.	Major	Possible	Extreme	Nil	Nil	Waste rock dumps stockpiles will be designed and situated to avoid interference with overland flows of surface water. Groundwater monitoring downstream of the waste rock dumps will be undertaken. Run-off and seepage interception and divert and retention structures will be utilised.	Moderate	Unlikely	Moderate

Process/ Functional Area	Activity	Aspect/ Hazard	Scenario	Impact	Inherent Risk			Behavioural Controls	System Controls	Engineering Controls	Residual Risk		
					Consequence	Likelihood	Risk	People-based controls that rely on skills, knowledge and experience of individuals and groups.	Executed by individuals within the bounds of a management system.	Execute automatically and do not require human intervention.	Consequence	Likelihood	Risk
Mining: Production	Dump Construction	Release - sediment	The construction of waste rock dumps may cause sediment to be mobilised which could cause degradation of any adjacent aquatic habitat through sediment build-up.	Increased turbidity and/or sedimentation of water courses may decrease their habitat value for fauna, particularly in the dry season when non-burrowing species are more restricted and at higher risk of disturbance. Taxa impacted directly may include macro-invertebrates (particularly more sensitive groups, e.g. EPT), and vertebrates that feed in / inhabit aquatic environments including frogs, fish, reptiles (e.g. ornamental snake and snake-necked turtle), mammals (e.g. water rat) and birds (e.g. Black-winged Stilt)	Major	Likely	Extreme	Nil	Appropriate erosion and sediment control measures implemented to prevent mobilisation of sediment into watercourses.	Run-off from all disturbed areas will pass through sediment dams, and bunds will be installed downstream of disturbance areas to prevent the release of sediment.	Minor	Unlikely	Low

Process/ Functional Area	Activity	Aspect/ Hazard	Scenario	Impact	Inherent Risk			Behavioural Controls	System Controls	Engineering Controls	Residual Risk		
					Consequence	Likelihood	Risk	People-based controls that rely on skills, knowledge and experience of individuals and groups.	Executed by individuals within the bounds of a management system.	Execute automatically and do not require human intervention.	Consequence	Likelihood	Risk
Mining: Production	Bulk hydrocarbon storage, field re-fuelling	Spill – hazmat bulk	Hydrocarbons stored for mining activities may be spilled, resulting in soil and surface water contamination.	Contamination of surface water with hydrocarbons may decrease their habitat value for fauna, particularly in the dry season when non-burrowing species are more restricted and at higher risk of disturbance. Taxa impacted directly may include macro-invertebrates (particularly more sensitive groups, e.g. EPT), and vertebrates that feed in / inhabit aquatic environments including frogs, fish, reptiles (e.g. ornamental snake and snake-necked turtle), mammals (e.g. water rat) and birds (e.g. Black-winged Stilt) Such an event would also impact upon any flora and fauna reliant on the water course for hydration.	Moderate	Likely	High	Operators are trained in spill management and reporting procedures.	Spill cleanup kits are located throughout the site; staff are trained in the use of spill containment kits.	All hydrocarbons will be stored according to AS 1940.	Moderate	unlikely	Moderate

Process/ Functional Area	Activity	Aspect/ Hazard	Scenario	Impact	Inherent Risk			Behavioural Controls	System Controls	Engineering Controls	Residual Risk		
					Consequence	Likelihood	Risk	People-based controls that rely on skills, knowledge and experience of individuals and groups.	Executed by individuals within the bounds of a management system.	Execute automatically and do not require human intervention.	Consequence	Likelihood	Risk
Mining: Production	Coal and waste rock haulage	Emissions - dust	Haulage activities may result in fugitive dust emissions which may impact upon surface water quality, riparian vegetation and consequently, habitat utilization by aquatic fauna.	Increased turbidity and/or sedimentation of water courses may decrease their habitat value for fauna, particularly in the dry season when non-burrowing species are more restricted and at higher risk of disturbance. Taxa impacted directly may include macro-invertebrates (particularly more sensitive groups, e.g. EPT), and vertebrates that feed in / inhabit aquatic environments including frogs, fish, reptiles (e.g. ornamental snake and snake-necked turtle), mammals (e.g. water rat) and birds (e.g. Black-winged Stilt)	Moderate	Likely	High	Nil	Dust suppression by water trucks on unsealed roads and disturbance areas.	Nil	Minor	Unlikely	Low

Process/ Functional Area	Activity	Aspect/ Hazard	Scenario	Impact	Inherent Risk			Behavioural Controls	System Controls	Engineering Controls	Residual Risk		
					Consequence	Likelihood	Risk	People-based controls that rely on skills, knowledge and experience of individuals and groups.	Executed by individuals within the bounds of a management system.	Execute automatically and do not require human intervention.	Consequence	Likelihood	Risk
Mining: Production	Product stockpiles	Emissions - dust	Product will be stockpiled as required prior to crushing. These stockpiles may result in fugitive dust emissions which may impact upon surface water quality, riparian vegetation and consequently, habitat utilization by aquatic fauna.	Increased turbidity and/or sedimentation of water courses may decrease their habitat value for fauna, particularly in the dry season when non-burrowing species are more restricted and at higher risk of disturbance. Taxa impacted directly may include macro-invertebrates (particularly more sensitive groups, e.g. EPT), and vertebrates that feed in / inhabit aquatic environments including frogs, fish, reptiles (e.g. ornamental snake and snake-necked turtle), mammals (e.g. water rat) and birds (e.g. Black-winged Stilt)	Minor	Possible	Moderate	Nil	Dust suppression by water trucks on unsealed roads and disturbance areas.	Nil	Minor	Unlikely	Low

Process/ Functional Area	Activity	Aspect/ Hazard	Scenario	Impact	Inherent Risk			Behavioural Controls	System Controls	Engineering Controls	Residual Risk		
					Consequence	Likelihood	Risk	People-based controls that rely on skills, knowledge and experience of individuals and groups.	Executed by individuals within the bounds of a management system.	Execute automatically and do not require human intervention.	Consequence	Likelihood	Risk
Mining: Production	Product stockpiles	Generation - ARD	The creation of product stockpiles could result in the generation of ARD from sulphide minerals contained within.	Increased acidity and heavy metals concentrations in water bodies may decrease their habitat value for fauna, particularly in the dry season when non-burrowing species are more restricted and at higher risk of disturbance. Taxa impacted directly may include macro-invertebrates (particularly more sensitive groups, e.g. EPT), and vertebrates that feed in / inhabit aquatic environments including frogs, fish (especially for species with low acidity tolerance such as the Glass Perch and Barred Grunter), reptiles (e.g. ornamental snake and snake-necked turtle), mammals (e.g. water rat) and birds (e.g. Black-winged Stilt). If the water becomes highly contaminated with ARD it could be toxic to all flora and fauna.	Major	Possible	Extreme	Nil	Nil	Product stockpiles will be situated to avoid interference with overland flows of surface water. Groundwater monitoring downstream of the waste rock dumps will be undertaken. Run-off and seepage interception and divert and retention structures will be utilised.	Moderate	Unlikely	Moderate

Process/ Functional Area	Activity	Aspect/ Hazard	Scenario	Impact	Inherent Risk			Behavioural Controls	System Controls	Engineering Controls	Residual Risk		
					Consequence	Likelihood	Risk	People-based controls that rely on skills, knowledge and experience of individuals and groups.	Executed by individuals within the bounds of a management system.	Execute automatically and do not require human intervention.	Consequence	Likelihood	Risk
Mining: Production	Product stockpiles	Generation - NMD	The creation of product stockpiles could result in the generation of NMD from saline elements contained within.	Increased salinity of water courses may decrease their habitat value for fauna, particularly in the dry season when non-burrowing species are more restricted and at higher risk of disturbance. Taxa impacted directly may include macro-invertebrates (particularly more sensitive groups, e.g. EPT), and vertebrates that feed in / inhabit aquatic environments including frogs, fish (especially species with low salt tolerance such as the rainbow fish), reptiles (e.g. ornamental snake and snake-necked turtle), mammals (e.g. water rat) and birds (e.g. Black-winged Stilt)If the water becomes highly contaminated with NMD it could become toxic to all flora and fauna.	Major	Possible	Extreme	Nil	Nil	Stockpiles will be designed and situated to avoid interference with overland flows of surface water. Groundwater monitoring downstream of the stockpile will be undertaken.	Moderate	Unlikely	Moderate

Process/ Functional Area	Activity	Aspect/ Hazard	Scenario	Impact	Inherent Risk			Behavioural Controls	System Controls	Engineering Controls	Residual Risk		
					Consequence	Likelihood	Risk	People-based controls that rely on skills, knowledge and experience of individuals and groups.	Executed by individuals within the bounds of a management system.	Execute automatically and do not require human intervention.	Consequence	Likelihood	Risk
Mining: Production	Product stockpiles	Release - sediment	The stockpiling of product may cause sediment to be mobilised which could cause degradation of any adjacent aquatic habitat.	Increased turbidity and/or sedimentation of water courses may decrease their habitat value for fauna, particularly in the dry season when non-burrowing species are more restricted and at higher risk of disturbance. Taxa impacted directly may include macro-invertebrates (particularly more sensitive groups, e.g. EPT), and vertebrates that feed in / inhabit aquatic environments including frogs, fish, reptiles (e.g. ornamental snake and snake-necked turtle), mammals (e.g. water rat) and birds (e.g. Black-winged Stilt)	Major	Likely	Extreme	Nil	Appropriate erosion and sediment control measures implemented to prevent mobilisation of sediment into watercourses.	Run-off from all disturbed areas will pass through sediment dams, and bunds will be installed downstream of disturbance areas to prevent the release of sediment. Run-off from stockpiles will be captured, treated and re-used on site	Minor	Unlikely	Low

Process/ Functional Area	Activity	Aspect/ Hazard	Scenario	Impact	Inherent Risk			Behavioural Controls	System Controls	Engineering Controls	Residual Risk		
					Consequence	Likelihood	Risk	People-based controls that rely on skills, knowledge and experience of individuals and groups.	Executed by individuals within the bounds of a management system.	Execute automatically and do not require human intervention.	Consequence	Likelihood	Risk
Mining: Production	Pit dewatering	Modification – groundwater levels/flows	Pit de-watering activities may lead to a reduction in the volume or flow rate of the remaining groundwater, and/or the contamination of surface water with the groundwater removed from the pit itself.	Contamination of surface water with groundwater may increase the EC, TDS and/or sulphates present in the surface water, potentially minimising the habitat suitability of the water course for macro-invertebrates, amphibians and fish.	Major	Likely	Extreme	Nil	Management of dewatered groundwater in the mine water management system.	Dams are designed by a qualified engineer. DERM approves and licences the design prior to construction..	Moderate	Rare	Moderate

Process/ Functional Area	Activity	Aspect/ Hazard	Scenario	Impact	Inherent Risk			Behavioural Controls	System Controls	Engineering Controls	Residual Risk		
					Consequence	Likelihood	Risk	People-based controls that rely on skills, knowledge and experience of individuals and groups.	Executed by individuals within the bounds of a management system.	Execute automatically and do not require human intervention.	Consequence	Likelihood	Risk
Mining: Production	Pit excavation	Emissions - dust	Excavation activities may result in fugitive dust emissions which may impact upon surface water quality, riparian vegetation and consequently, habitat utilization by aquatic fauna.	Increased turbidity and/or sedimentation of water courses may decrease their habitat value for fauna, particularly in the dry season when non-burrowing species are more restricted and at higher risk of disturbance. Taxa impacted directly may include macro-invertebrates (particularly more sensitive groups, e.g. EPT), and vertebrates that feed in / inhabit aquatic environments including frogs, fish, reptiles (e.g. ornamental snake and snake-necked turtle), mammals (e.g. water rat) and birds (e.g. Black-winged Stilt)	Moderate	Possible	High	Nil	Dust suppression by water trucks on unsealed roads and disturbance areas.	Nil	Minor	Unlikely	Low

Process/ Functional Area	Activity	Aspect/ Hazard	Scenario	Impact	Inherent Risk			Behavioural Controls	System Controls	Engineering Controls	Residual Risk		
					Consequence	Likelihood	Risk	People-based controls that rely on skills, knowledge and experience of individuals and groups.	Executed by individuals within the bounds of a management system.	Execute automatically and do not require human intervention.	Consequence	Likelihood	Risk
Processing: Production	Crushing	Emission - dust	Crushing activities may result in fugitive dust emissions which may impact upon surface water quality, riparian vegetation and consequently, habitat utilization by aquatic fauna.	Increased turbidity and/or sedimentation of water courses may decrease their habitat value for fauna, particularly in the dry season when non-burrowing species are more restricted and at higher risk of disturbance. Taxa impacted directly may include macro-invertebrates (particularly more sensitive groups, e.g. EPT), and vertebrates that feed in / inhabit aquatic environments including frogs, fish, reptiles (e.g. ornamental snake and snake-necked turtle), mammals (e.g. water rat) and birds (e.g. Black-winged Stilt)	Moderate	Possible	High	Nil	Dust suppression by water trucks on unsealed roads and disturbance areas.	Run-off from all disturbed areas will pass through sediment dams.	Minor	Unlikely	Low

Process/ Functional Area	Activity	Aspect/ Hazard	Scenario	Impact	Inherent Risk			Behavioural Controls	System Controls	Engineering Controls	Residual Risk		
					Consequence	Likelihood	Risk	People-based controls that rely on skills, knowledge and experience of individuals and groups.	Executed by individuals within the bounds of a management system.	Execute automatically and do not require human intervention.	Consequence	Likelihood	Risk
Processing: Production	Crushing	Release - sediment	The crushing process may cause sediment to be mobilised which could cause degradation of any adjacent aquatic habitat.	Increased turbidity and/or sedimentation of water courses may decrease their habitat value for fauna, particularly in the dry season when non-burrowing species are more restricted and at higher risk of disturbance. Taxa impacted directly may include macro-invertebrates (particularly more sensitive groups, e.g. EPT), and vertebrates that feed in / inhabit aquatic environments including frogs, fish, reptiles (e.g. ornamental snake and snake-necked turtle), mammals (e.g. water rat) and birds (e.g. Black-winged Stilt)	Major	Likely	Extreme	Nil	Appropriate erosion and sediment control measures implemented to prevent mobilisation of sediment into watercourses.	Run-off from all disturbed areas will pass through sediment dams, and bunds will be installed downstream of disturbance areas to prevent the release of sediment.	Minor	Unlikely	Low

Process/ Functional Area	Activity	Aspect/ Hazard	Scenario	Impact	Inherent Risk			Behavioural Controls	System Controls	Engineering Controls	Residual Risk		
					Consequence	Likelihood	Risk	People-based controls that rely on skills, knowledge and experience of individuals and groups.	Executed by individuals within the bounds of a management system.	Execute automatically and do not require human intervention.	Consequence	Likelihood	Risk
Processing: Production	Fines disposal	Failure - structure	The fines dam could suffer a loss of structural integrity over the life of the structure, resulting in the release of fines material which could contaminate surface water and soils and impact upon aquatic ecosystems.	Contamination of surface water with fines material could increase the turbidity and sedimentation, impacting on riparian and aquatic vegetation and all in-stream fauna species.	Major	Unlikely	High	Nil	Referable dams are inspected annually by a qualified engineer; dam walls are maintained as per the qualified engineer's recommendations.	Dams are designed by a qualified engineer. DERM approves and licences the design prior to construction.	Major	Rare	High

Process/ Functional Area	Activity	Aspect/ Hazard	Scenario	Impact	Inherent Risk			Behavioural Controls	System Controls	Engineering Controls	Residual Risk		
					Consequence	Likelihood	Risk	People-based controls that rely on skills, knowledge and experience of individuals and groups.	Executed by individuals within the bounds of a management system.	Execute automatically and do not require human intervention.	Consequence	Likelihood	Risk
Processing: Production	Fines disposal	Release – contaminate water	Seepage and/or overflow from fines dam impacting on surface water quality. Impact on any fauna able to access the dam as a water resource.	Contamination of surface water with fines and excess sediment may decrease aquatic habitat value for fauna, particularly in the dry season when non-burrowing species are more restricted and at higher risk of disturbance. Taxa impacted directly may include macro-invertebrates (particularly more sensitive groups, e.g. EPT), and vertebrates that feed in / inhabit aquatic environments including frogs, fish, reptiles (e.g. ornamental snake and snake-necked turtle), mammals (e.g. water rat) and birds (e.g. Black-winged Stilt) Such an event would also impact upon any riparian flora and terrestrial fauna reliant on the water course for hydration.	Moderate	Unlikely	Moderate	Nil	Nil	Dams are designed by a qualified engineer with a 1:100 year ARI, and 3 month critical wet season storage capacity. DERM approves and licences the design prior to construction.	Minor	Unlikely	Low

Process/ Functional Area	Activity	Aspect/ Hazard	Scenario	Impact	Inherent Risk			Behavioural Controls	System Controls	Engineering Controls	Residual Risk		
					Consequence	Likelihood	Risk	People-based controls that rely on skills, knowledge and experience of individuals and groups.	Executed by individuals within the bounds of a management system.	Execute automatically and do not require human intervention.	Consequence	Likelihood	Risk
Processing: Production	Fines disposal	Generation - ARD	The creation of fines dam could result in the seepage of ARD from sulphide minerals contained within.	Increased acidity and heavy metals concentrations in water courses may decrease their habitat value for fauna, particularly in the dry season when non-burrowing species are more restricted and at higher risk of disturbance. Taxa impacted directly may include macro-invertebrates (particularly more sensitive groups, e.g. EPT), and vertebrates that feed in / inhabit aquatic environments including frogs, fish (especially for species with low acidity tolerance, such as the Glass Perch and Barred Grunter), reptiles (e.g. ornamental snake and snake-necked turtle), mammals (e.g. water rat) and birds (e.g. Black-winged Stilt). If the water becomes highly contaminated with ARD it could be toxic to all flora and fauna.	Minor	Possible	Moderate	Nil	Nil	Dams are designed by a qualified engineer. DERM approves and licences the design prior to construction.	Minor	Unlikely	Low

Process/ Functional Area	Activity	Aspect/ Hazard	Scenario	Impact	Inherent Risk			Behavioural Controls	System Controls	Engineering Controls	Residual Risk		
					Consequence	Likelihood	Risk	People-based controls that rely on skills, knowledge and experience of individuals and groups.	Executed by individuals within the bounds of a management system.	Execute automatically and do not require human intervention.	Consequence	Likelihood	Risk
Processing: Production	Fines disposal	Generation - NMD	The creation of fines dam could result in the generation of NMD from saline elements contained within.	Increased salinity of water courses may decrease their habitat value for fauna, particularly in the dry season when non-burrowing species are more restricted and at higher risk of disturbance. Taxa impacted directly may include macro-invertebrates (particularly more sensitive groups, e.g. EPT), and vertebrates that feed in / inhabit aquatic environments including frogs, fish (especially species with low salt tolerance, such as the rainbow fish), reptiles (e.g. ornamental snake and snake-necked turtle), mammals (e.g. water rat) and birds (e.g. Black-winged Stilt). If the water becomes highly contaminated with NMD it could become toxic to all flora and fauna.	Minor	Possible	Moderate	Nil	Nil	Dams are designed by a qualified engineer. DERM approves and licences the design prior to construction.	Minor	Unlikely	Low

Process/ Functional Area	Activity	Aspect/ Hazard	Scenario	Impact	Consequence	Likelihood	Risk	Behavioural Controls	System Controls	Engineering Controls	Consequence	Likelihood	Risk
					Inherent Risk			People-based controls that rely on skills, knowledge and experience of individuals and groups.	Executed by individuals within the bounds of a management system.	Execute automatically and do not require human intervention.	Residual Risk		
Processing: Production	Fines disposal	Modification - landform	The fines dam could suffer a loss of structural integrity over the life of the structure, resulting in the release of fines material which could modify local surface hydrology.	Contamination of surface water with fines and excess sediment would decrease aquatic habitat value for fauna, particularly in the dry season when non-burrowing species are more restricted and at higher risk of disturbance. Taxa impacted directly may include macro-invertebrates (particularly more sensitive groups, e.g. EPT), and vertebrates that feed in / inhabit aquatic environments including frogs, fish, reptiles (e.g. ornamental snake and snake-necked turtle), mammals (e.g. water rat) and birds (e.g. Black-winged Stilt). Such an event would also impact upon any riparian flora and terrestrial fauna reliant on the water course for hydration. .	Moderate	Unlikely	Moderate	Nil	Referable dams are inspected annually by a qualified engineer; dam walls are maintained as per the qualified engineer's recommendations.	Dams are designed by a qualified engineer. DERM approves and licences the design prior to construction.	Moderate	Rare	Moderate

Process/ Functional Area	Activity	Aspect/ Hazard	Scenario	Impact	Inherent Risk			Behavioural Controls	System Controls	Engineering Controls	Residual Risk		
					Consequence	Likelihood	Risk	People-based controls that rely on skills, knowledge and experience of individuals and groups.	Executed by individuals within the bounds of a management system.	Execute automatically and do not require human intervention.	Consequence	Likelihood	Risk
Processing: Production	Fines disposal	Spill - fines	Burst tailings lines could result in contamination of surface water and soil.	Contamination of surface water with excess sediment and/or other contaminants would decrease aquatic habitat value for fauna, particularly in the dry season when non-burrowing species are more restricted and at higher risk of disturbance. Taxa impacted directly may include macro-invertebrates (particularly more sensitive groups, e.g. EPT), and vertebrates that feed in / inhabit aquatic environments including frogs, fish, reptiles (e.g. ornamental snake and snake-necked turtle), mammals (e.g. water rat) and birds (e.g. Black-winged Stilt) Such an event would also impact upon any riparian flora and terrestrial fauna reliant on the water course for hydration.	Major	Likely	Extreme	Operators are trained in spill management and reporting procedures.	Tailings lines are inspected regularly.		Minor	Unlikely	Low

Process/ Functional Area	Activity	Aspect/ Hazard	Scenario	Impact	Inherent Risk			Behavioural Controls	System Controls	Engineering Controls	Residual Risk		
					Consequence	Likelihood	Risk	People-based controls that rely on skills, knowledge and experience of individuals and groups.	Executed by individuals within the bounds of a management system.	Execute automatically and do not require human intervention.	Consequence	Likelihood	Risk
Supply	Hydrocarbon storage	Spill – hazmat bulk	Bulk hydrocarbons will be used in the project and the potential exists for spills to occur during storage and refuelling.	Contamination of surface water with hydrocarbons would decrease aquatic habitat value for fauna, particularly in the dry season when non-burrowing species are more restricted and at higher risk of disturbance. Taxa impacted directly may include macro-invertebrates (particularly more sensitive groups, e.g. EPT), and vertebrates that feed in / inhabit aquatic environments including frogs, fish, reptiles (e.g. ornamental snake and snake-necked turtle), mammals (e.g. water rat) and birds (e.g. Black-winged Stilt) Such an event would also impact upon any flora and fauna reliant on the water course for hydration.	Moderate	Likely	High	Operators are trained in spill management and reporting procedures.	Spill cleanup kits are located throughout the site; staff are trained in the use of spill containment kits.	All hydrocarbons will be stored according to AS 1940.	Minor	Unlikely	Low

Process/ Functional Area	Activity	Aspect/ Hazard	Scenario	Impact	Inherent Risk			Behavioural Controls	System Controls	Engineering Controls	Residual Risk		
					Consequence	Likelihood	Risk	People-based controls that rely on skills, knowledge and experience of individuals and groups.	Executed by individuals within the bounds of a management system.	Execute automatically and do not require human intervention.	Consequence	Likelihood	Risk
Mining: Maintenance	Vehicle washdown	Release – contaminate water	The vehicle washdown facility could release contaminated water, resulting in surface water and soil contamination.	Contamination of surface water with excess sediment and / or chemical contaminants would decrease aquatic habitat value for fauna, particularly in the dry season when non-burrowing species are more restricted and at higher risk of disturbance. Taxa impacted directly may include macro-invertebrates (particularly more sensitive groups, e.g. EPT), and vertebrates that feed in / inhabit aquatic environments including frogs, fish, reptiles (e.g. ornamental snake and snake-necked turtle), mammals (e.g. water rat) and birds (e.g. Black-winged Stilt) Such an event would also impact upon any riparian flora and terrestrial fauna reliant on the water course for hydration.	Moderate	Likely	High	Nil	Nil	The runoff from the vehicle washdown facility flows into a sediment trap which is cleaned out regularly.	Minor	Unlikely	Low

Process/ Functional Area	Activity	Aspect/ Hazard	Scenario	Impact	Inherent Risk			Behavioural Controls	System Controls	Engineering Controls	Residual Risk		
					Consequence	Likelihood	Risk	People-based controls that rely on skills, knowledge and experience of individuals and groups.	Executed by individuals within the bounds of a management system.	Execute automatically and do not require human intervention.	Consequence	Likelihood	Risk
Village Services: Management	Disposal of food waste	Increase – feral animals	Disposal of waste may contribute to increased occurrence of feral animals and insects if the waste is not managed adequately.	Increases in the density of pest species such as mice, rats and feral pigs may cause competition and predation pressure on native species as well as habitat destruction, particularly in riparian areas.	Minor	Almost Certain	High		Landfill area is covered at least weekly.	The landfill site is fenced.	Minor	Unlikely	Low

Process/ Functional Area	Activity	Aspect/ Hazard	Scenario	Impact	Inherent Risk			Behavioural Controls	System Controls	Engineering Controls	Residual Risk		
					Consequence	Likelihood	Risk	People-based controls that rely on skills, knowledge and experience of individuals and groups.	Executed by individuals within the bounds of a management system.	Execute automatically and do not require human intervention.	Consequence	Likelihood	Risk
Village Services: Management	Disposal of food waste	Release – contaminated water	Leachate from landfill may contaminate surface and ground water resources.	Contamination of surface water with excess nutrients and/or contaminants etc has the potential to increase the dissolved organic compounds, potentially decreasing aquatic habitat value for fauna, particularly in the dry season when non-burrowing species are more restricted and at higher risk of disturbance. Taxa impacted directly may include macro-invertebrates (particularly more sensitive groups, e.g. EPT), and vertebrates that feed in / inhabit aquatic environments including frogs, fish, reptiles (e.g. ornamental snake and snake-necked turtle), mammals (e.g. water rat) and birds (e.g. Black-winged Stilt).	Minor	Rare	Low	Nil	Landfill area is covered at least weekly.	The landfill design incorporates a low permeability base.	Minor	Rare	Low

Process/ Functional Area	Activity	Aspect/ Hazard	Scenario	Impact	Inherent Risk			Behavioural Controls	System Controls	Engineering Controls	Residual Risk		
					Consequence	Likelihood	Risk	People-based controls that rely on skills, knowledge and experience of individuals and groups.	Executed by individuals within the bounds of a management system.	Execute automatically and do not require human intervention.	Consequence	Likelihood	Risk
Village Services: Management	Sewage treatment	Release – contaminated water	The camp requires the operation of a sewage treatment plant. The STP may overflow resulting in the contamination of soil and water.	Contamination of surface water with sewage has the potential to increase the faecal coliforms, *E. coli*, and pH of the water and decrease the EC, potentially decreasing aquatic habitat value for fauna, particularly in the dry season when non-burrowing species are more restricted and at higher risk of disturbance. Taxa impacted directly may include macro-invertebrates (particularly more sensitive groups, e.g. EPT), and vertebrates that feed in / inhabit aquatic environments including frogs, fish, reptiles (e.g. ornamental snake and snake-necked turtle), mammals (e.g. water rat) and birds (e.g. Black-winged Stilt)	Moderate	Likely	High	Nil	The STP will be operated in accordance with the manufacturer's instructions.	The STP will be designed to match the camp's maximum requirements.	Minor	Unlikely	Low

Process/ Functional Area	Activity	Aspect/ Hazard	Scenario	Impact	Inherent Risk			Behavioural Controls	System Controls	Engineering Controls	Residual Risk		
					Consequence	Likelihood	Risk	People-based controls that rely on skills, knowledge and experience of individuals and groups.	Executed by individuals within the bounds of a management system.	Execute automatically and do not require human intervention.	Consequence	Likelihood	Risk
Vehicular transportation	Transport of personnel, product or resources by vehicle.	Collision with wildlife	The use of vehicles within the Project Area could result in animal strikes, particularly at creek crossings.	Death of aquatic bird species, amphibians and mammals utilizing the riparian corridors.	Low	Likely	Moderate	Nil	Drive to speed limits and conditions. Fatigue Management Policies are in place, and lighting systems on vehicles are well maintained.	Nil	Low	Possible	Low

Process/ Functional Area	Activity	Aspect/ Hazard	Scenario	Impact	Inherent Risk			Behavioural Controls	System Controls	Engineering Controls	Residual Risk		
					Consequence	Likelihood	Risk	People-based controls that rely on skills, knowledge and experience of individuals and groups.	Executed by individuals within the bounds of a management system.	Execute automatically and do not require human intervention.	Consequence	Likelihood	Risk
Vehicular transportation	Transport of personnel, product or resources by vehicle.	Emissions - dust	The use of vehicles within the Project Area could result in the production of fugitive dust emissions.	Increased turbidity and/or sedimentation of water courses may decrease their habitat value for fauna, particularly in the dry season when non-burrowing species are more restricted and at higher risk of disturbance. Taxa impacted directly may include macro-invertebrates (particularly more sensitive groups, e.g. EPT), and vertebrates that feed in / inhabit aquatic environments including frogs, fish, reptiles (e.g. ornamental snake and snake-necked turtle), mammals (e.g. water rat) and birds (e.g. Black-winged Stilt)	Moderate	Possible	High	Nil	Dust suppression by water trucks on unsealed roads and disturbance areas.		Minor	Unlikely	Low

Process/ Functional Area	Activity	Aspect/ Hazard	Scenario	Impact	Inherent Risk			Behavioural Controls	System Controls	Engineering Controls	Residual Risk		
					Consequence	Likelihood	Risk	People-based controls that rely on skills, knowledge and experience of individuals and groups.	Executed by individuals within the bounds of a management system.	Execute automatically and do not require human intervention.	Consequence	Likelihood	Risk
Decommissioning	Final void	Evapo-concentration	The creation of a final void could result in the concentration of salts in solution through the evaporation of water. This saline water could contaminate groundwater resources.	–The contamination of groundwater with saline water from the final void may potentially increase the salinity of surface water and decrease aquatic habitat value for fauna, particularly in the dry season when non-burrowing species are more restricted and at higher risk of disturbance. Taxa impacted directly may include macro-invertebrates (particularly more sensitive groups, e.g. EPT), and vertebrates that feed in / inhabit aquatic environments including frogs, fish (especially species with low salt tolerance, e.g. rainbow fish), reptiles (e.g. ornamental snake and snake-necked turtle), mammals (e.g. water rat) and birds (e.g. Black-winged Stilt)	Moderate	Possible	High	Nil	The EIS will identify the likelihood of salt accumulation in the final void. The project will be provided with an EA which will outline monitoring and management of any salinity issues.	The design of the final void will be approved by the relevant regulatory authority.	Moderate	Rare	Moderate

Process/ Functional Area	Activity	Aspect/ Hazard	Scenario	Impact	Inherent Risk			Behavioural Controls	System Controls	Engineering Controls	Residual Risk		
					Consequence	Likelihood	Risk	People-based controls that rely on skills, knowledge and experience of individuals and groups.	Executed by individuals within the bounds of a management system.	Execute automatically and do not require human intervention.	Consequence	Likelihood	Risk
Decommissioning	Final void	Generation - ARD	The creation of a final void could result in the generation of ARD from sulphide minerals present in the void wall and floor.	A change in the pH of the groundwater could impact all groundwater dependent communities in the immediate area, causing potential loss of riparian vegetation and aquatic habitat.	Major	Possible	Extreme	Nil	The EIS will identify the likelihood of ARD generation from the final void. The project will be provided with an EA which outlines the monitoring of any ARD issues.	Catchment of pit is limited by bunding and diversions to prevent the release of pit water.	Major	Rare	High

Process/ Functional Area	Activity	Aspect/ Hazard	Scenario	Impact	Inherent Risk			Behavioural Controls	System Controls	Engineering Controls	Residual Risk		
					Consequence	Likelihood	Risk	People-based controls that rely on skills, knowledge and experience of individuals and groups.	Executed by individuals within the bounds of a management system.	Execute automatically and do not require human intervention.	Consequence	Likelihood	Risk
Decommissioning	Final void	Generation - NMD	The creation of a final void could result in the generation of NMD from saline elements present in the void wall and floor.	Increased salinity of water courses may decrease their habitat value for fauna, particularly in the dry season when non-burrowing species are more restricted and at higher risk of disturbance. Taxa impacted directly may include macro-invertebrates (particularly more sensitive groups, e.g. EPT), and vertebrates that feed in / inhabit aquatic environments including frogs, fish, reptiles (e.g. ornamental snake and snake-necked turtle), mammals (e.g. water rat) and birds (e.g. Black-winged Stilt). If the water becomes highly contaminated with NMD it could become toxic to all flora and fauna.	Major	Possible	Extreme	Nil	The EIS will identify the likelihood of NMD generation from the final void. The project will be provided with an EA which outlines the monitoring of any NMD issues.	Catchment of pit is limited by bunding and diversions to prevent the release of pit water.	Major	Rare	High

Process/ Functional Area	Activity	Aspect/ Hazard	Scenario	Impact	Inherent Risk			Behavioural Controls	System Controls	Engineering Controls	Residual Risk		
					Consequence	Likelihood	Risk	People-based controls that rely on skills, knowledge and experience of individuals and groups.	Executed by individuals within the bounds of a management system.	Execute automatically and do not require human intervention.	Consequence	Likelihood	Risk
Decommissioning	Rehabilitation	Increase – weed species	Rehabilitation of the site is required following mining. An increase in the occurrence of weeds is possible until the native species become established.	An increase of weeds on the Project Site has the potential to result in heavy infestations of water courses, competing with native riparian flora species and potentially reducing available habitat for native fauna.	Moderate	Likely	High	Nil	Rehabilitation of disturbed areas will be completed as soon as possible after the land becomes available. Chemical herbicides and mechanical control measures will be used for severe weed outbreaks during the maintenance phase of the rehabilitation works.	Nil	Moderate	Unlikely	Moderate

Process/ Functional Area	Activity	Aspect/ Hazard	Scenario	Impact	Inherent Risk			Behavioural Controls	System Controls	Engineering Controls	Residual Risk		
					Consequence	Likelihood	Risk	People-based controls that rely on skills, knowledge and experience of individuals and groups.	Executed by individuals within the bounds of a management system.	Execute automatically and do not require human intervention.	Consequence	Likelihood	Risk
Decommissioning	Rehabilitation	Release - sediment	The rehabilitation of the site may cause sediment to be mobilised which could cause degradation of any adjacent aquatic habitat.	Increased turbidity and/or sedimentation of water courses may decrease their habitat value for fauna, particularly in the dry season when non-burrowing species are more restricted and at higher risk of disturbance. Taxa impacted directly may include macro-invertebrates (particularly more sensitive groups, e.g. EPT), and vertebrates that feed in / inhabit aquatic environments including frogs, fish, reptiles (e.g. ornamental snake and snake-necked turtle), mammals (e.g. water rat) and birds (e.g. Black-winged Stilt)	Major	Likely	Extreme	Nil	Nil	Run-off from all disturbed areas will pass through sediment dams, and bunds will be installed downstream of disturbance areas to prevent the release of sediment.	Minor	Unlikely	Low

Process/ Functional Area	Activity	Aspect/ Hazard	Scenario	Impact	Inherent Risk			Behavioural Controls	System Controls	Engineering Controls	Residual Risk		
					Consequence	Likelihood	Risk	People-based controls that rely on skills, knowledge and experience of individuals and groups.	Executed by individuals within the bounds of a management system.	Execute automatically and do not require human intervention.	Consequence	Likelihood	Risk
Decommissioning	Waste rock dumps	Generation of ARD	The creation of waste rock dumps could result in the generation of ARD from sulphide minerals present within.	Increased acidity and heavy metals concentrations of watercourses as a result of ARD leaching from waste rock dumps, may decrease their habitat value for fauna, particularly in the dry season when non-burrowing species are more restricted and at higher risk of disturbance. Taxa impacted directly may include macro-invertebrates (particularly more sensitive groups, e.g. EPT), and vertebrates that feed in / inhabit aquatic environments including frogs, fish (especially species with low acidity tolerance, such as the Glass Perch and Barred Grunter), reptiles (e.g. ornamental snake and snake-necked turtle), mammals (e.g. water rat) and birds (e.g. Black-winged Stilt). If the water becomes highly contaminated with ARD it could be toxic to all flora and fauna.	Major	Possible	Extreme	Nil	Nil	The waste rock dumps are designed by a registered engineer. Design and construction of store and release type cover and seepage interception trenches incorporated.	Moderate	Unlikely	Moderate

7.3 POTENTIAL RISK TO FLORA AND FAUNA

Table 19 identifies a total of 14 processes that carry a Moderate or High residual risk of impacting upon native flora and fauna of the Project Site. Each of these processes is discussed further in Table 19 below, along with recommended mitigation strategies for minimising the impact of these activities on those taxa considered to be most at risk.

Table 19 Potential Significant Risks to Flora and Fauna

Activity	Aspect/ Hazard	Residual Risk	Flora and Fauna at Risk	Potential Impacts	Recommended Mitigation Measures
Bulk hydrocarbon storage, field refuelling	Spill – hazmat bulk (e.g. significant oil spillage increasing toxicity, decreasing dissolved oxygen concentration, restriction of respiratory function of in-stream fauna and depletion of water resources)	Moderate	Riparian vegetation communities (e.g. River Red Gum communities), macro-invertebrates, amphibians, fish, reptiles (e.g. Eastern snake-necked turtle), mammals (e.g. Water rat), aquatic birds (e.g. Black-winged stilt).	Reduction in density and diversity of macro-invertebrates; amphibians and fish. Loss of prey resources for macro-invertebrates, amphibians, fish, reptiles, mammals, and aquatic birds. Contamination of water resources for riparian flora, terrestrial and aquatic mammals and birds.	Operators are trained in spill management and reporting procedures. Spill cleanup kits are located throughout the site and staff are trained in the use of spill containment kits. All hydrocarbons will be stored according to AS 1940.
Bulk earthworks and mine development	Modification – creek diversions (resulting in increased turbidity and sedimentation of watercourses, restriction of movement of in-stream fauna and removal of riparian vegetation).	High	Riparian vegetation communities (e.g. River Red Gum communities), macro-invertebrates, amphibians, fish, and reptiles (e.g. Eastern snake-necked turtle).	Reduction in density and diversity of macro-invertebrates; amphibians and fish. Localised loss of prey resources for macro-invertebrates, amphibians, fish, reptiles, mammals, and aquatic birds. Down-stream movement of in-stream fauna may be hindered, resulting in changes to breeding and migration patterns, causing a net loss of density and	Appropriate erosion and sediment control measures implemented to prevent mobilisation of sediment downstream. Rehabilitation of modified section of the creeks implemented as soon as possible, and designed to replicate the pre-existing ecosystem. The creek diversion designed to withstand projected flood events, provide suitable habitat for riparian flora and aquatic fauna and allow for the movement of in-stream fauna.

Activity	Aspect/ Hazard	Residual Risk	Flora and Fauna at Risk	Potential Impacts	Recommended Mitigation Measures
				diversity over time.	
Dump construction	Generation – ARD (contamination of surface water with ARD may result in increased acidity, and potentially increased toxicity, of water resources)	Moderate	Riparian vegetation communities (e.g. River Red Gum communities), macro-invertebrates, amphibians, fish, reptiles (e.g. Eastern snake-necked turtle), mammals (e.g. Water rat), aquatic birds (e.g. Black-winged stilt).	Reduction in density and diversity of macro-invertebrates; amphibians and fish. Loss of prey resources for macro-invertebrates, amphibians, fish, reptiles, mammals, and aquatic birds. Contamination of water resources for riparian flora, terrestrial and aquatic mammals and birds.	Rock dumps to be situated to avoid interference with overland flows of surface water. Groundwater monitoring downstream of the rock dumps to be undertaken. Run-off and seepage interception and divert and retention structures to be utilised.
Dump construction	Generation – NMD (contamination of surface water with NMD may cause increased salinity and potentially increased toxicity of water resources)	Moderate	Riparian vegetation communities (e.g. River Red Gum communities), macro-invertebrates, amphibians, fish, reptiles (e.g. Eastern snake-necked turtle), mammals (e.g. Water rat), aquatic birds (e.g. Black-winged stilt).	Reduction in density and diversity of macro-invertebrates; amphibians and fish. Loss of prey resources for macro-invertebrates, amphibians, fish, reptiles, mammals, and aquatic birds. Contamination of water resources for riparian flora, terrestrial and aquatic mammals and birds.	Rock dumps to be situated to avoid interference with overland flows of surface water. Groundwater monitoring downstream of the rock dumps to be undertaken. Run-off and seepage interception and divert and retention structures to be utilised.
Product stockpiles	Generation – ARD (contamination of surface water with ARD may result in increased acidity, and potentially	Moderate	Riparian vegetation communities (e.g. River Red Gum communities), macro-invertebrates, amphibians, fish, reptiles (e.g. Eastern snake-	Reduction in density and diversity of macro-invertebrates; amphibians and fish. Loss of prey resources for macro-invertebrates, amphibians, fish,	Stockpiles to be situated to avoid interference with overland flows of surface water. Groundwater monitoring downstream of the stockpiles to be undertaken. Run-off

Activity	Aspect/ Hazard	Residual Risk	Flora and Fauna at Risk	Potential Impacts	Recommended Mitigation Measures
	increased toxicity, of water resources)		necked turtle), mammals (e.g. Water rat), aquatic birds (e.g. Black-winged stilt).	reptiles, mammals, and aquatic birds. Contamination of water resources for riparian flora, terrestrial and aquatic mammals and birds.	and seepage interception and divert and retention structures to be utilised.
Product stockpiles	Generation – NMD (contamination of surface water with NMD may cause increased salinity and potentially increased toxicity of water resources)	Moderate	Riparian vegetation communities (e.g. River Red Gum communities), macro-invertebrates, amphibians, fish, reptiles (e.g. Eastern snake-necked turtle), mammals (e.g. Water rat), aquatic birds (e.g. Black-winged stilt).	Reduction in density and diversity of macro-invertebrates; amphibians and fish. Loss of prey resources for macro-invertebrates, amphibians, fish, reptiles, mammals, and aquatic birds. Contamination of water resources for riparian flora, terrestrial and aquatic mammals and birds.	Product stockpiles to be situated to avoid interference with overland flows of surface water. Groundwater monitoring downstream of the rock dumps to be undertaken. Run-off and seepage interception and divert and retention structures to be utilised.
Pit dewatering	Contamination of surface water with groundwater removed from the pit, potentially resulting in an increase in EC, TDS and/or sulphates within water courses.	Moderate	Riparian vegetation communities (e.g. River Red Gum communities), macro-invertebrates, amphibians, fish, reptiles (e.g. Eastern snake-necked turtle), mammals (e.g. Water rat), aquatic birds (e.g. Black-winged stilt).	Reduction in density and diversity of macro-invertebrates; amphibians and fish. Loss of prey resources for macro-invertebrates, amphibians, fish, reptiles, mammals, and aquatic birds. Contamination of water resources for riparian flora, terrestrial and aquatic mammals and birds.	Dams to be designed by a qualified engineer. DERM to approve and licence the design prior to construction.
Fines disposal	Failure – structure (resulting in	High	Riparian vegetation communities (e.g.	Reduction in density and diversity of macro-	Dams to be designed by a qualified engineer. DERM to

Activity	Aspect/ Hazard	Residual Risk	Flora and Fauna at Risk	Potential Impacts	Recommended Mitigation Measures
	contamination of water resources with fines material, causing an increase in turbidity and a decrease in dissolved oxygen).		River Red Gum communities), macro-invertebrates, amphibians, fish, reptiles (e.g. Eastern snake-necked turtle), mammals (e.g. Water rat), aquatic birds (e.g. Black-winged stilt).	invertebrates; amphibians and fish. Loss of prey resources for macro-invertebrates, amphibians, fish, reptiles, mammals, and aquatic birds. Contamination of water resources for riparian flora, terrestrial and aquatic mammals and birds.	approve and licence the design prior to construction.
Fines disposal	Modification – landform (the construction of fines dams may modify overland water flows and introduce contaminants to surface water resources)	Moderate	Riparian vegetation communities (e.g. River Red Gum communities), macro-invertebrates, amphibians, fish, reptiles (e.g. Eastern snake-necked turtle), mammals (e.g. Water rat), aquatic birds (e.g. Black-winged stilt).	Reduction in density and diversity of macro-invertebrates; amphibians and fish. Loss of prey resources for macro-invertebrates, amphibians, fish, reptiles, mammals, and aquatic birds. Contamination of water resources for riparian flora, terrestrial and aquatic mammals and birds.	Dams to be designed by a qualified engineer. DERM to approve and licence the design prior to construction.
Final void	Evapo-concentration (resulting in an increase in salinity of water in the final void. Contamination of surface water resources with this water may result in a subsequent increase in	Moderate	Riparian vegetation communities (e.g. River Red Gum communities), macro-invertebrates, amphibians, fish, reptiles (e.g. Eastern snake-necked turtle), mammals (e.g. Water rat), aquatic birds (e.g. Black-winged stilt).	Reduction in density and diversity of macro-invertebrates; amphibians and fish. Loss of prey resources for macro-invertebrates, amphibians, fish, reptiles, mammals, and aquatic birds. Contamination of water resources for riparian flora, terrestrial and	The design of the final void to be approved by the relevant regulatory authority.

Activity	Aspect/ Hazard	Residual Risk	Flora and Fauna at Risk	Potential Impacts	Recommended Mitigation Measures
	salinity of surface water)			aquatic mammals and birds.	
Final void	Generation – ARD (contamination of surface water with ARD may result in increased acidity, and potentially increased toxicity, of water resources)	High	Riparian vegetation communities (e.g. River Red Gum communities), macro-invertebrates, amphibians, fish, reptiles (e.g. Eastern snake-necked turtle), mammals (e.g. Water rat), aquatic birds (e.g. Black-winged stilt).	Reduction in density and diversity of macro-invertebrates; amphibians and fish. Loss of prey resources for macro-invertebrates, amphibians, fish, reptiles, mammals, and aquatic birds. Contamination of water resources for riparian flora, terrestrial and aquatic mammals and birds.	The design of the final void to be approved by the relevant regulatory authority.
Final void	Generation – NMD (contamination of surface water with NMD may cause increased salinity and potentially increased toxicity of water resources)	High	Riparian vegetation communities (e.g. River Red Gum communities), macro-invertebrates, amphibians, fish, reptiles (e.g. Eastern snake-necked turtle), mammals (e.g. Water rat), aquatic birds (e.g. Black-winged stilt).	Reduction in density and diversity of macro-invertebrates; amphibians and fish. Loss of prey resources for macro-invertebrates, amphibians, fish, reptiles, mammals, and aquatic birds. Contamination of water resources for riparian flora, terrestrial and aquatic mammals and birds.	Rock dumps to be situated to avoid interference with overland flows of surface water. Groundwater monitoring downstream of the rock dumps to be undertaken. Run-off and seepage interception and divert and retention structures to be utilised.
Rehabilitation	Increase – weed species	Moderate	Riparian vegetation communities (e.g. River Red gum communities), native taxa reliant on riparian vegetation (e.g.	Reduction in density, diversity and extent of native vegetation communities, particularly riparian communities, and native taxa reliant	Rehabilitation of disturbed areas to be completed as soon as possible after the land becomes available. Chemical and mechanical control measures to be used

Activity	Aspect/ Hazard	Residual Risk	Flora and Fauna at Risk	Potential Impacts	Recommended Mitigation Measures
			amphibians, mammals and aquatic birds).	on such communities for habitat (e.g. water rat, broad-palmed frog)	for severe weed infestations during maintenance phase of the rehabilitation works.
Waste rock dumps	Generation – ARD (contamination of surface water with ARD may result in increased acidity, and potentially increased toxicity, of water resources)	High	Riparian vegetation communities (e.g. River Red Gum communities), macro-invertebrates, amphibians, fish, reptiles (e.g. Eastern snake-necked turtle), mammals (e.g. Water rat), aquatic birds (e.g. Black-winged stilt).	Reduction in density and diversity of macro-invertebrates; amphibians and fish. Loss of prey resources for macro-invertebrates, amphibians, fish, reptiles, mammals, and aquatic birds. Contamination of water resources for riparian flora, terrestrial and aquatic mammals and birds.	Rock dumps to be situated to avoid interference with overland flows of surface water. Groundwater monitoring downstream of the rock dumps to be undertaken. Run-off and seepage interception and divert and retention structures to be utilised.

8.0 CONCLUSIONS, POTENTIAL IMPACTS, AND MITIGATION STRATEGIES

8.1 CONCLUSIONS

The following conclusions have been developed for this assessment:

- The Project site contains drainage lines and creeks of a range of orders, as classified by Conrick and Cockayne (2001). Pastoral dams, lacustrine wetlands, and palustrine wetlands were also present within the Project site;

- The majority of the drainage lines held little to no water during any of the surveys, despite recent rainfall events. This ephemerality is common in the region;

- The results from the baseline surveying of water quality on and surrounding the Project site show that water exceeds trigger values provided in the ANZECC (2000) Aquatic Ecosystems Guidelines at one or more sites for pH, EC, Total Nitrogen, Total Phosphorous, Nitrate, Sulphate, Turbidity, Aluminium, Arsenic, Cadmium, Chromium, Copper, Lead, Manganese, Selenium, Zinc, and Nickel. Further, Aluminium, Selenium, Copper, Chromium and Uranium levels exceeded the proposed trigger values provided in the ANZECC (2000) Livestock Drinking Water Guidelines;

- A total of five amphibian species (one introduced), 25 birds (13 of which are listed under the EPBC Act as Migratory and / or Marine), two mammals (one introduced), two reptiles and eight fish species were identified during the surveys;

- The Feral Pig, identified within riparian habitat, is listed as a Class 2 pest under the LP Act. AARC Terrestrial Flora and Fauna surveys have also identified the european rabbit (Class 2), and the house mouse (introduced, but not declared under the LP Act);

- Two Class 2 declared weed species under the LP Act were identified within riparian habitats (Velvety Tree Pear and Parkinsonia). Further, several weed species not declared were identified, with Noogoora Burr being seen at many sites;

- No Rare or Threatened animal or plant species were identified during the aquatic ecology assessment. Many of the creeks are fringed by Regional Ecosystem 10.3.14 (*Eucalyptus camaldulensis* woodland), which has an Of Concern DERM Biodiversity Status, due to weed infestation by species including Parkinsonia, and habitat degradation;

- During the June 2008 terrestrial flora and fauna AARC survey, the Little Pied Bat was recorded within riparian habitat, which is listed as Rare under the NC Act;

- SIGNAL scoring showed no sites fell within the “pristine” category of Quadrant 1. Sites within Quadrant 2 included AQ03, AQ05, AQ06, AQ23, AQ28, AQ29, AQ37 and AQ39. All other sites fell within Quadrant 4, likely as a result of numerous factors including sub-optimal timing in regards to recent flooding (March 2009), and disturbances by cattle grazing; and

- Habitat assessments showed all sites assessed fell within the ‘moderate’ to ‘good’ category, whilst AQ06 was close to the ‘pristine/favourable’ category. The low scores are due to high erosion potential, lack of stable in-stream habitat and / or limited riparian vegetation.

- Aquatic flora and fauna are most at risk from ARD, NMD and increased sedimentation of watercourses. The vegetation community most likely to be impacted by the Project are the River Red Gum riparian woodlands known to occur throughout the site. The fauna groups considered to be most at risk include macro-invertebrates, amphibians and fish (in particular those with limited tolerance to changes in salinity and pH, such as the Rainbow Fish and the Purple-Spotted Gudgeon).

8.2 POTENTIAL IMPACTS

The following potential impacts on nature conservation values may occur from the Project:

- Land clearing and mining activities may reduce the available habitat for native species of flora and fauna on the Project site;
- Clearing within riparian zones may lead to a loss of habitat connectivity across the mine, and habitat fragmentation;
- Clearing of large trees within the riparian zone may impact on the Little Pied Bat, which roosts in tree hollows near water;
- Noise, vibration and dust associated with the construction and operational phases of the Project may mean some species stay clear of areas they currently utilise;
- Earthworks may results in potential weed invasion particularly along watercourses;
- Earthworks may result in increased sedimentation in riparian woodlands downstream of the mine. Higher levels of erosion can lead to a loss of morphological diversity in streams. This in turn reduces habitat quality and may result in biodiversity losses in affected areas;
- Human occupation in an area will often facilitate the increase in feral animal numbers (e.g. exposed landfill sites providing food for Feral Pigs, Feral Cats, etc). An increase in feral animal numbers may impact on the native animals, leading to a decrease in their population sizes;
- Potential spills of chemicals and hydrocarbons may enter waterways, resulting in environmental harm; and
- The proposed diversions of Lagoon Creek and Sandy Creek may result in some impacts on the environmental values of the aquatic flora and fauna:
  - Clearing of riparian vegetation may result in erosion and sedimentation-related impacts, especially in the early years after the diversion, prior to re-establishment of foliage;
  - Clearing of riparian vegetation may result in fragmentation of a valuable wildlife corridor, which, while not a major issue for mobile species (birds, bats), can be detrimental for the smaller terrestrial species; and
  - Works occurring in the creek during and immediately following periods of flow may impede fish movements.

8.3 MITIGATION STRATEGIES

Suggested strategies to minimise the impacts on native flora and fauna, and recommendations regarding rehabilitation of the Project site, are outlined below.

8.3.1 General Flora and Fauna Management Strategies

The following general flora and fauna management strategies are recommended for this Project:

- Although the riparian and in-stream vegetation within the Project site is well-represented in the wider region, in recognition of the intrinsic value of ecological habitat, every effort should be made to keep proposed disturbance areas to a minimum, and disturbances should be stabilised immediately on completion of work. A 50m buffer zone should be implemented around the Of Concern Regional Ecosystem;

- To maintain the integrity of vegetated land that is not cleared, appropriate erosion and sediment controls are recommended to prevent sediment deposition in remaining habitat;

- Habitat clearing should be conducted only after:

  – the areas to be cleared have been clearly checked for wildlife, delineated and identified to equipment operators and supervisors; and

  – appropriate erosion and sediment control structures are in place.

- Infrastructure planning should avoid the creation of permanent, shallow water areas, such as septic and other tank overflows that form a permanent seep. These areas attract biting insects such as mosquitoes that can be disease vectors, and Cane Toads that are lethal to most snakes and other fauna species when ingested;

- Measures should be taken to minimise harm to affected fauna communities by inspecting the vegetation to be disturbed prior to clearing to ascertain whether any fauna are present. If fauna is present, it should be given the opportunity to move on naturally before clearing occurs;

- A segment of the Staff Induction Program should be allocated to informing staff of the conservation values on the Project site and surrounding areas to increase staff awareness of the species present. This could include photographs, brief descriptions and management requirements of native species;

- A Pest Management Plan should be developed, to monitor the presence of, and success of control strategies for pest plant and animal species within the Project site; and

- A rehabilitation strategy should be developed for the Project site. This strategy should embody the concepts and recommendations presented above and include provision for monitoring of rehabilitation progress over the life of the operation. The establishment of hollow-bearing tree species in riparian habitats should be included in the rehabilitation strategy.

8.4 MANAGEMENT OF PEST FLORA AND FAUNA

8.4.1 Weed Management Strategies

Two plant species declared under the LP Act were recorded in riparian areas during the survey:

1. Velvety Tree Pear (*Opuntia tomentosa*)
2. Parkinsonia (*Parkinsonia aculeata*)

Both are listed as Class 2 pest plants. Class 2 plants are those that are established in Queensland and have or could have an adverse economic, environmental or social impact. Landowners are expected to take reasonable steps to keep land free from Class 2 pests. Although not recorded during the survey, Parthenium (*Parthenium hysterophorus*) and Lantana (*Lantana camara*) are understood to have a presence on the Project site. Measures to control the spread of these weeds including vehicle washdowns should be adopted across the Project.

It is recommended that a Pest Management Plan be developed to limit the spread of these species on the Project site. Staff should be informed of the species of weed likely to be encountered on the Project site, the location of known weed infestations (particularly *Parthenium*), and how to report the presence of new infestations.

Pest fact sheets for all declared weed species observed on the Project site are provided in Appendix E.

8.4.2 Pest Fauna Management Strategies

Four introduced pest fauna species were recorded during site surveys:

1. Feral Pig (*Sus scrofa*);
2. European Rabbit (*Oryctolagus cuniculus*);
3. House Mouse (*Mus musculus*); and
4. Cane Toad (*Rhinella marina*).

The Feral Pig and European Rabbit are listed as Class 2 pests under the LP Act. Class 2 pests are those that are established in Queensland and have or could have an adverse economic, environmental or social impact. Landowners are expected to take reasonable steps to keep land free from Class 2 pests. Control strategies should be in-line with the local shire council pest control strategies, and the strategies suggested within the Pest Fact Sheets in Appendix E.

The Cane Toad and House Mouse are both non-declared under the LP Act, meaning that there is no legislative need for their control within the Project site. However, it is recommended that the activities within the Project site should not facilitate any increase in the population numbers of non-declared animals.

8.5 MANAGEMENT OF WATER QUALITY

It is recommended that water quality continue to be monitored both prior to any Project activities occurring, throughout the life of the Project, and throughout decommissioning and rehabilitation of the Project. As background water quality exceeds parameters provided in the ANZECC Guidelines, it is necessary to set site-specific water quality targets.

The Sampling Program for surface water, ground water and sediment, including setting site-specific trigger and target values, will be developed according to the conditions agreed as part of the EA negotiations.

Should the ongoing water quality monitoring program detect concentrations downstream of Project activities higher than the trigger or limit values derived from the site-specific data, then an investigation into the likely causes should be initiated. The results of the investigation and mitigation strategies, if necessary, should be reported to DERM.

8.6 CREEK DIVERSION RECOMMENDATIONS

The creek diversion should ideally mimic the natural materials and geometry of Lagoon Creek. The Australian Coal Association Research Program (ACARP) has conducted research into 'Design and Rehabilitation Criteria for Bowen Basin River Diversions' (Earth Tech, 2002) and the Department of Natural Resources and Mines have created the *Central West Water Management and Use Regional Guideline: Watercourse Diversions – Central Queensland Mining Industry* (undated). It is recommended that these be referred to for improved environmental performance of the Lagoon Creek diversion.

If possible, clearing of riparian vegetation for the proposed creek diversion should be conducted in a staged manner, to allow fauna to migrate to adjacent habitat areas.

If possible, works to divert Lagoon Creek should be conducted during the dry season when minimal (if any) water is present, so as to reduce impacts to fish movements.

The creek diversion rehabilitation should be monitored to ensure the vegetation is stable and self-sustaining.

8.7 RECOMMENDED MONITORING PROGRAM

It is recommended that reference sites be established upstream, downstream, and midstream of the Project site. Upstream and downstream monitoring will allow for natural variations in water quality, sediment quality, and topography, to be accounted for. These sites will enable background data to be collected, which may be used to set Environmental Authority limits.

8.7.1 Water Quality

Water quality analysis results are recommended to be compiled into an Environmental Monitoring database. Reference data using indicators such as water quality parameters outlined in the ANZECC (2000) Guidelines will allow the environmental values outlined in the *Environmental Protection (Water) Policy 1997* to be identified and protected. Once sufficient data is available, the data should be reassessed, and trigger levels for the Environmental Authority set as per the Queensland Water Quality Guidelines (2006), where site-specific contaminant limits are necessary.

8.7.2 Fauna Monitoring

It is recommended that a bi-annual monitoring program be established (pre- and post-wet season) at each reference site, to identify vertebrate and invertebrate fauna. This will allow detection and subsequent investigation into any disappearance (or appearance) of notable species within the creek systems of the Project site. Particular attention should be paid to the Lagoon Creek diversion area, to ensure pre-diversion habitat values and faunal components persist.

SIGNAL bi-plots of the macro-invertebrates will allow for the detection of upstream and downstream changes in macro-invertebrate communities, and analysing subsequent bi-plots will allow fluctuations caused by seasonality to be determined. This will allow differentiation between potential water quality changes and seasonality.

9.0 REFERENCES

Allen GR, Midgley SH and Allen M (2003). *Field Guide to the Freshwater Fishes of Australia*. CSIRO Publishing, Victoria.

Australian and New Zealand Environment and Conservation Council (2000) *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*. Australian and New Zealand Environment and Conservation Council, Agriculture and Resource Management Council of Australia and New Zealand.

Australian and New Zealand Standard ISO 31000:2009, *Risk Management – Principles and Guidelines*. Standards Australia (Sydney) and Standards New Zealand (Wellington), 16 October 2009.

Australian and New Zealand Standard (2006). Handbook 203:2006, *Environmental Risk Management – Principles and Process*, 3rd Edition, Standards Australia, Sydney,

Australian and New Zealand Standard 4360:2004, *Risk Management, 3rd Edition,* Standards Australia (Sydney) and Standards New Zealand (Wellington), 16 October 2009.

Australian Government (2007). *Australian Natural Resources Atlas* Available at:. http://www.anra.gov.au/. Accessed in May 2009.

BMA (2008). *Duania Coal Mine Project - Environmental Impact Statement, Appendix J.2*. Available at: http://www.bhpbilliton.com/bbContentRepository/docs/dauniaMineEisAppendix12.pdf. Accessed in May 2009.

Bunn SE, Davies PM, and Mosisch TD (1999). *Ecosystem measures of river health and their response to riparian and catchment degradation*. Freshwater Biology 41:333-345.

Bureau of Meteorology http://www.bom.gov.au. Weather stations 035019, 035000, and 036007.

Chessman B (2003). *SIGNAL 2 – A Scoring System for Macro-invertebrate ('Water Bugs') in Australian Rivers.* Monitoring River Health Initiative Technical Report no 31, Commonwealth of Australia, Canberra.

Cogger HG (2000). *Reptiles and Amphibians of Australia*. Reed New Holland, Australia.

Conrick and Cockayne (2001). *Queensland Australian River Assessment System (AUSRIVAS) Sampling and Processing Manual*. Department of Natural Resources and Mines, Rocklea.

Department of Employment, Economic Development and Innovation (2008). *Pest Fact Sheet : Cane Toad*. Available at: http://www.dpi.qld.gov.au/cps/rde/dpi/hs.xsl/4790_8270_ENA_HTML.htm.

Department of Environment and Resource Management (2007). *Watershed data – Native Companion Creek*. Available at: http://www.derm.qld.gov.au/watershed/precomp/120305a/arp.htm. (Site accessed in May 2009).

Department of Environment and Resource Management (2007). *Burdekin Basin Water Resource Plan*. Available at: http://www.derm.qld.gov.au/wrp/burdekin.html. (Site accessed in May 2009).

Department of Environment and Resource Management (2009). *WetlandMaps*. Available at http://www.epa.qld.gov.au/wetlandinfo/site/MappingFandD/WetlandMapsAndData/WetlandMaps.html. Site accessed in May 2009).

Department of Natural Resources (2003). *Threatened Species Profile – Little Pied Bat*. Available at: http://www.naturalresources.nsw.gov.au/care/pdfs/flora_fauna_narromine_d_2003-4.pdf.

Department of Natural Resources and Mines (undated). *Central West Water Management and Use Regional Guideline: Watercourse Diversions – Central Queensland Mining Industry*. Queensland Government.

Earth Tech (2002). *Bowen Basin River Diversions, Design and Rehabilitation Criteria.* Australian Coal Association Research Program.

Environment Protection and Biodiversity Conservation Act (1999).

Environmental Protection (Water) Policy 2009.

Fritz KM & Dodds WK (2005). *Harshness: characterisation of intermittent stream habitat over space and time*. Marine and Freshwater Research 56(1):13-23.

Growns IO and Davis JA, (1991). *Comparison of the macro-invertebrate communities in streams in logged and undisturbed catchments 8 years after harvesting*. Australian Journal of Marine and Freshwater Research 42:689-706.

Higgins, P.J., Peter, J.M. and Steele, W.K. (eds) 2001. *Handbook of Australian, New Zealand and Antarctic Birds*, Volume 5 (Tyrant-flycatchers to Chats). Oxford University Press, Melbourne.

Land Protection (Pest and Stock Route Management) Act 2002.

Marchant S and Higgins PJ (eds) (1993). *Handbook of Australian, New Zealand and Antarctic Birds*. Oxford University Press, Melbourne.

McNeil D (2005). *Billabongs: Refuges or Fish Traps*. Watershed, April 2005. Available at: http://www.ewatercrc.com.au/drought/downloads/100015.pdf.

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

Morcombe M (2002). *Field guide to Australian Birds*. Steve Parish Publishing Pty Ltd, Australia.

Native Fish Australia (2008). *Purple-spotted Gudgeon*. Available at: http://www.nativefish.asn.au/purple.html.

Nature Conservation Act 1992.

Nature Conservation (Wildlife) Regulation 2006.

Oldmeadow DF, Krasnicki T, & Fuller DA (1997). *Preliminary Classification and Ordination of 86 Tasmanian Rivers using Macro-invertebrate Samples from Riffles*. Available at: http://www.environment.gov.au/water/publications/environmental/rivers/nrhp/pubs/tas-appendix6.pdf.

Pizzey G and Knight F (2006). *The Field Guide to the Birds of Australia*. HarperCollins Publishers Pty Ltd, Australia.

Pusey B, Kennard MJ, and Arthington AH (2004). *Freshwater Fishes of North-eastern Australia*. CSIRO Publishing, Australia.

QEPA (2006) *Queensland Water Quality Guidelines*. Available at: http://www.epa.qld.gov.au/environment_management/water/queensland_water_quality_guidelines/queensland_water_quality_guidelines_march_2006_with_2007_minor_updates/.

Tappin AR (2009). *Rainbowfish*. Available at: http://members.optusnet.com.au/rainbowfishes/splendida.htm.

Tropical Savannas CRC (2008). *Issue 35: Burdekin water quality under scrutiny*. Available at: http://savanna.cdu.edu.au/publications/savanna_links_35.html?tid=587960.

Withers PC (1995). *Cocoon formation and structure in the aestivating Australian desert frogs, Neobatrachus and Cyclorana*. Australian Journal of Zoology, 43:429 – 441.

Appendix A: Database Search Results

Queensland Government

Wildlife Online Extract

Search Criteria: Species List for a Defined Area
Species: All
Type: All
Status: Rare and threatened species
Records: All
Date: All
Latitude: 22.7537 to 23.2045
Longitude: 146.9635 to 146.4747
Email: jmcphee-frew@aarc.net.au
Date submitted: Friday 05 Aug 2011 12:13:39
Date extracted: Friday 05 Aug 2011 12:16:11

The number of records retrieved = 5

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
animals	birds	Accipitridae	*Lophoictinia isura*	square-tailed kite		NT		1
animals	birds	Accipitridae	*Erythrotriorchis radiatus*	red goshawk		E	V	1
animals	birds	Columbidae	*Geophaps scripta scripta*	squatter pigeon (southern subspecies)		V	V	1
animals	birds	Meliphagidae	*Melithreptus gularis*	black-chinned honeyeater		NT		3
animals	reptiles	Scincidae	*Egernia rugosa*	yakka skink		V	V	1

CODES

I - Y indicates that the taxon is introduced to Queensland and has naturalised.

Q - Indicates the Queensland conservation status of each taxon under the *Nature Conservation Act 1992.* The codes are Extinct in the Wild (PE), Endangered (E), Vulnerable (V), Near Threatened (NT), Least Concern (C) or Not Protected ( ).

A - Indicates the Australian conservation status of each taxon under the *Environment Protection and Biodiversity Conservation Act 1999.* The values of EPBC are Conservation Dependent (CD), Critically Endangered (CE), Endangered (E), Extinct (EX), Extinct in the Wild (XW) and Vulnerable (V).

Records – The first number indicates the total number of records of the taxon for the record option selected (i.e. All, Confirmed or Specimens).
This number is output as 99999 if it equals or exceeds this value. The second number located after the / indicates the number of specimen records for the taxon.
This number is output as 999 if it equals or exceeds this value.

Queensland Government

Wildlife Online Extract

Search Criteria: Species List for a Defined Area
Species: All
Type: All
Status: Rare and threatened species
Records: All
Date: All
Latitude: 23.657 to 23.2045
Longitude: 146.9632 to 146.4747
Email: jmcphee-frew@aarc.net.au
Date submitted: Friday 05 Aug 2011 12:14:43
Date extracted: Friday 05 Aug 2011 12:16:14

The number of records retrieved = 1

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
animals	birds	Accipitridae	*Lophoictinia isura*	square-tailed kite		NT		1

CODES

I - Y indicates that the taxon is introduced to Queensland and has naturalised.

Q - Indicates the Queensland conservation status of each taxon under the *Nature Conservation Act 1992.* The codes are Extinct in the Wild (PE), Endangered (E), Vulnerable (V), Near Threatened (NT), Least Concern (C) or Not Protected ( ).

A - Indicates the Australian conservation status of each taxon under the *Environment Protection and Biodiversity Conservation Act 1999.* The values of EPBC are Conservation Dependent (CD), Critically Endangered (CE), Endangered (E), Extinct (EX), Extinct in the Wild (XW) and Vulnerable (V).

Records – The first number indicates the total number of records of the taxon for the record option selected (i.e. All, Confirmed or Specimens).
This number is output as 99999 if it equals or exceeds this value. The second number located after the / indicates the number of specimen records for the taxon.
This number is output as 999 if it equals or exceeds this value.

Queensland Government

Wildlife Online Extract

Search Criteria: Species List for a Defined Area
Species: All
Type: All
Status: Rare and threatened species
Records: All
Date: All
Latitude: 22.7505 to 23.2045
Longitude: 145.9895 to 146.4747
Email: jmcphee-frew@aarc.net.au
Date submitted: Friday 05 Aug 2011 12:15:31
Date extracted: Friday 05 Aug 2011 12:16:25

The number of records retrieved = 7

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
animals	birds	Accipitridae	*Lophoictinia isura*	square-tailed kite		NT		1
animals	birds	Columbidae	*Geophaps scripta scripta*	squatter pigeon (southern subspecies)		V	V	2
animals	reptiles	Scincidae	*Ctenotus capricorni*			NT		2/2
plants	higher dicots	Apocynaceae	*Cerbera dumicola*			NT		2/1
plants	higher dicots	Euphorbiaceae	*Bertya pedicellata*			NT		2/1
plants	higher dicots	Fabaceae	*Desmodium macrocarpum*			NT		3/2
plants	higher dicots	Myrtaceae	*Corymbia clandestina*			V	V	1

CODES

I - Y indicates that the taxon is introduced to Queensland and has naturalised.

Q - Indicates the Queensland conservation status of each taxon under the *Nature Conservation Act 1992.* The codes are Extinct in the Wild (PE), Endangered (E), Vulnerable (V), Near Threatened (NT), Least Concern (C) or Not Protected ( ).

A - Indicates the Australian conservation status of each taxon under the *Environment Protection and Biodiversity Conservation Act 1999.* The values of EPBC are Conservation Dependent (CD), Critically Endangered (CE), Endangered (E), Extinct (EX), Extinct in the Wild (XW) and Vulnerable (V).

Records – The first number indicates the total number of records of the taxon for the record option selected (i.e. All, Confirmed or Specimens).
This number is output as 99999 if it equals or exceeds this value. The second number located after the / indicates the number of specimen records for the taxon.
This number is output as 999 if it equals or exceeds this value.

Queensland Government

Wildlife Online Extract

Search Criteria: Species List for a Defined Area
Species: All
Type: All
Status: Rare and threatened species
Records: All
Date: All
Latitude: 23.6536 to 23.2045
Longitude: 145.9827 to 146.4747
Email: jmcphee-frew@aarc.net.au
Date submitted: Friday 05 Aug 2011 12:16:40
Date extracted: Friday 05 Aug 2011 12:31:02

The number of records retrieved = 4

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
animals	reptiles	Scincidae	*Ctenotus capricorni*			NT		1
plants	higher dicots	Fabaceae	*Desmodium macrocarpum*			NT		3/3
plants	higher dicots	Mimosaceae	*Acacia spania*			NT		4/3
plants	higher dicots	Myrtaceae	*Micromyrtus rotundifolia*			V		2/1

CODES

I - Y indicates that the taxon is introduced to Queensland and has naturalised.

Q - Indicates the Queensland conservation status of each taxon under the *Nature Conservation Act 1992.* The codes are Extinct in the Wild (PE), Endangered (E), Vulnerable (V), Near Threatened (NT), Least Concern (C) or Not Protected ( ).

A - Indicates the Australian conservation status of each taxon under the *Environment Protection and Biodiversity Conservation Act 1999.* The values of EPBC are Conservation Dependent (CD), Critically Endangered (CE), Endangered (E), Extinct (EX), Extinct in the Wild (XW) and Vulnerable (V).

Records – The first number indicates the total number of records of the taxon for the record option selected (i.e. All, Confirmed or Specimens).
This number is output as 99999 if it equals or exceeds this value. The second number located after the / indicates the number of specimen records for the taxon.
This number is output as 999 if it equals or exceeds this value.

Australian Government
Department of Sustainability, Environment, Water, Population and Communities

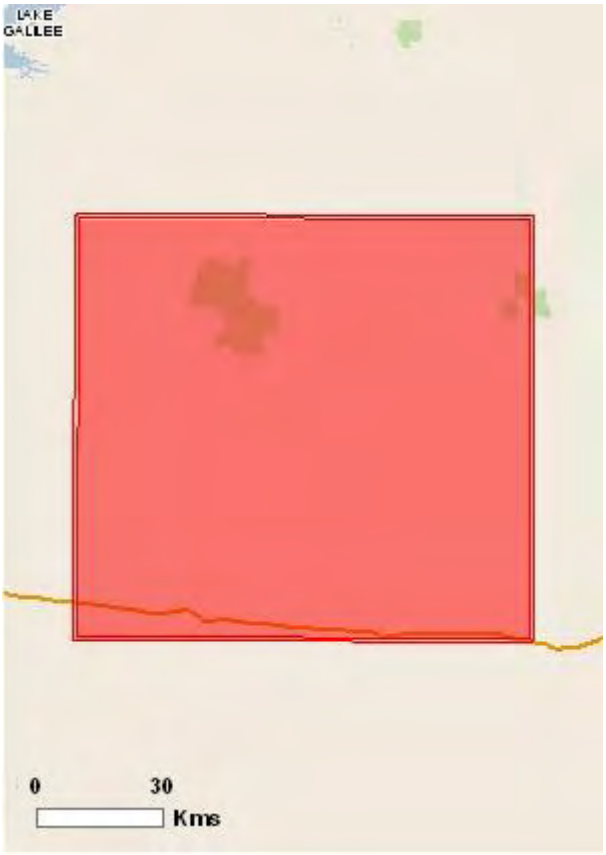
EPBC Act Protected Matters Report: Coordinates

This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected.

Information on the coverage of this report and qualifications on data supporting this report are contained in the caveat at the end of the report.

Information about the EPBC Act including significance guidelines, forms and application process details can be found at http://www.environment.gov.au/epbc/assessmentsapprovals/index.html

Report created: 03/08/11 09:14:43



Coordinates

Buffer: 1.0Km

Summary

Matters of National Environmental Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the Administrative Guidelines on Significance - see http://www.environment.gov.au/epbc/assessmentsapprovals/guidelines/index.html.

World Heritage Properties:	None
National Heritage Places:	None
Wetlands of International Significance (Ramsar Wetlands):	1
Great Barrier Reef Marine Park:	None
Commonwealth Marine Areas:	None
Threatened Ecological Communitites:	5
Threatened Species:	10
Migratory Species:	12

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place and the heritage values of a place on the Register of the National Estate. Information on the new heritage laws can be found at http://www.environment.gov.au/heritage/index.html

Please note that the current dataset on Commonwealth land is not complete. Further information on Commonwealth land would need to be obtained from relevant sources including Commonwealth agencies, local agencies, and land tenure maps.

A permit may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species. Information on EPBC Act permit requirements and application forms can be found at http://www.environment.gov.au/epbc/permits/index.html.

Commonwealth Lands:	None
Commonwealth Heritage Places:	None
Listed Marine Species:	10
Whales and Other Cetaceans:	None

Critical Habitats:	None
Commonwealth Reserves:	None

Report Summary for Extra Information

This part of the report provides information that may also be relevant to the area you have nominated.

Place on the RNE:	None
State and Territory Reserves:	4
Regional Forest Agreements:	None
Invasive Species:	11
Nationally Important Wetlands:	None

Details

Matters of National Environmental Significance

Wetlands of International Significance (RAMSAR Sites) [Resource Information]

Name	Proximity
Coongie lakes	Upstream from Ramsar site

Threatened Ecological Communities [Resource Information]

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Name	Status	Type of Presence
Brigalow (Acacia harpophylla dominant and co-dominant)	Endangered	Community known to occur within area
Coolibah - Black Box Woodlands of the Darling Riverine Plains and the Brigalow Belt South Bioregions	Endangered	Community may occur within area
Natural Grasslands of the Queensland Central Highlands and the northern Fitzroy Basin	Endangered	Community may occur within area
The community of native species dependent on natural discharge of groundwater from the Great Artesian Basin	Endangered	Community known to occur within area
Weeping Myall Woodlands	Endangered	Community likely to occur within area

Threatened Species [Resource Information]

Name	Status	Type of Presence
BIRDS		
Geophaps scripta scripta Squatter Pigeon (southern) [64440]	Vulnerable	Species or species habitat likely to occur within area
Neochmia ruficauda ruficauda Star Finch (eastern), Star Finch	Endangered	Species or species habitat likely to occur within area

(southern) [26027]		
Poephila cincta cincta		
Black-throated Finch (southern) [64447]	Endangered	Species or species habitat likely to occur within area
Rostratula australis		
Australian Painted Snipe [77037]	Vulnerable	Species or species habitat may occur within area
MAMMALS		
Dasyurus hallucatus		
Northern Quoll [331]	Endangered	Species or species habitat may occur within area
PLANTS		
Acacia ramiflora		
[7242]	Vulnerable	Species or species habitat may occur within area
Dichanthium queenslandicum		
King Blue-grass [5481]	Vulnerable	Species or species habitat likely to occur within area
REPTILES		
Denisonia maculata		
Ornamental Snake [1193]	Vulnerable	Species or species habitat known to occur within area
Egernia rugosa		
Yakka Skink [1420]	Vulnerable	Species or species habitat known to occur within area
Furina dunmalli		
Dunmall's Snake [59254]	Vulnerable	Species or species habitat may occur within area

Migratory Species [Resource Information]

Name	Status	Type of Presence
Migratory Marine Birds		
Apus pacificus		
Fork-tailed Swift [678]		Species or species habitat may occur within area
Ardea alba		
Great Egret, White Egret [59541]		Species or species habitat may occur within area
Ardea ibis		
Cattle Egret [59542]		Species or species habitat may occur within area
Migratory Terrestrial Species		
Haliaeetus leucogaster		
White-bellied Sea-Eagle [943]		Species or species habitat likely to occur within area
Hirundapus caudacutus		
White-throated Needletail [682]		Species or species habitat may occur within area
Merops ornatus		
Rainbow Bee-eater [670]		Species or species habitat may occur within area
Myiagra cyanoleuca		
Satin Flycatcher [612]		Species or species habitat likely to occur within area
Migratory Wetlands Species		
Ardea alba		
Great Egret, White Egret [59541]		Species or species habitat may occur within area
Ardea ibis		

Cattle Egret [59542]		Species or species habitat may occur within area
Gallinago hardwickii		
Latham's Snipe, Japanese Snipe [863]		Species or species habitat may occur within area
Nettapus coromandelianus albipennis		
Australian Cotton Pygmy-goose [25979]		Species or species habitat may occur within area
Rostratula benghalensis s. lat.		
Painted Snipe [889]	Vulnerable*	Species or species habitat may occur within area

Other Matters Protected by the EPBC Act

Listed Marine Species [Resource Information]

Name	Status	Type of Presence
Birds		
Apus pacificus		
Fork-tailed Swift [678]		Species or species habitat may occur within area
Ardea alba		
Great Egret, White Egret [59541]		Species or species habitat may occur within area
Ardea ibis		
Cattle Egret [59542]		Species or species habitat may occur within area
Gallinago hardwickii		
Latham's Snipe, Japanese Snipe [863]		Species or species habitat may occur within area
Haliaeetus leucogaster		
White-bellied Sea-Eagle [943]		Species or species habitat likely to occur within area
Hirundapus caudacutus		
White-throated Needletail [682]		Species or species habitat may occur within area
Merops ornatus		
Rainbow Bee-eater [670]		Species or species habitat may occur within area
Myiagra cyanoleuca		
Satin Flycatcher [612]		Species or species habitat likely to occur within area
Nettapus coromandelianus albipennis		
Australian Cotton Pygmy-goose [25979]		Species or species habitat may occur within area
Rostratula benghalensis s. lat.		
Painted Snipe [889]	Vulnerable*	Species or species habitat may occur within area

Extra Information

State and Territory Reserves [Resource Information]

Bimblebox, QLD
Cudmore, QLD
Narrien Range, QLD
Cudmore, QLD

Invasive Species [Resource Information]

Weeds reported here are the 20 species of national significance (WoNS), along with other introduced plants that are considered by the States and Territories to pose a particularly significant threat to biodiversity. The following feral animals are reported: Goat, Red Fox, Cat, Rabbit, Pig, Water Buffalo and Cane Toad. Maps from Landscape Health Project, National Land and Water Resouces Audit, 2001.

Name	Status	Type of Presence
Frogs		
Bufo marinus Cane Toad [1772]		Species or species habitat likely to occur within area
Mammals		
Capra hircus Goat [2]		Species or species habitat likely to occur within area
Felis catus Cat, House Cat, Domestic Cat [19]		Species or species habitat likely to occur within area
Oryctolagus cuniculus Rabbit, European Rabbit [128]		Species or species habitat likely to occur within area
Sus scrofa Pig [6]		Species or species habitat likely to occur within area
Vulpes vulpes Red Fox, Fox [18]		Species or species habitat likely to occur within area
Plants		
Acacia nilotica subsp. indica Prickly Acacia [6196]		Species or species habitat may occur within area
Cryptostegia grandiflora Rubber Vine, Rubbervine, India Rubber Vine, India Rubbervine, Palay Rubbervine, Purple Allamanda [18913]		Species or species habitat likely to occur within area
Lantana camara Lantana, Common Lantana, Kamara Lantana, Large-leaf Lantana, Pink Flowered Lantana, Red Flowered Lantana, Red-Flowered Sage, White Sage, Wild Sage [10892]		Species or species habitat likely to occur within area
Parkinsonia aculeata Parkinsonia, Jerusalem Thorn, Jelly Bean Tree, Horse Bean [12301]		Species or species habitat likely to occur within area
Parthenium hysterophorus Parthenium Weed, Bitter Weed, Carrot Grass, False Ragweed [19566]		Species or species habitat likely to occur within area

Caveat

The information presented in this report has been provided by a range of data sources as acknowledged at the end of the report.

This report is designed to assist in identifying the locations of places which may be relevant in determining obligations under the Environment Protection and Biodiversity Conservation Act 1999. It holds mapped locations of World Heritage and Register of National Estate properties, Wetlands of International Importance, Commonwealth and State/Territory reserves, listed threatened, migratory and

marine species and listed threatened ecological communities. Mapping of Commonwealth land is not complete at this stage. Maps have been collated from a range of sources at various resolutions.

Not all species listed under the EPBC Act have been mapped (see below) and therefore a report is a general guide only. Where available data supports mapping, the type of presence that can be determined from the data is indicated in general terms. People using this information in making a referral may need to consider the qualifications below and may need to seek and consider other information sources.

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

For species where the distributions are well known, maps are digitised from sources such as recovery plans and detailed habitat studies. Where appropriate, core breeding, foraging and roosting areas are indicated under 'type of presence'. For species whose distributions are less well known, point locations are collated from government wildlife authorities, museums, and non-government organisations; bioclimatic distribution models are generated and these validated by experts. In some cases, the distribution maps are based solely on expert knowledge.

Only selected species covered by the following provisions of the EPBC Act have been mapped:

- migratory and
- marine

The following species and ecological communities have not been mapped and do not appear in reports produced from this database:

- threatened species listed as extinct or considered as vagrants
- some species and ecological communities that have only recently been listed
- some terrestrial species that overfly the Commonwealth marine area
- migratory species that are very widespread, vagrant, or only occur in small numbers.

The following groups have been mapped, but may not cover the complete distribution of the species:

- non-threatened seabirds which have only been mapped for recorded breeding sites;
- seals which have only been mapped for breeding sites near the Australian continent.

Such breeding sites may be important for the protection of the Commonwealth Marine environment.

Coordinates

-22.75046 145.98951,-22.75365 146.96347,-23.65697 146.96323,-23.65364 145.98269,-22.75046 145.98951

Acknowledgements

This database has been compiled from a range of data sources. The department acknowledges the following custodians who have contributed valuable data and advice:

-Department of Environment, Climate Change and Water, New South Wales
-Department of Sustainability and Environment, Victoria
-Department of Primary Industries, Parks, Water and Environment, Tasmania
-Department of Environment and Natural Resources, South Australia
-Parks and Wildlife Service NT, NT Dept of Natural Resources, Environment and the Arts
-Environmental and Resource Management, Queensland
-Department of Environment and Conservation, Western Australia
-Department of the Environment, Climate Change, Energy and Water
-Birds Australia
-Australian Bird and Bat Banding Scheme

-Australian National Wildlife Collection
-Natural history museums of Australia
-Museum Victoria
-Australian Museum
-SA Museum
-Queensland Museum
-Online Zoological Collections of Australian Museums
-Queensland Herbarium
-National Herbarium of NSW
-Royal Botanic Gardens and National Herbarium of Victoria
-Tasmanian Herbarium
-State Herbarium of South Australia
-Northern Territory Herbarium
-Western Australian Herbarium
-Australian National Herbarium, Atherton and Canberra
-University of New England
-Ocean Biogeographic Information System
-Australian Government, Department of Defence
-State Forests of NSW
-Other groups and individuals

The Department is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

Please feel free to provide feedback via the Contact Us page.

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Appendix B: Survey Site Summary

AQ01 – this site is located north (downstream) of the Project boundary on a 3rd order creek. The survey area consisted of a non-flowing pool with a maximum depth of 50 cm, and a length of >200 m. the stream sediment ranged from mud through to coarse sand. The banks were notably eroded and undercut in areas. Some in-stream debris was present (branches and leaf litter), and sedges were present along the banks. Trailing roots in the water provided additional in-stream habitat. Benthic algae was noted. Noogoora Burr was noted at the site.

Photo Plate 13 AQ01 Upstream and Downstream (Wet Season)

AQ02 – this site was located north (downstream) of the Project. Occasional small, shallow, stagnant pools were present within the three channels of the creek bed. The site was located along a section of Lagoon Creek, vegetated with River Red Gums and Black Tea Trees (*Melaleuca bracteata*). Occasional grasses were present on the banks, but sedges were notably absent. Noogoora Burr was noted at the site.

Photo Plate 14 AQ02 Upstream and Downstream (Wet Season)

AQ03 – this survey site was located within the Project site on Lagoon Creek along the eastern boundary of MLA 70425. The site contained a large non-flowing pool (approximately 60 m by 10 m), as well as a smaller pool. This site contained a lot of in-stream vegetation, predominately Black Tea Trees. The stream sediments ranged from mud (where water was held) through to moderately coarse sand in the dry areas of the creek bed. There was evident of some erosion on the banks. Mid-channel vegetation included Black Tea Trees and juvenile Myrtacea individuals, and Noogoora Burr was noted at the site. The water had an oily film on the surface, and the pools contained a lot of debris. There was a maximum depth of 1 m in the pools, and brown / red benthic algae was noted.

Photo Plate 15 AQ03 Upstream and Downstream (Wet Season)

AQ04 – this site was located within a dammed section of Lagoon Creek (2nd order). This site will be impacted by the proposed creek diversion. This site contained a non-flowing, highly turbid pool of water, 10 m by 200 m. The stream sediment consisted of a white clay interspersed with areas of sand. The banks were moderately stable; however there was evidence of bank disturbance by cattle. There was no evidence of any recent significant flow event. There were many fallen trees within the pool, which had a maximum depth of 1.2 m. There was no living in-stream vegetation. The riparian vegetation consisted of a single tree width River Red Gum community. Little change in water levels was observed between the wet and dry seasons.

Photo Plate 16 AQ04 Upstream and Downstream (Wet Season)

Photo Plate 17 AQ04 Upstream and Downstream (Dry Season)

AQ05 – this site was located along Lagoon Creek, upstream of the Wendouree Homestead. This site was characterised by two distinct habitats - a large non-flowing pool with a maximum depth of 1.4 m, and numerous small, shallow, terrace pools heavily vegetated by Wavy Marshwort (*Nymphoides crenata*), *Marsilea mutica*, and grasses. The riparian vegetation was an open Brigalow (*Acacia harpophylla*) woodland. Banks were largely exposed with limited ground cover evident; those species that persisted in the ground layer were predominantly exotic and included *Alternanthera angustiflora* and tussocks of Umbrella Cane Grass (*Leptochloa digitata)*. . Cattle access was evident at the site. Stream sediment consisted of a loamy mud. Aquatic vegetation was significantly reduced in density and extent during the dry season, with no vegetation evident in the water and extensive reduction in the density of riparian grasses. The water level was also lower than during the wet season, however the large pool and associated smaller pools were still present.

Photo Plate 18 AQ05 Upstream and Downstream (Wet Season)

Photo Plate 19 AQ05 Upstream and Downstream (Dry Season)

AQ06 –this site was located outside of the Project area, on Native Companion Creek. The stream sediment was mostly gravel, with occasional sand banks. The banks were moderately unstable within 20-40m of the road crossing, and there was evidence of erosion in these areas, however the banks became more stable further along the creek away from the crossing. The water was flowing at the site during both wet and dry seasons, and sections of ripples were present. The ripple zones had a maximum depth of 5 cm, while the still backwater areas had a maximum depth of 50 cm. There were in-stream logs and Melaleucas present. Castor Oil Bush and Noogoora Burr were noted at the site. No significant change in water level was recorded during the dry season.

Photo Plate 20 AQ06 Upstream and Downstream (Wet Season)

Photo Plate 21 AQ06 Upstream and Downstream (Dry Season)

AQ07 – this site was located on Well Creek, upstream of a road crossing. The site was dry at the time of the survey. Stream sediments consisted of moderately coarse sands. Black Tea Trees and Moreton Bay Ashes (*Corymbia tessellaris*) were present both in-stream and within the riparian zone. Noogoora Burr was noted at the site. No photo available for this site.

AQ08 – this site was located within Sandy Creek, upstream of a road crossing. The creek was dry at the time of the survey. The stream sediment was sand. The in-stream vegetation consisted of *Eucalyptus* species, and there was also a large sedge, herb, and grass component. The banks were well vegetated and moderately stable, with the only signs of erosion noted around the road crossing.

Photo Plate 22 AQ08 Upstream and Downstream (Wet Season)

Photo Plate 23 AQ08 Upstream and Downstream (Dry Season)

AQ09 – this site was located at a pastoral dam located on the south-eastern boundary of the EPCA. The western bank of the dam was devoid of vegetation and showed signs of erosion; however the other banks were well vegetated and stable. Shallow water to the south provided a wetland habitat that was colonised by Cyperaceae and *Potamogeton* species, while water depth exceeded 1.6 m in the deep pool to the north. The banks were dominated by *Ludwigia octovalvis*, with occasional *Eucalyptus melanophloia* (Silver-leafed Ironbark). Some dead and dying *Eucalyptus populnea were present within the shallows to the south.*

Photo Plate 24 AQ09 Wet Season and Dry Season

AQ10 – this site was located within a drainage line on the south-eastern boundary of MLA 70426. It was dry at the time of the survey. The vegetation surrounding the drainage line included regrowth Silver-leafed Ironbarks and River Red Gum. The sediment at the site ranged from fine sand to rock. Extensive erosion was evident on site, with bank failure exposing tree roots and bedrock.

Photo Plate 25 AQ10 Upstream and Downstream (Wet Season)

Photo Plate 26 AQ10 Upstream and Downstream (Dry Season)

AQ11 – this reference site was located within a dry tributary of Native Companion Creek outside of the Project site, adjacent to the Clermont – Alpha Road. This section of creek was characterised by many small, vegetated mid-channel islands. Erosion was plainly evident, with banks showing signs of cattle disturbance and bank failure. Vegetation along the banks consisted of River Red Gum, with large *Sida cordifolia* plants within the shrub layer. The benthic sediment composed predominantly of fine sand sediment.

Photo Plate 27 AQ11 Upstream and Downstream (Wet Season)

Photo Plate 28 AQ11 (Dry Season)

AQ12 – this site was located within a dry creek bed in the south-eastern corner of the Project site, along the Hobartville Road, within a Cypress Pine (*Callitris glaucophylla*) woodland. Occasional Noogoora Burr were noted. The creek bed had a fine sand sediment with some surface rocks, and was vegetated with grasses noted to be present in the surrounding paddock. Cattle access was evident along with high levels of erosion and storm damage.

Photo Plate 29 AQ12 Upstream and Downstream (Wet Season)

Photo Plate 30 AQ12 Upstream and Downstream (Dry Season)

AQ13 – this site was located within a dry creek bed on the south-eastern boundary, along Hobartville Road. The site was highly degraded as a result of extensive erosion, heavy storm damage and past clearing activities. Upstream was noted to be fine sand, downstream had a rocky base. Brigalow (*Acacia harpophylla*) and Black Tea Trees were noted to be the dominant riparian vegetation. Cattle access was evident.

Photo Plate 31 AQ13 Upstream and Downstream (Wet Season)

Photo Plate 32 AQ13 Upstream and Downstream (Dry Season)

AQ14 was located in a dry creek bed along the Hobartville Road. Erosion was extensive. The site had a rock base, with a sand cover. Upstream the creek bed was wide, downstream the creek bed became narrower and deeper. Mixed tree species were present on the banks and included *Eucalyptus melanophloia* and *Callitris glaucophylla*.

Photo Plate 33 AQ14 Upstream and Downstream (Wet Season)

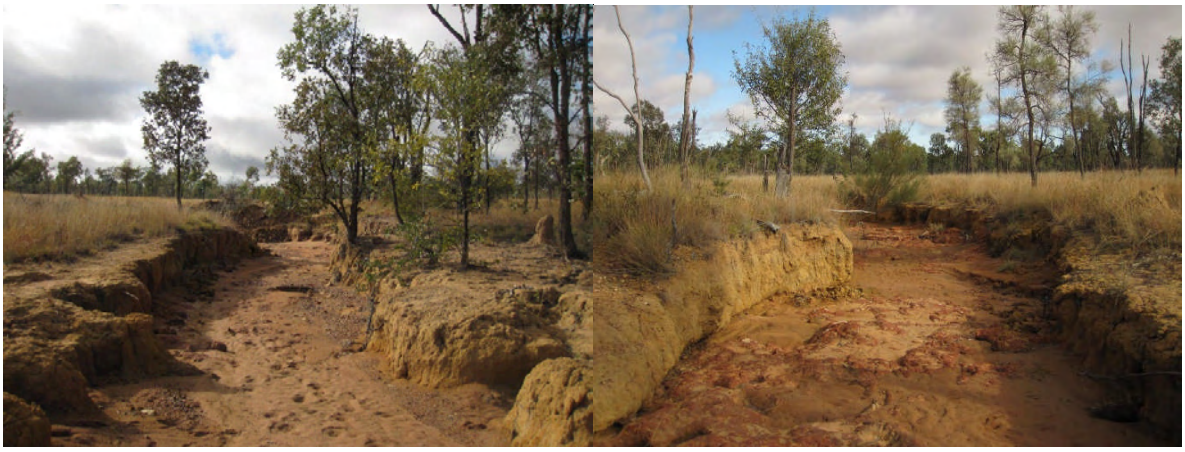


Photo Plate 34 AQ14 Upstream and Downstream (Dry Season)

AQ15 – this site was located on Sandy Creek on the northern boundary of MLA 70426. The site was dry at the time of the survey. River Red Gums dominated the riparian vegetation. Mid-channel islands were vegetated with grasses, and Native Currant Bush (*Carissa lanceolata*). No weeds were visible along bank, however individuals of Red Natal Grass and Buffel Grass were present away from bank.

Photo Plate 35 AQ15 Upstream and Downstream (Wet Season)

Photo Plate 36 AQ15 Upstream and Downstream (Dry Season)

AQ16 – this 3rd order site was located downstream of the confluence of two creeks, along the western boundary of the Project site (upstream site). The site was characterised by fine sands, with a River Red Gum riparian community. Dense thickets of *Sida cordifolia* were present away from the banks of the site, however no in-stream vegetation was present, and no sedges were noted.

Photo Plate 37 AQ16 Upstream and Downstream (Wet Season)

Photo Plate 38 AQ16 Upstream and Downstream (Dry Season)

AQ17 was located within a very narrow, highly turbid section of non-flowing water. The riparian vegetation consisted of Brigalow, and Poplar Box with young *Eucalyptus camaldulensis* along the banks.. This 2nd order site had a muddy substrate, and a maximum depth of 50 cm. Heavy cattle use was noted, and a feral cat was observed in the area during the most recent dry season survey. Noogoora Burr was also noted.

Photo Plate 39 AQ17 Upstream and Downstream (Wet Season)

Photo Plate 40 AQ17 Upstream and Downstream (Dry Season)

AQ18 – this 2nd order site was located along a muddy / clayey, bendy section of creek with a Brigalow riparian community. A road intersected the site, so the two non-flowing pools were sampled. The water was highly turbid. The banks were noted to be unstable, and Velvety Tree Pear was present.

Photo Plate 41 AQ18 Upstream and Downstream (Wet Season)

AQ19 – this site was located in the north-western section of the Project site, within a mixed species woodland. The site was within a small drainage line holding a pool of water. The banks were eroded, with exposed root systems of the riparian trees evident. The site was a cattle watering point. Sedges and *Ludwigia octovalvis* were present on the banks.

Photo Plate 42 AQ19 Upstream and Downstream (Wet Season)

AQ20 – this site was located at the head of a drainage line, within a non-remnant area. No riparian or wetland species were evident. The site was dry at the time of the survey, and the creek had an orange rock base with a layer of very fine sand overlaying it.

Photo Plate 43 AQ20 Survey Site (Wet Season)

AQ21 – this site was located at the confluence of two 1st order drainage lines. Some erosion was evident. The dry creek bed was characterised by a rock base overlain with fine sand and occasional pebbles. River Red gums dominated the riparian vegetation, with Red Natal and *Petalostigma* sp present in-stream.

Photo Plate 44 AQ21 Upstream and Downstream (Wet Season)

AQ22 was located within a dry 1st order drainage line. No aquatic or wetland species were noted at the site. The very narrow fringe of riparian vegetation consisted of Brigalow, River Red Gum, Native Currant Bush (*Carissa lanceolata*), and Buffel Grass (*Cenchrus ciliaris*).

Photo Plate 45 AQ22 Upstream and Downstream (Wet Season)

AQ23 was located downstream of the confluence of Saltbush Creek and Lagoon Creek. The site consisted of a large, turbid pool of water in the wet season that became several, smaller pools during the dry season. Lots of grasses and sedges were present on the banks, and trailing in to the water. The riparian vegetation consisted of mixed Eucalypt species woodland, bordered by non-remnant vegetation. The site was extensively utilised by cattle and signs of erosion were evident along some exposed banks.

Photo Plate 46 AQ23 Upstream and Downstream (Wet Season)

Photo Plate 47 AQ23 Upstream and Downstream (Dry Season)

AQ24 – located within a dry sandy creek bed. Vegetation present at the site included Poplar Box (*Eucalyptus populnea*) and River Red Gum trees, with Bauhinias and Silver-leafed Ironbarks also present. *Dichanthium* sp and *Carissa ovata* were present on the banks. Some issues with erosion were evident around the creek crossing through vehicle and cattle disturbance.

Photo Plate 48 AQ24 Upstream and Downstream (Wet Season)

Photo Plate 49 AQ24 Upstream and Downstream (Dry Season)

AQ25 – this site was a small, marshy area within a Brigalow patch, and adjacent to a pastoral dam. The area was dry during the June 2011 survey. Sedges and grasses were evident on the banks, many of which persisted into the dry season.

Photo Plate 50 AQ25 Survey Site (Wet and Dry Season)

AQ25_A – this was a pastoral dam located adjacent to AQ25. This site was sampled for aquatic fauna during the June 2011 Dry Season survey to contribute to the overall understanding of aquatic species present within the Project site.

Photo Plate 51 AQ25A Survey Site (Dry Season)

AQ26 – the site was located within a small depression area, with a tiny pool of water present. The sediments were a sandy loam. The surrounding vegetation was a non-remnant grassland community. The site shows clear evidence of heavy cattle disturbance.

Photo Plate 52 AQ26 Survey Site (Wet and Dry Season)

AQ27 – this site consisted of a series of small palustrine bog holes. Some of these were dry at the time of the wet season survey, whilst no pools were present during the dry season. Nardoo (*Marsilea mutica*) and *Enneapogon* sp were present at all bog holes during the wet season, with *Cynodon dactylon* and *Leptochloa digitata* persisting into the drier periods. A more concise vegetative description is given in the Terrestrial Flora and Fauna report by AARC.

Photo Plate 53 AQ27 Survey Site (Wet and Dry Season)

AQ28 – located in the middle of MLA 70426, along the eastern boundary. The site was characterised by a large lagoon (>200 m long) vegetated with various lily species including *Ottelia ovalifolia* and *Nymphaea immutabilis*. The sediment at the site was clay. The water level appeared stable and was turbid in areas. The banks showed some signs of degradation as a result of cattle disturbance; however they were well vegetated and gently sloping across the majority of the site. Soft Roly Poly (*Salsola kali*) and Chenopodeacea sp were present on the banks.

Photo Plate 54 AQ28 Survey Site (Wet and Dry Season)

AQ29 – a marshy palustrine area on the MLA 70426. Some standing water was present as very shallow pools. Aquatic plants were present including *Marsilea drummondii*, *Monochoria cyanea*, *Cyperus polystachyos*, and Mud Grass (*Pseudoraphis spinescens*).

Photo Plate 55 AQ29 Survey Site (Wet and Dry Season)

AQ30 – this site was located on a drainage line / depression area in non-remnant grassland. An algal film was present on the stagnant water at the site. Cattle access was evident.

Photo Plate 56 AQ30 Upstream and Downstream (Wet Season)

AQ31 was located within a lacustrine wetland of the northern area of the Project site. The large lake was a cattle watering point and held significantly more water during the most recent June 2011 survey compared to earlier seasons. The sediment was grey cracking clay, and the water had changed from highly turbid during drier periods to a clearer state during the recent survey. The water had a maximum depth of 1.6 m during dry periods but was over 2 metres in June 2011. Macrophytes (in-stream plants) were also absent during dry periods but were prevalent during the recent survey, and included species of *Vallisneria*, *Potamogeton* and *Marsilea.* Riparian vegetation also included several Cyperaceae species.

Photo Plate 57 AQ31 Survey Site (Wet and Dry Season)

AQ32 – palustrine wetland. The site was dry at the time of the survey. Nardoo, Enneapogon, and Sedge were present. A hard clay sediment was characteristic of the area. Surrounding vegetation include *Eucalyptus populnea* and *Acacia harpophylla*. Young *Eucalyptus camaldulensis* were also found in the area (10-12m) and included many saplings under 2m tall.

Photo Plate 58 AQ32 Survey Site (Wet and Dry Season)

AQ33 – palustrine wetland according to database searches. There was no water at the time of the survey. A cracking clay was characteristic of the site. There were no aquatic plants noted, barring occasional Nardoo plants in lower areas. Some dead *Cyperus* sp. were also noted during dry season. It is likely that this site would hold surface water for only a limited time following rainfall.

Photo Plate 59 AQ33 Survey Site (Wet and Dry Season)

AQ34 – a 1st order drainage line. The site held no water at the time of the survey. The site had some steep, eroded banks and showed signs of storm damage; however no obvious signs of cattle disturbance were noted. Cracking clay and sands characterised the creek sediment. No aquatic plants were noted. Noogoora Burr was present.

Photo Plate 60 AQ34 Survey Site (Wet and Dry Season)

AQ35 – dry palustrine area of the Project site that occurred on a gently undulating plain. Aquatic sedges were present along with *Leptochloa digitata* tussocks within and around the lower lying areas, and is surrounded by a Brigalow (*Acacia harpophylla*) community. This site was located near a recorded Parthenium patch.

Photo Plate 61 AQ35 Survey Site (Wet and Dry Season)

AQ36 (WC1) – this 3rd order site was located in a rocky pool situated on Well Creek, in the western flank of the Project site. The site had steep rocky banks and was >2m deep in sections. The site was noted to have high fish assemblage and the overall aquatic health was considered good. Given the volume of water at the pool, it is believed the site holds water during both the wet and dry seasons.

Photo Plate 62 AQ36 (WC1) Upstream and Downstream (Wet Season)

AQ37 (WC2) - this site was located on Wells Creek, upstream of a road crossing. Small isolated pools were present at the time of survey. Stream sediments consisted of moderately coarse sands. Black Tea Trees and Moreton Bay Ashes (*Eucalyptus tessellaris*) were present both in-stream and within the riparian zone. Noogoora Burr was noted at the site.

Photo Plate 63 AQ37 (WC2) Downstream (Wet Season)

AQ38 (SC1) – was located in a sandy stretch of Lagoon Creek in the northern section of the Project site. The site was not flowing at the time of survey, however pools were significant, indicating recent flow events. Pools were <1m and contained a sand/vegetation detritus mixed benthic substrate.

Photo Plate 64 AQ38 (SC1) Upstream and Downstream (Wet Season)

AQ39 (A1) – this site was located within a drainage line on the western boundary of the Project site. Although not flowing at the time of survey, the drainage held significant water, and was >1m deep at the study location. The vegetation surrounding the drainage line included River Red Gum. The sediment at the site ranged from fine sand to small pebbles. Some erosion was evident, however the site was considered to hold moderate ecological value.

Photo Plate 65 AQ39 (A1) Upstream and Downstream (Wet Season)

AQ40 (SM1) - located within a dry sandy creek bed of varying width in the western flank of the Project site. Riparian vegetation was composed of mature stands of River Red Gum with associated Bloodwoods and the Quinine bush, *Petalostigma pubescens,* within the shrub layer. Vegetated sandbars included Cyperaceae species and terrestrial grasses including *Bothriochloa bladhii.* Surrounding areas dense with *Sida cordifolia* suggest past disturbances, whilst Noogoora Burr and *Alternanthera angustiflora* were also noted in the area.

Photo Plate 66 AQ40 (SM1) Upstream and Downstream (Dry Season)

AQ41 (SM2) – located within a dry sandy creek bed in the western flank of the Project site. This site was situated on a tributary of a similar order yet further upstream of AQ40, and the dominant vegetation of River Red Gum interspersed with Bloodwoods was also similar. A healthy shrub layer of *Grevillea* and *Acacia* species provided habitat for honeyeaters observed during the dry season whilst a diverse ground layer of grasses and rushes (including *Lomandra* sp.) were found along the banks. No signs of erosion were observed away from the road crossing.

Photo Plate 67 AQ41 (SM2) Upstream and Downstream (Dry Season)

AQ42 (SM3) - located within a dry creek bed in the eastern flank of the Project site. A sandy substrate still remained in places whilst other areas had been scoured away to the underlying bedrock. Large amounts of erosion had also occurred, with bank failure evident along the watercourse. Regrowth of Silver-leafed Ironbarks interspersed with Poplar Box lined the banks and surrounds, whilst no aquatic vegetation persisted into the dry season.

Photo Plate 68 AQ42 (SM3) Upstream and Downstream (Dry Season)

AQ43 - located within a dry sandy creek bed in the south-eastern corner of the Project site. Young River Red Gum lined the banks and the community also included Poplar Box and the Cypress Pine *Callitris glaucophylla*.

Photo Plate 69 AQ43 Upstream and Downstream (Dry Season)

AQ44 - located within a rocky stream bed in the south-eastern portion of the Project site. The gently sloping banks are stable with a moderate cover of riparian vegetation dominated by Lancewood and Silver-leaved Ironbark. The stream bed contained a range of habitats from small stony pools to sandy runs.

Photo Plate 70 AQ44 Upstream and Downstream (Dry Season)

AQ45 – a flat sandy creek bed outside the south-eastern boundary of the Project site. The low banks supported a dense riparian community dominated by Buffel grass and River Red Gum. The majority of the sediment was fine grained providing limited stable creek-bed habitat.

Photo Plate 71 AQ45 Upstream and Downstream (Dry Season)

AQ 46 - a large, heavily disturbed river bed on the eastern boundary of the Project site. The river was dry at the time of the surveys, however the channel showed moderate potential for in-stream fauna habitat. The banks were unstable with high, steep sides, extensive erosion and exposed roots.

Photo Plate 72 AQ46 Upstream and Downstream (Dry Season)

AQ47 – a sandy channel situated close to Degulla Rd in the northern section of the Project site. Low banks and dense vegetation provide moderate bank stability, however there is some evidence of erosion in places. The dominant vegetation comprises River Red Gum and Poplar Box.

Photo Plate 73 AQ47 Upstream and Downstream (Dry Season)

AQ48 – located within the bulk sample project in the centre of the Project site, adjacent to an access road and its associated culvert. Moderate habitat for in-stream fauna was present, with some bends and stream bed contours. Some evidence of erosion was present where the banks were highest, however dense riparian vegetation, dominated by Rive Red Gum and Silver-Leaved Ironbark, provide moderate bank stabilisation.

Photo Plate 74 AQ48 Upstream and Downstream (Dry Season)

AQ49 – situated south of the mine camp in the central portion of the Project site. Heavily disturbed and eroded banks present, however channel variations provide good in-stream habitat. Banks are predominantly devoid of vegetation, with only scattered River Red Gum, Brigalow and Poplar Box.

Photo Plate 75 AQ49 Upstream and Downstream (Dry Season)

Appendix C: Water Quality Analysis Results

17 Hamill St Garbutt Townsville QLD 4814

We go beyond our laboratory NATA/ISO/IEC accreditation and ISO9000 compliance. We will co-ordinate responses with you as well as with other specialists and GUARANTEE not to leave you on your own. We are available 7 days.

Report Ref. No. 090316_1 chem AARC

Amy Creighton and Julie Byrd
AustralAsian Resource Consultants Pty. Ltd.
Ph: (07) 4724 3555 Fax: (07) 4724 3811 Mob: 0428 748 722

Client Name: AustralAsian RC **Client Ref. AARC**	Sample Collection Date and Time: 16-21.03.09 *not stated* hours	Preliminary Report Dates:	Final Report Date: 08.04.09
Received Sample Date and Time 23.03.09 1030 hours	Sample Test Date and Time *Samples preserved*	Collection and Test Time Differential *Samples preserved*	Sample Collector

Table 1: Physico-chemical

Sample ID	pH (pH units)	Total dissolved Solids dried at 180°C (mg/L)	Total Nitrogen (mg/L)	Total Phosphorous (mg/L as P)	Nitrate as N (mg/L)	Sulphate (mg/L)	Fluride (mg/L)	Turbidity (NTU)
LOR	0.01	1	0.1	0.1	0.01	0.01	**0.01**	0.02
AQ1	NR	236	1.42	0.76	1.29	<0.01	0.34	47.9
AQ2	NR	194	1.90	1.95	1.19	<0.01	0.30	106
AQ3	NR	112	1.22	0.94	1.19	<0.01	0.33	37.8
AQ4	NR	68	10.83	4.11	10.56	<0.01	0.22	230.0
AQ5	NR	76	10.53	1.28	10.26	1	0.11	97.6
AQ9	NR	82	2.51	0.78	2.38	<0.01	0.37	36.0
AQ17	NR	152	4.45	7.68	3.38	1	0.41	638.0
AQ18	NR	92	4.13	3.16	3.91	<0.01	0.46	220.0
AQ19	NR	114	3.36	11.17	1.96	<0.01	0.35	765
AQ23	NR	106	4.18	1.40	4.08	<0.01	0.26	51.6
AQ25	NR	172	291.2	5.22	289.73	<0.01	0.52	>1000
AQ27	NR	96	1.18	0.72	1.10	1	0.28	7.65
AQ28	NR	96	1.75	0.68	1.69	<0.01	0.16	12.78
AQ29	NR	122	2.87	1.01	2.60	<0.01	0.22	34.2
AQ31	NR	212	54.48	5.21	53.76	1	0.25	500

Table 2: Metals

Sample ID	Al (mg/L)	U (mg/L)	As (mg/L)	B (mg/L)	Cd (mg/L)	Cr (mg/L)	Ca (mg/L)	Cu (mg/L)	Pb (mg/L)	Mn (mg/L)	*Hg (mg/L)	Mo (mg/L)	Sb (mg/L)	Ni (mg/L)	Se (mg/L)	Zn (mg/L)
LOR	0.003	0.004	0.006	0.05	0.001	0.001	0.02	0.002	0.003	0.001	0.0001	0.005	0.005	0.004	0.01	0.004
AQ1	3.087	0.034	0.016	0.065	0.002	0.009	39.37	0.003	0.008	6.057	<0.0001	0.008	0.116	0.008	0.01	0.008
AQ2	8.130	0.035	0.018	0.075	0.002	0.011	27.13	0.004	0.011	4.275	<0.0001	0.008	0.041	0.009	0.02	0.004
AQ3	1.462	0.023	0.011	0.073	0.001	0.004	11.91	0.004	0.008	0.376	<0.0001	0.005	<0.005	0.004	0.01	<0.002
AQ4	11.000	0.035	0.009	0.072	0.001	0.011	7.16	0.005	0.012	0.147	<0.0001	0.006	<0.005	0.007	0.01	0.005
AQ5	10.710	0.024	0.008	0.055	0.001	0.008	7.04	0.003	0.006	0.140	<0.0001	<0.005	<0.005	0.005	0.01	0.003
AQ9	2.163	0.012	0.009	0.089	0.004	0.010	3.66	0.003	0.010	0.066	<0.0001	<0.005	<0.005	0.007	0.01	<0.004
AQ17	30.380	0.131	0.008	0.113	0.001	0.018	11.49	0.007	0.016	0.695	<0.0001	0.005	<0.005	0.010	0.01	0.008
AQ18	19.210	0.060	0.011	0.053	0.001	0.012	8.58	0.005	0.008	0.481	<0.0001	<0.005	<0.005	0.009	0.01	0.003
AQ19	0.075	0.210	0.006	0.071	0.001	0.018	15.88	0.016	0.023	2.369	<0.0001	<0.005	<0.005	0.018	<0.01	0.022
AQ23	3.979	0.018	0.011	0.081	0.002	0.007	7.40	0.004	0.010	0.234	<0.0001	0.013	<0.005	0.007	0.01	<0.002
AQ25	41.330	0.231	0.011	0.104	0.001	0.039	29.66	0.042	0.036	2.728	<0.0001	0.006	<0.005	0.026	<0.01	0.075
AQ27	0.217	0.009	0.010	0.066	0.001	0.003	8.09	<0.002	0.007	0.040	<0.0001	0.005	<0.005	<0.004	0.01	<0.002
AQ28	0.531	0.008	0.009	0.060	0.002	0.004	5.54	0.002	0.008	0.064	<0.0001	0.005	<0.005	<0.004	0.01	<0.002
AQ29	0.307	0.063	0.011	0.052	0.001	0.004	6.31	0.002	0.009	0.586	<0.0001	<0.005	<0.005	0.005	0.01	<0.002
AQ31	15.140	0.074	0.007	0.112	0.002	0.022	9.17	0.009	0.018	0.199	<0.0001	0.008	0.006	0.017	0.01	0.011

NR = not requested; LOR = limit of reporting

17 Hamill St Garbutt Townsville QLD 4814

We go beyond our laboratory NATA/ISO/IEC accreditation and ISO9000 compliance. We will co-ordinate responses with you as well as with other specialists and GUARANTEE not to leave you on your own. We are available 7 days.

Report Ref. No. 090316_1 chem AARC

Analysis Methods: metals by ICP-OES according to APHA 3120B; pH APHA 4500H+B; turbidity APHA2130B; TDS APHA2540C; Alkalinity APHA2320B; Carbonates APHA2320B; Silica APHA4500C, chlorine APHA4500B, fluoride APHA4500D, sulphate APHA4500E, chloride APHA 4500-Cl B, nitrate APHA4500E, ammonia APHA4500F, TOC APHA5310C; phosphate APHA4500P-E, hardness APHA2340C, Total Suspended Solids APHA2540D, total N APHA 4500-N, total P APHA 4500P, TPH/TOG APHA 5520 B, TOC APHA 5310

Report Summary: Samples were analysed as received;
Note: Total metals were determined as acid digested metals.
The samples are indicative only at the time of sampling and further regular monitoring is recommended.

Dr. J. Catmull (PhD,BScHons,MASM,MACCS) Dr. Michael ten Lohuis (PhD,BScHons,MASM,MACCS)

CERTIFICATE OF ANALYSIS

Work Order	: **EB1005772**	Page	: 1 of 3
Client	: **AUSTRALASIAN RESOURCE CONSULTANTS**	Laboratory	: Environmental Division Brisbane
Contact	: MR BRENDAN MASSY	Contact	: Greg Vogel
Address	: SUITE 5B 1 SWANN ROAD TARINGA QLD, AUSTRALIA 4068	Address	: 32 Shand Street Stafford QLD Australia 4053
E-mail	: bmassy@aarc.net.au	E-mail	: Services.Brisbane@alsenviro.com
Telephone	: +61 07 32178772	Telephone	: +61-7-3243 7222
Facsimile	: +61 07 32178775	Facsimile	: +61-7-3243 7218
Project	: HPPL Surface Water	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Order number	: ----		
C-O-C number	: ----	Date Samples Received	: 31-MAR-2010
Sampler	: ----	Issue Date	: 16-APR-2010
Site	: ----		
		No. of samples received	: 5
Quote number	: BN/159/09	No. of samples analysed	: 5

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

NATA Accredited Laboratory 825

This document is issued in accordance with NATA accreditation requirements.

Accredited for compliance with ISO/IEC 17025.

Signatories

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Stephen Hislop	Senior Inorganic Chemist	Inorganics

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insuffient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When date(s) and/or time(s) are shown bracketed, these have been assumed by the laboratory for processing purposes. If the sampling time is displayed as 0:00 the information was not provided by client.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting

- **It has been noted that the TDS for sample SC1 is less than the SO4.Both results have been confirmed by reanalysis. Turbimetric SO4 testing returned results of 898 mg/L.**
- **TDS by method EA-015 may bias high due to the presence of fine particulate matter, which may pass through the prescribed GF/C paper.**

Analytical Results

Sub-Matrix: **WATER**

Compound	CAS Number	LOR	Unit	Client sample ID: A1	SC1	WC2	WC1	SM2
				Client sampling date / time: 17-MAR-2010 16:00	17-MAR-2010 11:45	17-MAR-2010 08:15	16-MAR-2010 12:00	20-MAR-2010 10:30
				EB1005772-001	EB1005772-002	EB1005772-003	EB1005772-004	EB1005772-005
EA015: Total Dissolved Solids								
^ Total Dissolved Solids @180°C	GIS-210-010	1	mg/L	**106**	**324**	**141**	**102**	**122**
ED040F: Dissolved Major Anions								
Sulfate as SO4 2-	14808-79-8	1	mg/L	**3**	**1000**	**18**	**2**	**12**
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	**6**	**12**	**15**	**5**	<1
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	**0.32**	**0.08**	**0.02**	**0.19**	**0.18**
Antimony	7440-36-0	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Arsenic	7440-38-2	0.001	mg/L	<0.001	**0.002**	**0.002**	<0.001	<0.001
Beryllium	7440-41-7	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Copper	7440-50-8	0.001	mg/L	**0.002**	**0.001**	<0.001	**0.002**	**0.001**
Cobalt	7440-48-4	0.001	mg/L	<0.001	**0.003**	**0.010**	<0.001	<0.001
Nickel	7440-02-0	0.001	mg/L	**0.002**	**0.003**	**0.005**	**0.002**	**0.001**
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Zinc	7440-66-6	0.005	mg/L	<0.005	<0.005	<0.005	**0.012**	**0.086**
Manganese	7439-96-5	0.001	mg/L	**0.014**	**0.642**	**2.19**	**0.028**	**0.030**
Molybdenum	7439-98-7	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Uranium	7440-61-1	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Boron	7440-42-8	0.05	mg/L	<0.05	<0.05	**0.05**	<0.05	**0.05**
Iron	7439-89-6	0.05	mg/L	**0.28**	**1.74**	**0.43**	**0.30**	**0.56**
EG035F: Dissolved Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	**0.2**	<0.1	<0.1	<0.1	<0.1
EK059G: NOX as N by Discrete Analyser								
Nitrite + Nitrate as N	----	0.01	mg/L	<0.01	<0.01	<0.01	<0.05	<0.01
EK061: Total Kjeldahl Nitrogen (TKN)								
Total Kjeldahl Nitrogen as N	----	0.1	mg/L	**0.4**	**0.4**	**0.1**	<0.1	<0.1
EK062: Total Nitrogen as N (TKN + NOx)								
^ Total Nitrogen as N	----	0.1	mg/L	**0.4**	**0.4**	**0.1**	<0.1	<0.1

CERTIFICATE OF ANALYSIS

Work Order	: **EB1112051**	Page	: 1 of 6
Client	: **AUSTRALASIAN RESOURCE CONSULTANTS**	Laboratory	: Environmental Division Brisbane
Contact	: MR PAUL JACKSON	Contact	: Customer Services
Address	: SUITE 5B 1 SWANN ROAD TARINGA QLD, AUSTRALIA 4068	Address	: 32 Shand Street Stafford QLD Australia 4053
E-mail	: pjackson@aarc.net.au	E-mail	: Brisbane.Enviro.Services@alsglobal.com
Telephone	: +61 07 3217 8772	Telephone	: +61 7 3243 7222
Facsimile	: +61 07 32178775	Facsimile	: +61 7 3243 7218
Project	: Alpha Coal	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Order number	: ----		
C-O-C number	: ----	Date Samples Received	: 22-JUN-2011
Sampler	: J.Stibbard, D.Taylor	Issue Date	: 13-JUL-2011
Site	: ----		
		No. of samples received	: 7
Quote number	: BN/279/10/BN/232/10	No. of samples analysed	: 7

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

NATA Accredited Laboratory 825

This document is issued in accordance with NATA accreditation requirements.

Accredited for compliance with ISO/IEC 17025.

Signatories

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Celine Conceicao	Spectroscopist	Sydney Inorganics
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics
Wisam Marassa	Metals Coordinator	Sydney Inorganics

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insuffient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting

- **It is recognised that EG020T (Total Metals) is less than EG020F (Dissolved Metals) for some samples. However, the difference is within experimental variation of the methods.**
- **TDS by method EA-015 may bias high due to the presence of fine particulate matter, which may pass through the prescribed GF/C paper.**

Analytical Results

Sub-Matrix: **WATER**

Compound	CAS Number	LOR	Unit	Client sample ID: AQ04	AQ05	AQ17	AQ23	AQ25
				Client sampling date / time: 17-JUN-2011 09:25	15-JUN-2011 15:40	17-JUN-2011 13:48	16-JUN-2011 09:11	15-JUN-2011 16:39
				EB1112051-001	EB1112051-002	EB1112051-003	EB1112051-004	EB1112051-005
EA015: Total Dissolved Solids								
^ Total Dissolved Solids @180°C	GIS-210-010	5	mg/L	**98**	**91**	**479**	**514**	**473**
ED040F: Dissolved Major Anions								
Sulfate as SO4 2-	14808-79-8	1	mg/L	<1	<1	**7**	**2**	**3**
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	**10**	**11**	**4**	**9**	**4**
ED093T: Total Major Cations								
Calcium	7440-70-2	1	mg/L	**11**	**13**	**5**	**12**	**7**
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	**0.11**	**0.08**	**0.42**	**0.14**	**0.04**
Antimony	7440-36-0	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Arsenic	7440-38-2	0.001	mg/L	<0.001	**0.001**	<0.001	<0.001	**0.002**
Beryllium	7440-41-7	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Lead	7439-92-1	0.001	mg/L	<0.001	**0.001**	<0.001	**0.005**	**0.003**
Manganese	7439-96-5	0.001	mg/L	**0.003**	**0.004**	**0.104**	**0.004**	**0.004**
Molybdenum	7439-98-7	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Nickel	7440-02-0	0.001	mg/L	**0.001**	**0.001**	**0.001**	**0.001**	**0.002**
Uranium	7440-61-1	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Zinc	7440-66-6	0.005	mg/L	**0.008**	<0.005	<0.005	**0.005**	**0.009**
EG020T: Total Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	**1.78**	**1.56**	**8.79**	**24.0**	**21.8**
Antimony	7440-36-0	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Arsenic	7440-38-2	0.001	mg/L	<0.001	**0.002**	**0.002**	**0.004**	**0.006**
Beryllium	7440-41-7	0.001	mg/L	<0.001	<0.001	<0.001	**0.001**	<0.001
Lead	7439-92-1	0.001	mg/L	**0.002**	**0.001**	**0.006**	**0.015**	**0.005**
Manganese	7439-96-5	0.001	mg/L	**0.084**	**0.093**	**0.146**	**0.300**	**0.191**
Molybdenum	7439-98-7	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Nickel	7440-02-0	0.001	mg/L	**0.002**	**0.002**	**0.004**	**0.011**	**0.010**
Uranium	7440-61-1	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Zinc	7440-66-6	0.005	mg/L	<0.005	**0.006**	**0.005**	**0.020**	**0.028**
EG035F: Dissolved Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
EG094F: Dissolved Metals in Fresh Water by ORC-ICPMS								
Selenium	7782-49-2	0.2	µg/L	**0.2**	<0.2	**0.2**	**0.2**	**0.2**
Cadmium	7440-43-9	0.05	µg/L	<0.05	<0.05	<0.05	<0.05	<0.05
Chromium	7440-47-3	0.2	µg/L	**0.3**	**0.2**	**0.5**	**0.4**	**0.5**

Analytical Results

Sub-Matrix: **WATER**

Compound	CAS Number	LOR	Unit	Client sample ID: AQ04 Client sampling date / time: 17-JUN-2011 09:25 EB1112051-001	AQ05 15-JUN-2011 15:40 EB1112051-002	AQ17 17-JUN-2011 13:48 EB1112051-003	AQ23 16-JUN-2011 09:11 EB1112051-004	AQ25 15-JUN-2011 16:39 EB1112051-005
EG094F: Dissolved Metals in Fresh Water by ORC-ICPMS - Continued								
Copper	7440-50-8	0.5	µg/L	**1.6**	**1.4**	**1.0**	**2.8**	**2.8**
EG094T: Total metals in Fresh water by ORC-ICPMS								
Selenium	7782-49-2	0.2	µg/L	**0.2**	<0.2	**0.2**	**0.4**	**0.4**
Cadmium	7440-43-9	0.05	µg/L	<0.05	<0.05	<0.05	<0.05	<0.05
Chromium	7440-47-3	0.2	µg/L	**2.0**	**1.6**	**8.0**	**19.7**	**16.8**
Copper	7440-50-8	0.5	µg/L	**2.9**	**2.2**	**4.9**	**12.1**	**8.2**
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	<0.1	<0.1	<0.1	<0.1	**0.2**
EK055G: Ammonia as N by Discrete Analyser								
Ammonia as N	7664-41-7	0.01	mg/L	**0.04**	**0.02**	**0.43**	**0.07**	**0.02**
EK057G: Nitrite as N by Discrete Analyser								
Nitrite as N	----	0.01	mg/L	<0.01	<0.01	**0.05**	<0.01	<0.01
EK058G: Nitrate as N by Discrete Analyser								
^ Nitrate as N	14797-55-8	0.01	mg/L	**0.03**	**0.02**	**0.52**	**0.08**	**0.06**
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser								
Nitrite + Nitrate as N	----	0.01	mg/L	**0.03**	**0.02**	**0.57**	**0.08**	**0.06**
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser								
Total Kjeldahl Nitrogen as N	----	0.1	mg/L	**1.3**	**1.3**	**1.8**	**2.9**	**1.2**
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser								
^ Total Nitrogen as N	----	0.1	mg/L	**1.3**	**1.3**	**2.4**	**3.0**	**1.3**
EK067G: Total Phosphorus as P by Discrete Analyser								
Total Phosphorus as P	----	0.01	mg/L	**0.13**	**0.16**	**0.35**	**0.70**	**0.18**

Analytical Results

Sub-Matrix: **WATER**

Compound	CAS Number	LOR	Unit	Client sample ID	AQ28	AQ44	----	----	----
				Client sampling date / time	15-JUN-2011 18:00	15-JUN-2011 14:00	----	----	----
					EB1112051-006	EB1112051-007	----	----	----
EA015: Total Dissolved Solids									
^ Total Dissolved Solids @180°C	GIS-210-010	5	mg/L		----	**395**	----	----	----
ED040F: Dissolved Major Anions									
Sulfate as SO4 2-	14808-79-8	1	mg/L		----	**2**	----	----	----
ED093F: Dissolved Major Cations									
Calcium	7440-70-2	1	mg/L		**14**	**1**	----	----	----
ED093T: Total Major Cations									
Calcium	7440-70-2	1	mg/L		**15**	**2**	----	----	----
EG020F: Dissolved Metals by ICP-MS									
Aluminium	7429-90-5	0.01	mg/L		**0.02**	**0.17**	----	----	----
Antimony	7440-36-0	0.001	mg/L		<0.001	<0.001	----	----	----
Arsenic	7440-38-2	0.001	mg/L		<0.001	<0.001	----	----	----
Beryllium	7440-41-7	0.001	mg/L		<0.001	<0.001	----	----	----
Lead	7439-92-1	0.001	mg/L		**0.002**	<0.001	----	----	----
Manganese	7439-96-5	0.001	mg/L		**0.011**	**0.002**	----	----	----
Molybdenum	7439-98-7	0.001	mg/L		<0.001	<0.001	----	----	----
Nickel	7440-02-0	0.001	mg/L		<0.001	<0.001	----	----	----
Uranium	7440-61-1	0.001	mg/L		<0.001	<0.001	----	----	----
Zinc	7440-66-6	0.005	mg/L		<0.005	<0.005	----	----	----
EG020T: Total Metals by ICP-MS									
Aluminium	7429-90-5	0.01	mg/L		**0.12**	**9.58**	----	----	----
Antimony	7440-36-0	0.001	mg/L		<0.001	<0.001	----	----	----
Arsenic	7440-38-2	0.001	mg/L		<0.001	**0.001**	----	----	----
Beryllium	7440-41-7	0.001	mg/L		<0.001	<0.001	----	----	----
Lead	7439-92-1	0.001	mg/L		<0.001	**0.006**	----	----	----
Manganese	7439-96-5	0.001	mg/L		**0.028**	**0.026**	----	----	----
Molybdenum	7439-98-7	0.001	mg/L		<0.001	<0.001	----	----	----
Nickel	7440-02-0	0.001	mg/L		<0.001	**0.003**	----	----	----
Uranium	7440-61-1	0.001	mg/L		<0.001	<0.001	----	----	----
Zinc	7440-66-6	0.005	mg/L		<0.005	<0.005	----	----	----
EG035F: Dissolved Mercury by FIMS									
Mercury	7439-97-6	0.0001	mg/L		<0.0001	<0.0001	----	----	----
EG035T: Total Recoverable Mercury by FIMS									
Mercury	7439-97-6	0.0001	mg/L		<0.0001	<0.0001	----	----	----
EG094F: Dissolved Metals in Fresh Water by ORC-ICPMS									
Selenium	7782-49-2	0.2	µg/L		<0.2	**0.2**	----	----	----
Cadmium	7440-43-9	0.05	µg/L		<0.05	<0.05	----	----	----
Chromium	7440-47-3	0.2	µg/L		<0.2	**0.8**	----	----	----

Analytical Results

Sub-Matrix: WATER				Client sample ID	AQ28	AQ44	----	----	----
				Client sampling date / time	15-JUN-2011 18:00	15-JUN-2011 14:00	----	----	----
Compound	CAS Number	LOR	Unit		EB1112051-006	EB1112051-007	----	----	----
EG094F: Dissolved Metals in Fresh Water by ORC-ICPMS - Continued									
Copper	7440-50-8	0.5	µg/L		**0.5**	**0.9**	----	----	----
EG094T: Total metals in Fresh water by ORC-ICPMS									
Selenium	7782-49-2	0.2	µg/L		<0.2	**0.4**	----	----	----
Cadmium	7440-43-9	0.05	µg/L		<0.05	<0.05	----	----	----
Chromium	7440-47-3	0.2	µg/L		<0.2	**10.6**	----	----	----
Copper	7440-50-8	0.5	µg/L		**1.2**	**3.8**	----	----	----
EK040P: Fluoride by PC Titrator									
Fluoride	16984-48-8	0.1	mg/L		----	<0.1	----	----	----
EK055G: Ammonia as N by Discrete Analyser									
Ammonia as N	7664-41-7	0.01	mg/L		**0.04**	**0.01**	----	----	----
EK057G: Nitrite as N by Discrete Analyser									
Nitrite as N	----	0.01	mg/L		<0.01	<0.01	----	----	----
EK058G: Nitrate as N by Discrete Analyser									
^ Nitrate as N	14797-55-8	0.01	mg/L		**0.02**	**0.03**	----	----	----
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser									
Nitrite + Nitrate as N	----	0.01	mg/L		**0.02**	**0.03**	----	----	----
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser									
Total Kjeldahl Nitrogen as N	----	0.1	mg/L		**0.8**	**1.4**	----	----	----
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser									
^ Total Nitrogen as N	----	0.1	mg/L		**0.8**	**1.4**	----	----	----
EK067G: Total Phosphorus as P by Discrete Analyser									
Total Phosphorus as P	----	0.01	mg/L		**0.07**	**0.17**	----	----	----

CERTIFICATE OF ANALYSIS

Work Order	: **EB1112311**	Page	: 1 of 6
Client	: **AUSTRALASIAN RESOURCE CONSULTANTS**	Laboratory	: Environmental Division Brisbane
Contact	: MR PAUL JACKSON	Contact	: Customer Services
Address	: SUITE 5B 1 SWANN ROAD TARINGA QLD, AUSTRALIA 4068	Address	: 32 Shand Street Stafford QLD Australia 4053
E-mail	: pjackson@aarc.net.au	E-mail	: Brisbane.Enviro.Services@alsglobal.com
Telephone	: +61 07 3217 8772	Telephone	: +61 7 3243 7222
Facsimile	: +61 07 32178775	Facsimile	: +61 7 3243 7218
Project	: Alpha Coal	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Order number	: ----		
C-O-C number	: ----	Date Samples Received	: 24-JUN-2011
Sampler	: J Stibbard /D Taylor	Issue Date	: 15-JUL-2011
Site	: ----		
		No. of samples received	: 7
Quote number	: BN/279/10/BN/232/10	No. of samples analysed	: 7

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

NATA Accredited Laboratory 825

This document is issued in accordance with NATA accreditation requirements.

Accredited for compliance with ISO/IEC 17025.

Signatories

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Celine Conceicao	Spectroscopist	Sydney Inorganics
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics
Raymond Commodor	Instrument Chemist	Sydney Inorganics
Wisam Marassa	Metals Coordinator	Sydney Inorganics

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insuffient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting

- **It is recognized that EG020A-F (Dissolved Metals) results are higher than EG020A-T (Total Metals) for some samples. However, the difference is within experimental variation of the methods.**
- **LCS recovery for Cu falls outside Dynamic Control Limits. It is however within ALS Static Control Limits and hence deemed acceptable.**
- **TDS by method EA-015 may bias high due to the presence of fine particulate matter, which may pass through the prescribed GF/C paper.**

Analytical Results

Sub-Matrix: **WATER**

Compound	CAS Number	LOR	Unit	Client sample ID: AQ06	AQ09	AQ31	AQ49	AQ31_R
				Client sampling date / time: 20-JUN-2011 12:33	20-JUN-2011 15:53	19-JUN-2011 09:35	18-JUN-2011 15:49	19-JUN-2011 09:35
				EB1112311-001	EB1112311-002	EB1112311-003	EB1112311-004	EB1112311-005
EA015: Total Dissolved Solids								
^ Total Dissolved Solids @180°C	GIS-210-010	5	mg/L	**255**	**106**	**162**	**161**	**126**
ED040F: Dissolved Major Anions								
Sulfate as SO4 2-	14808-79-8	1	mg/L	**2**	<1	<1	<1	<1
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	**31**	**3**	**8**	**12**	**8**
ED093T: Total Major Cations								
Calcium	7440-70-2	1	mg/L	**33**	**4**	**8**	**13**	**9**
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	**0.03**	**0.26**	**0.36**	**0.61**	**0.34**
Antimony	7440-36-0	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Arsenic	7440-38-2	0.001	mg/L	<0.001	<0.001	**0.001**	<0.001	**0.001**
Beryllium	7440-41-7	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Lead	7439-92-1	0.001	mg/L	**0.009**	<0.001	<0.001	<0.001	**0.002**
Manganese	7439-96-5	0.001	mg/L	**0.149**	**0.006**	**0.002**	**0.002**	**0.003**
Molybdenum	7439-98-7	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Nickel	7440-02-0	0.001	mg/L	**0.001**	<0.001	**0.002**	**0.001**	**0.002**
Uranium	7440-61-1	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Zinc	7440-66-6	0.005	mg/L	**0.006**	**0.007**	<0.005	<0.005	<0.005
EG020T: Total Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	**0.13**	**0.22**	**0.76**	**2.03**	**0.80**
Antimony	7440-36-0	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Arsenic	7440-38-2	0.001	mg/L	<0.001	**0.001**	**0.002**	**0.002**	<0.001
Beryllium	7440-41-7	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	<0.001	**0.002**	**0.001**
Manganese	7439-96-5	0.001	mg/L	**0.175**	**0.014**	**0.076**	**0.061**	**0.079**
Molybdenum	7439-98-7	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Nickel	7440-02-0	0.001	mg/L	**0.002**	<0.001	**0.002**	**0.002**	**0.003**
Uranium	7440-61-1	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Zinc	7440-66-6	0.005	mg/L	**0.005**	<0.005	<0.005	**0.006**	<0.005
EG035F: Dissolved Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
EG094F: Dissolved Metals in Fresh Water by ORC-ICPMS								
Selenium	7782-49-2	0.2	µg/L	<0.2	<0.2	<0.2	<0.2	<0.2
Cadmium	7440-43-9	0.05	µg/L	<0.05	<0.05	<0.05	<0.05	<0.05
Chromium	7440-47-3	0.2	µg/L	<0.2	**0.2**	**0.2**	**0.4**	<0.2

Analytical Results

Sub-Matrix: **WATER**

Compound	CAS Number	LOR	Unit	Client sample ID: AQ06	AQ09	AQ31	AQ49	AQ31_R
				Client sampling date / time: 20-JUN-2011 12:33	20-JUN-2011 15:53	19-JUN-2011 09:35	18-JUN-2011 15:49	19-JUN-2011 09:35
				EB1112311-001	EB1112311-002	EB1112311-003	EB1112311-004	EB1112311-005
EG094F: Dissolved Metals in Fresh Water by ORC-ICPMS - Continued								
Copper	7440-50-8	0.5	µg/L	**0.5**	**0.5**	**2.0**	**2.0**	**1.9**
EG094T: Total metals in Fresh water by ORC-ICPMS								
Selenium	7782-49-2	0.2	µg/L	<0.2	<0.2	<0.2	<0.2	<0.2
Cadmium	7440-43-9	0.05	µg/L	<0.05	<0.05	<0.05	<0.05	<0.05
Chromium	7440-47-3	0.2	µg/L	**0.5**	**0.3**	**1.2**	**2.6**	**1.4**
Copper	7440-50-8	0.5	µg/L	**1.6**	**0.5**	**2.1**	**3.5**	**2.3**
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	**0.2**	<0.1	<0.1	<0.1	<0.1
EK055G: Ammonia as N by Discrete Analyser								
Ammonia as N	7664-41-7	0.01	mg/L	**0.02**	**0.03**	**0.03**	**0.05**	**0.04**
EK057G: Nitrite as N by Discrete Analyser								
Nitrite as N	----	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
EK058G: Nitrate as N by Discrete Analyser								
^ Nitrate as N	14797-55-8	0.01	mg/L	**0.03**	**0.03**	**0.05**	**0.06**	**0.04**
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser								
Nitrite + Nitrate as N	----	0.01	mg/L	**0.03**	**0.03**	**0.05**	**0.06**	**0.04**
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser								
Total Kjeldahl Nitrogen as N	----	0.1	mg/L	**0.3**	**0.9**	**1.2**	**2.2**	**1.2**
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser								
^ Total Nitrogen as N	----	0.1	mg/L	**0.3**	**0.9**	**1.2**	**2.3**	**1.2**
EK067G: Total Phosphorus as P by Discrete Analyser								
Total Phosphorus as P	----	0.01	mg/L	**0.05**	**0.07**	**0.08**	**0.29**	**0.08**

Analytical Results

Sub-Matrix: **WATER**

Compound	CAS Number	LOR	Unit	Client sample ID: AQ49_R	AQ48	----	----	----
				Client sampling date / time: 18-JUN-2011 15:40	21-JUN-2011 12:00	----	----	----
				EB1112311-006	EB1112311-007	----	----	----
EA015: Total Dissolved Solids								
^ Total Dissolved Solids @180°C	GIS-210-010	5	mg/L	**198**	**182**	----	----	----
ED040F: Dissolved Major Anions								
Sulfate as SO4 2-	14808-79-8	1	mg/L	<1	<1	----	----	----
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	**12**	**14**	----	----	----
ED093T: Total Major Cations								
Calcium	7440-70-2	1	mg/L	**13**	**14**	----	----	----
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	**0.55**	**0.08**	----	----	----
Antimony	7440-36-0	0.001	mg/L	<0.001	<0.001	----	----	----
Arsenic	7440-38-2	0.001	mg/L	<0.001	<0.001	----	----	----
Beryllium	7440-41-7	0.001	mg/L	<0.001	<0.001	----	----	----
Lead	7439-92-1	0.001	mg/L	<0.001	**0.002**	----	----	----
Manganese	7439-96-5	0.001	mg/L	**0.002**	**0.002**	----	----	----
Molybdenum	7439-98-7	0.001	mg/L	<0.001	<0.001	----	----	----
Nickel	7440-02-0	0.001	mg/L	**0.001**	<0.001	----	----	----
Uranium	7440-61-1	0.001	mg/L	<0.001	<0.001	----	----	----
Zinc	7440-66-6	0.005	mg/L	<0.005	**0.006**	----	----	----
EG020T: Total Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	**2.33**	**1.40**	----	----	----
Antimony	7440-36-0	0.001	mg/L	<0.001	<0.001	----	----	----
Arsenic	7440-38-2	0.001	mg/L	**0.002**	<0.001	----	----	----
Beryllium	7440-41-7	0.001	mg/L	<0.001	<0.001	----	----	----
Lead	7439-92-1	0.001	mg/L	**0.002**	**0.003**	----	----	----
Manganese	7439-96-5	0.001	mg/L	**0.071**	**0.054**	----	----	----
Molybdenum	7439-98-7	0.001	mg/L	<0.001	<0.001	----	----	----
Nickel	7440-02-0	0.001	mg/L	**0.002**	**0.002**	----	----	----
Uranium	7440-61-1	0.001	mg/L	<0.001	<0.001	----	----	----
Zinc	7440-66-6	0.005	mg/L	**0.008**	**0.019**	----	----	----
EG035F: Dissolved Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	----	----	----
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	----	----	----
EG094F: Dissolved Metals in Fresh Water by ORC-ICPMS								
Selenium	7782-49-2	0.2	µg/L	<0.2	<0.2	----	----	----
Cadmium	7440-43-9	0.05	µg/L	<0.05	<0.05	----	----	----
Chromium	7440-47-3	0.2	µg/L	**0.4**	**0.2**	----	----	----

Analytical Results

Sub-Matrix: WATER				Client sample ID	AQ49_R	AQ48	----	----	----
				Client sampling date / time	18-JUN-2011 15:40	21-JUN-2011 12:00	----	----	----
Compound	CAS Number	LOR	Unit		EB1112311-006	EB1112311-007	----	----	----
EG094F: Dissolved Metals in Fresh Water by ORC-ICPMS - Continued									
Copper	7440-50-8	0.5	µg/L		**2.0**	**2.0**	----	----	----
EG094T: Total metals in Fresh water by ORC-ICPMS									
Selenium	7782-49-2	0.2	µg/L		<0.2	<0.2	----	----	----
Cadmium	7440-43-9	0.05	µg/L		<0.05	<0.05	----	----	----
Chromium	7440-47-3	0.2	µg/L		**2.4**	**1.8**	----	----	----
Copper	7440-50-8	0.5	µg/L		**3.1**	**3.0**	----	----	----
EK040P: Fluoride by PC Titrator									
Fluoride	16984-48-8	0.1	mg/L		<0.1	<0.1	----	----	----
EK055G: Ammonia as N by Discrete Analyser									
Ammonia as N	7664-41-7	0.01	mg/L		**0.04**	**0.03**	----	----	----
EK057G: Nitrite as N by Discrete Analyser									
Nitrite as N	----	0.01	mg/L		<0.01	<0.01	----	----	----
EK058G: Nitrate as N by Discrete Analyser									
^ Nitrate as N	14797-55-8	0.01	mg/L		<0.01	<0.01	----	----	----
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser									
Nitrite + Nitrate as N	----	0.01	mg/L		<0.01	<0.01	----	----	----
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser									
Total Kjeldahl Nitrogen as N	----	0.1	mg/L		**1.1**	**0.8**	----	----	----
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser									
^ Total Nitrogen as N	----	0.1	mg/L		**1.1**	**0.8**	----	----	----
EK067G: Total Phosphorus as P by Discrete Analyser									
Total Phosphorus as P	----	0.01	mg/L		**0.09**	**0.05**	----	----	----

Appendix D: Dominant Vegetation Species List

Table 20 Dominant Vegetation Species List

Botanical Name	AQ1	AQ2	AQ3	AQ4	AQ5	AQ6	AQ7	AQ8	AQ9	AQ10	AQ11	AQ12	AQ13	AQ14	AQ15	AQ16	AQ17
Abutilon sp.				X	X												
Acacia cambagei													X				
Acacia farnesiana				X													
Acacia harpophylla					X								X				X
Acacia oswaldii					X												
Achyranthes aspera				X													
Archidendropsis basaltica								X		X							
Alternanthera angustifolia	X		X		X						X						
Basilicum polystachyon					X												
*Bothriochloa decipiens**								X									
Callitris glaucophylla														X			
Carissa lanceolata					X					X					X		
Cenchrus ciliaris	X			X						X		X	X				X
Cenchrus sp				X													
*Chrysopogon filipes**						X											
Crinum sp																	

Table 20 (cont) Dominant Vegetation Species List

Botanical Name	AQ1	AQ2	AQ3	AQ4	AQ5	AQ6	AQ7	AQ8	AQ9	AQ10	AQ11	AQ12	AQ13	AQ14	AQ15	AQ16	AQ17
Cucumis anguria var. *anguria**										X							
Cynodon dactylon					X												
Cyperaceae sp						X			X								
Cyperus conicus var. *conicus*			X							X					X		
Cyperus dactylotes	X		X						X		X						
Cyperus difformis	X																
Cyperus iria			X														
*Cyperus javanicus**						X											
Echinochloa colona					X					X							
Eleocharis acuta					X												
Eremophila mitchellii					X					X	X		X				
Eragrostis elongatus				X	X				X	X							
Eragrostis speciosa			X					X			X				X		
Eucalyptus camaldulensis		X		X	X	X		X		X	X	X			X	X	X
Eucalyptus melanophloia									X	X				X			
Eucalyptus populnea				X	X				X			X					X

Table 20 (cont) Dominant Vegetation Species List

Botanical Name	AQ1	AQ2	AQ3	AQ4	AQ5	AQ6	AQ7	AQ8	AQ9	AQ10	AQ11	AQ12	AQ13	AQ14	AQ15	AQ16	AQ17
Corymbia tesselaris							X										
Fimbristylis microcarya										X							
Fuirena incrassata										X							
Grewia retusifolia											X						
Ipomoea plebia	X					X					X						
Juncus usitatus										X							
Leptochloa digitata				X	X												
Lomandra sp	X					X										X	
Ludwigia octovalvis									X								
Marsilea mutica					X												
Melaleuca bracteata	X	X	X			X	X						X				
Melinus repens	X							X		X		X			X		
Monochoria cyanea					X												
Nymphoides crenata					X												
Opuntia tomentosa	X																
*Panicum larcomianum**						X											
Persicaria decipiens						X			X								
Petalostigma pubescens											X			X	X		

Table 20 (cont) Dominant Vegetation Species List

Botanical Name	AQ1	AQ2	AQ3	AQ4	AQ5	AQ6	AQ7	AQ8	AQ9	AQ10	AQ11	AQ12	AQ13	AQ14	AQ15	AQ16	AQ17
Poaceae sp												X			X		
Potamogeton sp									X								
Ricinus communis						X											
Scoparia dulcis			X														
Sida sp	X			X							X						
Sida cordifolia																X	X
Sorghum x almum																	X
Spermacoce bracystema			X														
Sporobolus caroli										X							
Stylosanthes scabra				X										X			
Themeda triandra	X							X		X	X			X	X		
Verbena incompta	X																
Verbesina encelioides	X		X	X							X						
Xanthium pungens		X	X			X	X					X					X

* Species only recently identified and were not included in Terrestrial Flora and Fauna report

Table 20 (cont) Dominant Vegetation Species List

Botanical Name	AQ18	AQ19	AQ20	AQ21	AQ22	AQ23	AQ24	AQ25	AQ26	AQ27	AQ28	AQ29	AQ30	AQ31	AQ32	AQ33
Acacia harpophylla	X							X							X	X
Acacia salicina							X									
Alternanthera angustifolia						X				X	X			X	X	X
Ammania multiflora						X						X				
Aristida sp			X													
Basilicum polystachyon	X					X					X				X	
Bothriochloa bladhii						X	X									
Carissa lanceolata	X															
Carissa ovata							X									
Cenchrus sp			X				X				X			X		
Centipeda sp.															X	
Chloris pectinata																X
Cynodon dactylon									X	X	X			X		X
Cyperaceae sp		X							X							
*Cyperus betchei**															X	
Cyperus dactylotes	X	X		X	X					X	X		X			
Cyperus difformis						X		X	X							
Cyperus iria								X					X			

Table 20 (cont) Dominant Vegetation Species List

Botanical Name	AQ18	AQ19	AQ20	AQ21	AQ22	AQ23	AQ24	AQ25	AQ26	AQ27	AQ28	AQ29	AQ30	AQ31	AQ32	AQ33
Cyperus polystachyos								X	X			X				
Dichanthium sericeum	X						X									
Echinochloa colona										X	X		X			
Eleocharis acuta											X				X	
Eleocharis philippensis											X					
Enneapogon sp	X									X						
Eragrostis elongatus						X	X		X					X	X	
Eucalyptus camaldulensis				X		X	X				X			X	X	
Eucalyptus populnea						X	X				X	X			X	
Fabaceae sp										X						
Fimbristylis littoralis											X					
Fimbristylis sp						X										
Leptochloa digitata	X					X				X	X			X		
Leptochloa fusca				X				X				X	X			
Ludwigia octovalvis		X														
Lysiphyllum sp							X									
Marsilea drummondii												X		X	X	
Marsilea mutica										X	X					
Melaleuca bracteata							X									

Table 20 (cont) Dominant Vegetation Species List

Botanical Name	AQ18	AQ19	AQ20	AQ21	AQ22	AQ23	AQ24	AQ25	AQ26	AQ27	AQ28	AQ29	AQ30	AQ31	AQ32	AQ33
Melinis repens				X												
Monochoria cyanea								X				X				
Najas tenuifolia										X						
Nymphaea immutabilis											X					
Nymphoides crenata											X					
Ottelia ovalifolia											X					
Parkinsonia aculeata														X		
Persicaria decipiens							X									
Petalostigma sp				X												
Poaceae sp	X						X			X	X					
Potamogeton sp											X					
Pseudraphis spinescens						X						X				
Salsola kali											X					
Schoenoplectus dissachanthus											X					
Senna sp.											X					
Senna occidentalis														X		
Sporobolus caroli																X
Stylosanthes scabra									X							

Table 20 (cont) Dominant Vegetation Species List

Botanical Name	AQ18	AQ19	AQ20	AQ21	AQ22	AQ23	AQ24	AQ25	AQ26	AQ27	AQ28	AQ29	AQ30	AQ31	AQ32	AQ33
Vallisneria sp.														X		
Xanthium pungens						X								X		

* Species only recently identified and were not included in the Terrestrial Flora and Fauna report

Table 20 (cont) Dominant Vegetation Species List

Botanical Name	AQ34	AQ35	AQ36	AQ37	AQ38	AQ39	AQ40	AQ41	AQ42	AQ43	AQ44	AQ45	AQ47	AQ48	AQ49
Acacia harpophylla	X	X	X			X		X	X	X					X
Acacia longispicata								X							
Acacia salicina														X	
Acacia shirleyi											X				
Alphitonia excelsa								X							
Alternanthera angustifolia					X		X	X					X		X
Ammania multiflora			X	X		X			X						
Archidendropsis basaltica									X	X					
Aristida sp					X	X		X							
Basilicum polystachyon	X					X			X				X		X
Bothriochloa bladhii			X		X			X		X					
Callitris glaucophylla										X					
Carissa lanceolata				X		X									
Carissa ovata	X	X		X		X			X						
Corymbia terminalis							X	X							
Corymbia tesselaris							X								
Cenchrus sp	X	X		X	X			X		X		X			
Cynodon dactylon														X	

Table 20 (cont) Dominant Vegetation Species List

Botanical Name	AQ34	AQ35	AQ36	AQ37	AQ38	AQ39	AQ40	AQ41	AQ42	AQ43	AQ44	AQ45	AQ47	AQ48	AQ49
Cyperaceae sp			X	X		X							X		
Cyperus dactylotes						X		X							
Cyperus difformis						X			X				X		
Cyperus iria					X	X									
Cyperus polystachyos				X				X	X						
Dichanthium sericeum				X	X	X									
Echinochloa colona				X	X				X						
Eleocharis acuta			X		X										
Eleocharis philippensis			X		X	X			X						
Elytrophorus spicatus		X													
Enneapogon sp			X			X									
Eragrostis elongata									X						
Eragrostis speciosa									X						
Eremophila mitchellii														X	
Eucalyptus camaldulensis			X	X	X	X	X	X	X	X		X	X	X	X
Eucalyptus melanophloia									X		X			X	
Eucalyptus populnea	X								X	X			X		X
Heteropogon contortus									X	X		X			

Table 20 (cont) Dominant Vegetation Species List

Botanical Name	AQ34	AQ35	AQ36	AQ37	AQ38	AQ39	AQ40	AQ41	AQ42	AQ43	AQ44	AQ45	AQ47	AQ48	AQ49
Fabaceae sp						X		X							
Fimbristylis littoralis				X		X									
Fimbristylis sp				X	X	X		X	X						
Grevillea pteridifolia								X							
Leptochloa digitata		X			X			X	X				X	X	X
Leptochloa fusca				X	X	X			X						
Lomandra sp.							X	X							
Ludwigia octovalvis					X	X			X						
Lysiphyllum sp			X	X				X							
Marsilea mutica								X							
Melaleuca bracteata			X	X				X							
Melinis repens				X	X		X	X	X						
Monochoria cyanea			X		X		X	X	X						
Najas tenuifolia			X			X		X	X						
Nymphaea immutabilis			X				X	X							
Nymphoides crenata				X			X	X	X						
Parkinsonia aculeata			X	X	X				X				X		
Petalostigma sp			X		X	X	X	X							
Poaceae sp							X								

Table 20 (cont) Dominant Vegetation Species List

Botanical Name	AQ34	AQ35	AQ36	AQ37	AQ38	AQ39	AQ40	AQ41	AQ42	AQ43	AQ44	AQ45	AQ47	AQ48	AQ49
Potamogeton sp				X		X			X						
Pseudraphis spinescens				X				X							
Salsola kali				X	X	X									
Schoenoplectus dissachanthus							X								
Sorghum x almum		X													
Senna occidentalis								X	X						
Sida cordifolia							X								
Xanthium pungens			X		X		X								

Appendix E: Pest Fact Sheets

Cane toads

Bufo marinus

The cane toad *(Bufo marinus) i*s not a declared pest in Queensland, so there is no legal requirement to control them.

Their original introduction in 1935 was to control agricultural pests, but they proved ineffective.

For the past 60 years, cane toads have been expanding their territory in Australia, and are capable of colonising at least four of the mainland Australian states.

As the toad's geographical range continues to expand, concern has increased about their detrimental environmental effects, particularly on the wetlands of the Northern Territory.

Studies into the feasibility of biological control have commenced.

History of introduction and spread

The cane toad or giant toad *(Bufo marinus)* is an amphibian, native to Central and South America. They have been introduced throughout the world as a biological control for insect pests of agriculture, most notably sugarcane.

A consignment of cane toads from Hawaii was released into Queensland cane fields in 1935. The introduction was surrounded by controversy as to the potential costs and benefits to Australia.

It was hoped that the toad would control Frenchi and greyback beetles—pests of economic importance to the sugarcane industry.

Queensland Government

PA21 September 2009

By 1941, however, it had become evident that the cane toad was exerting only limited control over its intended prey. There were two main reasons for this:

- Greyback beetles are only rarely in contact with the ground and Frenchi beetles invade cane fields at a time when the toads are absent due to a lack of protective cover.
- The cane toad has a wide-ranging and indiscriminate diet, and it was not solely dependant upon its intended prey.

The unlimited food source, suitable environment and low rates of predation allowed dynamic reproduction and spread. Toads were recorded in Brisbane only 10 years after release. The toad continues to thrive and has now invaded the Northern Territory and New South Wales (see Figure 1).

Figure 1 Current distribution of the cane toad

The cane toad's advance is only limited by environmental factors, such as the availability of water for breeding, tolerable temperatures, suitable shelter and an abundance of food

Toads at the frontier of their range of expansion may be larger than those in established populations. This is most probably due to greater food supply, combined with a lower incidence of disease.

Description and general information

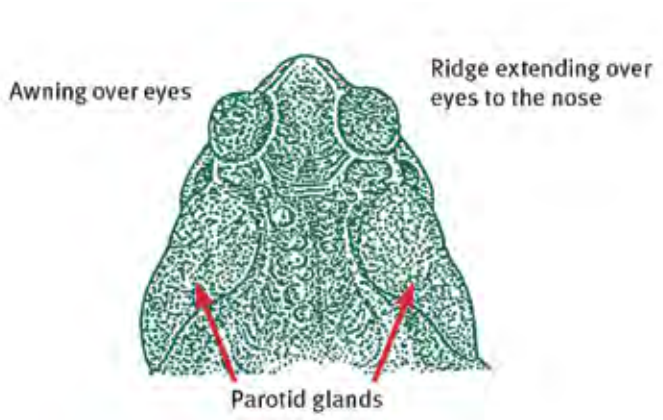
In comparison with native frog and toad species, adult cane toads have a distinctive head and face, and are large and heavily built creatures (adults may grow to 20 cm).

Following their aquatic larval stages (eggs and tadpoles), cane toads are generally encountered at night near any source of light. Cane toads are ground-dwelling—they are poor climbers and unable to jump very high.

A definite visor or awning extends over each eye and a high angular bony ridge extends from the eyes to the nose.

The parotid glands (see Figure 2) are perhaps the most characteristic feature of the adult cane toad. These glands are large, protuberant, and are situated on the head behind each ear. These glands carry a toxin.

Figure 2 Distinguishing features of the cane toad



The cane toad's hands and feet are relatively small and lack discs at the tips of the digits. Webbing is absent between the fingers but is distinct and leathery between the toes.

Colouring on the dorsal (upper) surface may be brown, olive-brown or reddish-brown. The ventral (under) surface varies from white to yellow and is usually mottled with brown.

Warts are present on all cane toads; however, males possess more than females. Warts are dark brown at the caps.

Mating

Mating can occur at any time of the year and depends only on available food and permanent water. The mating call is a continuous purring trill that sounds like a running motor.

In situations where females are scarce or absent, male cane toads may have the ability to undergo a sex change to become fertile females; however, this has not been proved.

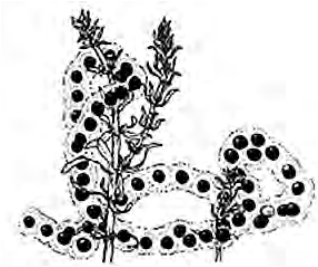
Eggs

Both cane toads and native frogs spawn in slow-moving or still water, but their eggs can be easily distinguished.

Cane toad eggs are laid in long, gelatinous 'strings' with the developing tadpoles appearing as a row of small black dots along the length. The strings are unique to cane toads, with native frogs eggs laid in clusters, generally appearing as blobs of jelly attached to water plants or debris. Native frogs generally produce egg clusters as mounds of foam floating on the water surface.

Compared with native species, cane toad egg production is dynamic and a single clutch can contain up to 35 000 eggs. Remove any cane toad eggs found in the water and allow to dry out.

Figure 3 Drawing of toad spawn from *Wildlife of greater Brisbane*, page 166



Tadpoles

The cane toad is the only species in Australia that has a pure black tadpole. Native frogs have lighter-coloured undersides with a great range of colours and markings—cane toad tadpoles may turn paler colours to almost transparent at night.

Cane toad tadpoles are small and usually congregate in vast, slow-moving shoals. This 'shoaling' behaviour is uncharacteristic of most native species.

Unlike cane toad tadpoles, native species develop lungs at an early stage and periodically rise to the surface in order to exchange their lung gasses. Large groupings of tadpoles that do not break the water surface for air indicate cane toads.

Young toads

Following emergence from the water, the young toadlets usually congregate around the moist perimeter of the water body for about a week before they eventually disperse.

Young toads are very difficult to distinguish from the native *Uperoleiea* species, which also have parotid glands, but all *Uperolelea* species have bright red patches in the groin area.

Under ideal conditions toadlets may reach adult size within a year.

Toxicity

Bufo marinus produce venom in glands occurring in most of the skin on their upper surface. The venom is concentrated in the parotid glands as a creamy-white solution, which is released when the animal experiences extreme provocation or direct localised pressure (e.g. grasped by the mouth of a predator).

The parotid solution is highly toxic and when ingested it produces drastic acceleration of the heartbeat, shortness of breath, salivation and prostration. It is extremely painful if accidentally rubbed into the eye.

Ingestion of toads by domestic and most native animals can result in death. In some recorded cases, death has occurred within 15 minutes.

Field observations suggest that some predatory Australian species have learned how to feed safely on cane toads.

Birds have been observed flipping toads over to avoid the parotid glands. Predatory reptiles may have more trouble adapting, being unable to remove a toad from the mouth once they start feeding.

Effects on wildlife

The cane toad is poisonous at all stages of its life cycle and most native frog larvae and many aquatic invertebrates are dramatically affected by their presence.

Cane toads are voracious feeders that consume a wide variety of insects, frogs, small reptiles, mammals and even birds. Perhaps the only limiting factor to the prey taken is the width of the cane toad's mouth.

It has been suggested that cane toad competition for food and breeding grounds has been responsible for reducing the populations of some native frogs. However, many native frogs are arboreal (tree-dwelling) and occupy different niches. Cane toads don't have the native frogs' ability to 'shut down' during dry seasons when resources are limited.

Pressure from cane toads may displace native animals (frogs and other species) where they already suffer due to manipulation of their habitat by humans and grazing animals. Animals that use waterholes as retreat sites during the dry season are especially vulnerable—toads will congregate here in large numbers.

Public health

Cane toads readily eat animal and human faecal material and, in areas of poor hygiene, they have been known to transmit disease such as salmonella.

Control

Control of the cane toad has never been enforced and has remained at the discretion of the individual. Recently, the Brisbane City Council established the Cane Toad Eradication Committee that urges residents to exercise greater control of the pest.

Freezing is the most humane form of treatment. As a reaction to cold, cane toads initiate dormancy and eventually die in their sleep.

Fencing is recommended to keep toads out of ponds intended for native fish and frogs; a height of 50 cm is sufficient. Bird wire with 1 cm holes may keep toads out of an area.

CSIRO are investigating organisms for biological control. However, exhaustive testing would be necessary to ensure that viral or bacterial agents are cane toad specific and not harmful to native species.

Injured or 'lost' frogs

Brisbane Forest Park	07 3300 4855
Wildlife Preservation Society of Queensland	07 3221 0194
Queensland Museum	07 3840 7555

WILVO's Wildlife Volunteer's Organistaion (check your local phone directory to see if a group operates in your area).

Further information

Further information is available from your local government office, or from your local primary industries and fisheries biosecurity officer: contact details are available through 13 25 23.

PR09_4541R

Castor oil plant

Ricinus communis

Castor oil plant spreads over sandy soil areas, creek banks and gullies. This can lead to a significant loss of prime grazing land.

The seeds of castor oil contain ricin, a poison that is extremely toxic to livestock and humans. Leaves have a lesser amount of toxin. Symptoms of poisoning in animals usually do not appear for a few hours or several days.

Seeds cause gastrointestinal disorders and leaves tend to cause neuromuscular disorders. Poisoning in livestock is rarely reported though, as castor oil plant is seldom grazed by stock when other pasture plants are available. Also, small amounts of the plant will induce an immunity to poisoning.

Declaration details

Castor oil plant is not declared under the *Land Protection (Pest and Stock Route Management) Act 2002*; however, plants that are not declared under state legislation may have control requirements imposed by local governments.

Description and general information

Castor oil plant is a tall, branching perennial shrub that grows to 3 m high and occasionally higher. It has stout, hollow branches that are a dull pale green or red. Older branches and trunks turn greyish.

Large leaves (10–60 cm across) are widely spaced on the branches and grow on long, stout, hollow stalks attached off-centre to the bottom of the leaf. Each leaf is divided into 7–9 pointed triangular segments with toothed edges and conspicuous veins. Leaves are glossy, dark reddish-green when young and glossy green when mature.

The flowers are crowded in stout, erect spikes in the forks of the upper branches. Female flowers are in the upper part of the spikes and male flowers at the base.

Female flowers develop into fruit about 2.5 cm across that are covered with soft green or red spines. The fruit have three segments, each segment containing one large, mottled, smooth seed. When ripe, the fruit explode violently and throw the seeds a distance of several metres.

Queensland Government

PP44 April 2010

The name castor oil plant is sometimes mis-applied to bellyache bush (*Jatropha gossypifolia*). Bellyache bush can be found in similar habitats but is usually smaller than castor oil plant; has leaves with only three smooth, rounded lobes; and has small, smooth fruits found in clusters in the upper parts of the plant.

Habitat and distribution

Castor oil plant is native to Africa and Asia, and is now naturalised throughout Australia. It is often abundant along watercourses and floodplains, disturbed or waste land, and roadsides. It may be common locally after heavy rains or floods.

Control

Individual plants or small infestations may be removed by cultivation or hand-pulling. Broadscale infestations may require spraying with herbicides to control the plant.

Herbicides registered for the control of castor oil plant are provided in Table 1.

Further information

Further information is available from your local government office, or by contacting Biosecurity Queensland (call 13 25 23 or visit our website at www.biosecurity.qld.gov.au).

Table 1. Herbicides registered for the control of castor oil plant

Situation	Herbicide	Rate	Comments
Foliar (overall spray)	2,4-D amine	4.2 L/ha	Add wetting agent Spray plant to point of run-off
Basal spray/cut stump	Garlon 600/Triclopyr	1.7 L per 100 L diesel	Basal spray around entire base of plant to a height of 40 cm when plant is actively growing Cut stump at any time of year, but treat stump immediately after cutting

Read the label carefully before use. Always use the herbicide in accordance with the directions on the label.

PR10–4908

Invasive plants and animals

Feral pigs in Queensland

- distribution, ecology and impact

DECLARED CLASS 2

Domestic pigs *(Sus scrofa*) were introduced to Australia by early settlers. Subsequent accidental and deliberate releases resulted in the wild (feral) population establishing throughout Australia. Feral pigs damage crops, stock and property, spread weeds and transmit diseases such as Leptospirosis and Foot and Mouth. They also cause environmental damage, digging up large areas of native vegetation and spreading weeds.

Feral pigs are declared Class 2 pests under *Land Protection (Pest and Stock Route Management) Act 2002*. Declaration requires landholders to control declared pest on the land under their control. A local government may serve a notice upon a landholder requiring control of declared pests.

For information on Control of feral pigs see DPI&F Pest Fact PA7. For specific information of Feral Pig management in the wet tropics, see DPI&F Pest Fact PA8.

Description

Australian feral pigs have more in common with their Eurasian cousins than with domestic pigs. They are smaller, leaner and more muscular than domestic pigs, with well-developed shoulders and necks and smaller, shorter hindquarters. Their hair is sparse and longer and coarser than domestic pigs. Feral pigs also have longer, larger snouts and tusks, straight tails, smaller mostly pricked ears and much narrower backs.

Colouring is predominantly black, buff-coloured or spotted black and white. Some are agouti-patterned (dark hair with a lighter tip). Juveniles may be striped. Colours vary between and within areas.

Growth potential is similar to domestic pigs, although harsh environmental conditions tend to stunt development. The weight of an average adult female feral pig is roughly 50 to 60 kg, with the males usually weighing 80 to 100 kg. Exceptional animals have reached 260 kg.

Older boars (razorbacks) have massive heads and shoulders and a raised and prominent back bone which slopes steeply down to small hams and short hind legs. A keratinous plaque or shield up to three centimetres thick usually develops on their shoulders and flanks. This provides some protection from serious injury during fights with other boars.

Some boars develop a crest or mane of stiff bristles extending from their neck down the middle of their back, which stands straight on end when the animal is enraged.

Distribution

Feral pigs inhabit about 40% of Australia from subalpine grasslands to monsoonal floodplains and are found in all habitat types in Queensland – see figure 1.

Areas need supply only the basics of food, water and cover.

Estimations of numbers of feral pigs in Australia range up to 24 million. The greatest concentrations of feral pigs are on the larger drainage basins and swamp areas of the coast and inland.

Biology and behaviour

Feral pigs are capable of migrating considerable distances but they tend to stay in home ranges, with watering points the focus of activity, particularly during hot weather. Pigs have few sweat glands, so high temperatures require them to drink more often and wallow in water or mud to cool off. Dense cover is the preferred habitat, providing protection from the sun and their main predator, man.

Female and juvenile pigs usually live in small family groups with a home range of 2–20 km^2. Adult males are typically solitary, with a home range of 8–50 km^2. Range size varies with season, habitat, food availability and disturbance. Herds of 400 pigs have been recorded in Cape York.

Most pigs remain in their home ranges, even when subject to some disturbance such as infrequent hunting by people and dogs. Regular disturbance will drive them on.

Feral pigs are generally nocturnal, spending daylight hours sheltering in dense cover. They are shy animals and will avoid humans, making it easy to miss their presence or to drastically underestimate their numbers.

Pigs are omnivorous, eating plants and animal flesh. They are extremely opportunistic feeders, exploiting any temporarily abundant food. They prefer green feed and will eat grains, sugar cane and other crops, fruits and vegetables. They root extensively for tubers, worms and soil invertebrates. Small animals are preyed upon. Stock losses occur primarily with lambs but occasionally with newborn calves. Carrion (dead and rotting flesh) is also consumed.

Feral pigs have relatively high energy and protein requirements, particularly during pregnancy and lactation. These requirements are not available for all the year in all areas, so pigs often have to move to other parts of their home range during pregnancy.

This seasonal need for either more food, or high energy or protein-rich food, is often the reason for their impact on agricultural crops. It is also the weakness in their ecology that can be exploited for management purposes.

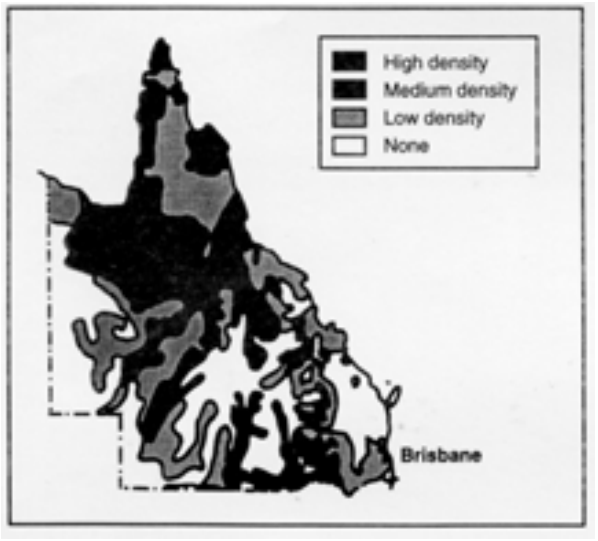


FIGURE 1 − DISTRIBUTION OF FERAL PIGS IN QUEENSLAND

Life cycle

The reproductive potential of feral pigs is more similar to rabbits than other large mammals in Australia. In good conditions feral pig populations may increase fivefold in a 12 month period.

Under favourable conditions breeding occurs all year. Adult females have a 21−day oestrus cycle, with a gestation period of about 113 days, producing a litter of four to 10 piglets, depending on the sow's age, weight and food supply.

Sows can make nests of available vegetation just before farrowing. Nests can be 3 m long by 1.5 m wide and up to 1 m high, with a domed roof.

Nests are usually less than 2 km from available water. Piglets normally spend the first 1–5 days of life inside the nest, with the sow inside or close by.

The next fertile mating can occur after 2–3 months of farrowing, allowing sows to produce two litters per year if good seasonal conditions prevail.

Weaning occurs after 2–3 months. Sexual maturity is reached when sows weigh about 25 kg, usually around 6 months of age.

Mortality of juveniles is high if the mother's dietary protein intake is low (up to 100% mortality in dry seasons). Adult mortality does not vary as much with seasonal conditions, but few animals live more than five years.

Estimating populations

Sightings are the least reliable guide to feral pig presence. Careful observation of the signs of pig activity will allow an experienced observer to estimate population densities. A beginner, however, may see nothing.

The following is a list of common pig signs that may be used to establish relative numbers and sizes:

- fresh digging or rooting of ground (causing a ploughed appearance) indicates recent pig activity, but the area affected gives little indication of numbers as large areas can be dug by a small number of pigs
- tracks and faeces on and off pads. Faeces size, shape and consistency vary with age and diet, but is typically 3–6 cm wide, 7–22 cm long and well formed. Close inspection can enable diet to be established – plant matter and seeds, egg shell and bone fragments, wool and marsupial hair
- mud or hair at holes in fences where pigs have pushed through
- wallows – distinctive oval depressions in mud
- tusk marking and mud rubs on trees and fence posts give an indication of pig size
- nests in vegetation made by sows before farrowing should only be approached with caution
- spotlighting, aerial survey, and use of dogs can be used for actual pig counts.

Impact on man and the environment

Feral pigs wide habitat range, omnivorous diet and potential for rapid population growth in good seasons mean that few agricultural pursuits are unaffected. Damage is estimated at $100 million annually.

Economic impact is of three types:

1. value of the direct losses to agricultural production
2. value of the continuing expenditure on pig control
3. value of lost opportunities to take profit from alternative investment of this expenditure.

Examples of direct agricultural losses:

Crops

Pigs can damage almost all crops from sowing to harvest, starting with uprooting seed and seedlings to feeding on or trampling mature crop.

They feed on seed and grain crops (except safflower), fruit (especially banana, mango, papaw, macadamia and lychee) and vegetable crops.

Most damage to sugar cane occurs during the dry season. Older cane with a high sugar content is preferred. Pigs can "camp" in a paddock for several weeks, causing substantial damage as sufficient moisture can be obtained from the cane.

Livestock

Predation on livestock is basically limited to lambs. Research has shown feral pigs can take up to 40% of lambs. This not only reduces income from the sale of lambs but also reduces the opportunity for herd improvement by limiting selection for optimum wool traits.

Pasture

Pastures are damaged by grazing and rooting. Pigs can also transport weeds and their diggings provide ideal conditions for weed establishment.

Fences and watering points

Wallowing pigs damage and foul the water in tanks and bore drains and silt up troughs. Rooting can weaken dam walls. Being large, powerful animals, pigs can breach fences, allowing passage of other pest animals.

Environmental concerns

Pig activity has a **dramatic** affect on creeks and lakes. In many areas concentrated rooting "ploughs" up to 20 m around the waterline.

Such disturbance of the soil and natural vegetation degrades water quality and the habitat for small animals of the land and water. It also creates erosion and allows the establishment of exotic weeds.

Predation of native fauna does occur and examination of faeces has shown remains of marsupials, reptiles and insects, ground-nesting birds and their eggs.

Diseases and parasites

Feral pigs can carry many infectious diseases and internal and external parasites. Some are endemic (already present) while others are still exotic to Australia.

Many of the diseases can not only spread to domestic pigs but to other livestock and humans. Diseases naturally transmitted from animal to man are called zoonoses.

Zoonoses currently in feral pigs in Australia:

- **Tuberculosis** (TB) – a serious disease of the lungs. Once common but now rare, it is contracted by eating inadequately cooked flesh of infected animals.
- **Brucellosis, Porcine and Bovine** – a bacterial disease causing severe long-term illness, undulant fever and possible infertility, both strains are contracted by handling raw meat. Porcine Brucellosis is rare in Queensland.

Feral pigs were blamed for the spread of TB and Bovine Brucellosis amongst cattle but both diseases have been eradicated from Queensland without directly targeting feral pigs.

- **Sparganosis** – a parasite that can infest the muscles of humans, forming encyst lumps, is common in pigs from swampy areas; contracted by ingesting raw meat.
- **Melioidosis** – a serious bacterial disease which causes abscesses.
- **Leptospirosis** – a serious bacterial disease; in humans called Weil's disease, causing very high temperatures, kidney trouble and jaundice; can be fatal. It is found in up to 20% of feral pigs in Queensland.
- **Q Fever** – this disease occurs in all animals and is well known by meat workers. It can cause very high temperature and result in heart problems; can be fatal.

Leptospirosis and Q Fever infection can occur through contact with blood, meat and urine through broken skin, intake of urine-contaminated food or water, and inhalation of infectious airborne organisms.

Brucellosis, Leptospirosis and Q Fever cause flu-like symptoms similar to Ross River Fever. Leptospirosis and Q Fever can be fatal.

To prevent contracting these diseases it is advisable to avoid handling feral pigs. Slaughtering and butchering should be undertaken only at licensed premises where there is a full-time meat inspector on duty to ensure that animals are free of the above diseases.

If you must handle feral pig meat use suitable protective clothing (mask, goggles, strong rubber gloves and plastic apron and boots) to minimise contamination with blood, urine and faeces.

Rare or undercooked meat should not be eaten; meat should be thoroughly cooked to avoid contracting pathogens.

Exotic livestock diseases

A major concern with feral pigs are their potential to harbour or spread exotic diseases. The cost to the Australian community if Foot and Mouth Disease were introduced to Australia is estimated at $3 billion in lost export trade, even if the outbreak were eradicated immediately. This would result in major social upheaval in rural Australia.

Other exotic diseases of concern:

- **Swine vesicular disease** – viral disease affecting only pigs
- **Aujeszky's disease** – highly contagious herpes viral disease affecting several animal species, killing up to 100% of affected piglets.
- **African swine fever** – highly contagious viral disease affecting only pigs, mortality rate high.
- **Classical swine fever** (CSF) or hog cholera, highly contagious viral disease of pigs, in acute form killing up to 90% of infected animals.

For more information on animal diseases contact your local DPI&F veterinarian.

Exotic zoonotic diseases and parasites

- **Japanese encephalitis** – a virus spread from pigs to humans by mosquitoes, causing acute severe problems of the nervous system – pain, sleepiness, and coma.
- **Rabies** – a serious disease affecting the brain - can be fatal.
- **Screw-worm fly** – maggots from this fly can attack healthy flesh and if untreated can cause massive wounds to animals and humans.
- **Trichinosis** – is a helminth (roundworm). All mammals are susceptible, with humans infected by eating improperly cooked meat.

North Queensland's popularity as a tourist destination is increasing. Many international visitors have travelled through countries infected with exotic diseases before entering Australia. Feral pigs are known to frequent rubbish tips around tourist lodges and to scavenge human waste.

There is a real danger that an exotic disease could enter Australia via this contact and remain undetected for some time. Such a time lapse could allow the disease to become widespread, making eradication difficult or even impossible.

Biosecurity Queensland gratefully acknowledge the contribution from Choquenot, D., McIlroy, J. and Korn T. (1996) *Managing Vertebrate Pests: Feral Pigs*, Bureau of Resource Sciences, AGPS, Canberra. Commonwealth of Australia copyright reproduced by permission.

Further information

Further information is available from animal control/environmental staff at your local government or, if your council does not have animal control staff, from your local Department Primary Industries and Fisheries Land Protection Officer: contact details available through 13 25 23.

Fact sheet

DECLARED CLASS 3 PEST PLANT

Lantana

Lantana camara

Currently, lantana covers more than 5 million ha of the east coast from southern New South Wales to Far North Queensland. Small infestations of lantana have also been found in central west Queensland, the Northern Territory, Western Australia, South Australia and Victoria. Efforts are under way to control these.

Lantana is mainly spread by people (as ornamental plants) and fruit-eating birds. It forms dense thickets that smother and kill native vegetation and are impenetrable to animals, people and vehicles.

Research indicates more than 1400 native species are negatively affected by lantana invasion, including many endangered and threatened species. As lantana is a woody shrub that has thin, combustible canes, its presence can also create hotter bushfires.

Declaration details

All lantana species are declared Class 3 plants under the *Land Protection (Pest and Stock Route Management) Act 2002*. Lantana species cannot be sold or distributed and landholders may be required to control these plants if they pose a threat to an environmentally significant area.

Description and general information

Lantana is a heavily branched shrub that can grow in compact clumps, dense thickets or as a climbing vine.

The stems are square in cross section, with small, recurved prickles. Most leaves are about 6 cm long and are covered in fine hairs. They are bright green above, paler beneath and have round-toothed edges. Leaves grow opposite one another along the stem. When crushed the leaves produce a distinctive odour.

Flowers appear throughout most of the year in clustered, compact heads about 2.5 cm in diameter. Flower colours vary from pale cream to yellow, white, pink, orange and red. Lantana produces round, berry-like fruit that turn from glossy green to purplish-black when ripe.

For rural producers, lantana poses problems of stock poisoning and invasion of desirable pasture. An economic impact assessment indicated lantana costs the Queensland grazing sector in excess of $70 million (2005–06 values) per year.It is now illegal to sell or distribute any variety of lantana in Queensland. However, garden plantings are still common in many areas and have the potential to cause problems of their own.

PP34 January 2011

Queensland Government

Despite being sold and marketed as 'sterile' plants, research indicates some ornamental lantana varieties have the ability to set seed and can spread vegetatively. They also produce some viable pollen and have the potential to cross-pollinate with wild forms, creating new varieties that could naturalise in the environment.

If the number of naturalised varieties increases due to genetic drift from ornamental varieties it will make finding effective biological control agents even more difficult, and potentially extend the climatic tolerances and range of the weed's spread.

Habitat and distribution

Lantana is native to the tropical and subtropical regions of Central and South America.

It is found throughout most coastal and subcoastal areas of eastern Australia, from Far North Queensland to southern New South Wales. It grows in a wide variety of habitats, from exposed dry hillsides to wet, heavily shaded gullies.

Toxicity

Many lantana varieties are poisonous to stock. It is difficult to tell which varieties are toxic so it is better to treat all forms as potentially poisonous. The toxins in lantana include the triterpene acids, lantadene A (rehmannic acid), lantadene B, and their reduced forms.

Most cases of lantana poisoning occur when new stock are introduced into lantana-infested areas. Stock bred on lantana-infested country avoid lantana unless forced to eat it due to lack of other fodder. Young animals introduced to lantana areas are most at risk.

Symptoms of lantana poisoning depend on the quantity and type of lantana consumed and, under some circumstances, the intensity of light to which the animals are exposed.

Early symptoms of depression are noticeable, with head swaying, loss of appetite, constipation and frequent urination. After a day or two the eyes and the skin of the nose and mouth start yellowing with jaundice, and the muzzle becomes dry and warm. The eyes may become inflamed and have a slight discharge. The animal also becomes increasingly sensitive to light. Finally, the muzzle becomes inflamed, moist and very painful ('pink nose'). Areas of skin may peel and slough off. Death commonly occurs 1–4 weeks after symptoms occur. Death from acute poisoning can occur 3–4 days after eating the plant.

If animals show any of the early symptoms, they should be moved to lantana-free areas, kept in the shade and monitored. Veterinary treatment should be sought immediately. Some remedies may include intravenous fluids, treating skin damage with antibiotics, or drenching with an activated charcoal slurry.

Care should be taken when introducing new or young animals into a paddock if lantana is present. Ensure they have enough fodder to stop them eating lantana in quantities sufficient to result in poisoning. During drought, animals should not be placed in lantana-infested areas without alternative food.

Control

Using a mix (integration) of control methods gives the best results. Size, density and geographic location of infestations are important considerations for choosing which control methods to use. A general principle is to commence control programs in areas of light infestations and work towards the denser infestations.

For large lantana infestations, treatment with herbicides by foliar spraying is usually not economically feasible. However, fire, dozing/stick raking, slashing/cutting, aerial helicopter spraying can reduce dense infestations, making follow-up spot treatments with chemicals more economically viable.

Lantana seed banks remain viable for at *least* four years, so follow-up control to kill seedlings before they mature is vital to ensure initial management efforts to control the parent bush are not wasted.

Appropriate fire regimes may become part of a management program to ensure lantana invasiveness is reduced and pasture is maintained.

Removal of lantana within areas of remnant vegetation may require a permit under the *Vegetation Management Act 1999*. Further information should be sought from the Department of Environment and Resource Management before works commence.

Mechanical control

Stick raking or ploughing can be effective in removing standing plants. However, regrowth from stumps and/or increased seedling germination in disturbed soil is common and the site will require follow-up treatment.

Grubbing of small infestations—for example, along fence lines—can be a useful and effective method of removing plants, though this is time consuming.

Repeated slashing can also reduce the vigour of lantana, exhausting its stored resources and reducing its likelihood of re-shooting.

Some locations—for example, very steep inclines or gullies—are not suitable for mechanical control options because of the danger of overturning machinery and soil erosion.

Fire

Regular burning will reduce the capacity of plants to survive; however, initial kill rates are variable.

The effectiveness of this method will depend on the suitability of available fuel loads, fire intensity, temperature, relative humidity, soil moisture and season. Pasture re-establishment can then provide competition to inhibit lantana seed germination.

Fire is not recommended in non–fire tolerant vegetated areas such as rainforest, or wooded or plantation areas.

A typical control program for fire may include:

- exclude stock to establish a pasture fuel load
- burning (may require a permit)
- sow improved pastures—consult your local Biosecurity Queensland officer for advice
- continue to exclude stock until pasture has established and seeded
- burn again in summer before rain and spot spray lantana regrowth when › 0.5 m high and when it is actively growing (see Table 1).

Herbicide control

Herbicide recommendations for lantana are shown in Table 1. Users of herbicides have a legal obligation to read herbicide labels and use only the registered rates. Always use herbicides responsibly; adhere to legislation and safety requirements.

Variation in results can be a result of inconsistent application methods, mix rates or seasonal variation. Red-flowered and pink-edged red-flowered lantana are often considered the most difficult to control because their leaves are often smaller and tougher. However, herbicides can kill these varieties if you carefully follow application procedures.

For single-stemmed lantana, basal bark spraying and cut stump methods also give good results at any time of year (but best when the plant is actively growing). On multi-stemmed varieties, you will obtain best results by carefully applying herbicide to each stem.

When treating actively growing plants less than 2 m high, overall spraying of foliage to the point of run-off is recommended. Splatter gun techniques are also effective and particularly useful in hard-to-access areas. This is best done in autumn—when sap flows draw the poison down into the root stock, but before night temperatures get too cold.

Remove grazing animals from spray areas during and soon after treatment. Stress can cause increased sugar levels in the leaves of lantana plants, making them more palatable.

Landholders and contractors should check if the property is situated in a hazardous area. This prevents the use of some chemicals, as defined in the *Agricultural Chemicals Distribution Control Act 1966*.

Biological control

Since 1914, 31 biological control agents have been introduced into Australia in an attempt to control lantana. Seventeen have established, of which several insect species cause seasonal damage, reducing the vigour and competitiveness of lantana in some areas.

Biosecurity Queensland research programs continue to investigate agents suitable for release in Australia, and test the viability of these agents in an effort to identify more effective biological control agents.

It is important to remember that biological control alone should not be relied upon for managing lantana infestations. Consideration should be given to other available control techniques.

The four most important biological control agents are:

- **sap-sucking bug (*Teleonemia scrupulosa*)**
  Found in dry areas from Cooktown to Wollongong, this small, mottled, bug feeds on the underside of leaves, growing tips and flower buds, causing the leaves to drop early and stopping the plant from flowering.
- **leaf-mining beetle (*Uroplata girardi*)**
  Found in most lantana infestations from Cape Tribulation to Sydney as well as around Darwin, except in very dry or high altitude areas. The adult beetles are dark brown. They shelter in curled leaves and feed on the upper leaf surfaces. Larvae feed in leaves causing blotches to spread across the leaf. This beetle reduces plant vigour and can suppress flowering.
- **leaf-mining beetle (*Octotoma scabripennis*)**
  Found in most lantana infestations from Atherton to Wollongong. Adults of this species feed on the upper leaf surface, while larvae feed and mine the centre of the leaf and cause blotches. This activity reduces plant vigour and can suppress flowering.
- **seed-feeding fly (*Ophiomyia lantanae*)**
  Found from Cape Tribulation to Eden in New South Wales and also around Darwin and Perth. *Ophiomyia* is a small black fly that feeds on flowers and lays eggs on the green fruits. The maggots of the fly eat the seed and make the fruit unattractive to birds, reducing seed spread.

Other agents such as *Aconophora compressa* (a stem-sucking bug) and *Leptobyrsa decora* (a sap-sucking bug) have caused some damage in specific geographic areas.

Note: Landholders are advised not to consume their time collecting established insects for distribution. Due to their own ability to disperse, these insects will be periodically/seasonally present in areas that are climatically suitable for them.

Further information

Further information is available from your local government office, or by contacting Biosecurity Queensland (call 13 25 23 or visit our website at www.biosecurity.qld.gov.au).

Table 1. Herbicides for control of lantana

Method of application: active ingredient (trade name)[a]	Rate	Optimum time[b]	Remarks
Foliar (overall) spray			
Fluroxypyr (Starane® 200)	0.5 L to 1 L/100 L water	December to April	Thorough wetting of plants is required, higher rate should be used for larger plants
Glyphosate (Roundup® 360, Glyphosate 360®)	1 L/100 L water	October to April	Wet plant thoroughly. Glyphosate affects any green plant it comes into contact with. Glyphosate is available in a range of strengths
Picloram + 2,4-D (Tordon® 75-D)	0.65 L/100 L water	February to April	Wet plant thoroughly. Legumes are affected if sprayed
Dichlorprop (Lantana® 600)	0.5 L/100 L water	December to April	Must thoroughly wet all leaves. Please refer to product label for situation details
Picloram + triclopyr + aminopyralid (Grazon Extra®)	0.35 L to 0.5 L/100 L water	February to April	Wet plant thoroughly. Use the higher rate on larger plants. Legumes may be affected if sprayed
2,4-D amine (Amicide® 625)	0.32 L/100 L water	March to May	Red-flowered lantanas are more resistant to 2,4-D. Will kill young legumes
Metsulfuron methyl, (Brush-off®, Brushkiller® 600,Lynx® 600)	10 g/100 L water[b]	March to May	Results variable. Not found effective in tropics. Follow-up sprays are necessary
Metsulfuron methyl + glyphosate (Cutout®)	95 g/100 L water	March to May	Apply to bushes up to 2 m tall. Spray to thoroughly wet all foliage and stems. Spray to penetrate throughout the bush
Metsulfuron methyl + glyphosate (Trounce®)	173 g/100 L water	March to May	Apply when actively growing. Do not apply during periods of stress
Aminopyralid + fluroxypyr (Hotshot®)	0.5 L to 0.7 L/100 L water	October to April	Spray all foliage, including stems, to the point of run-off
(i) Basal bark (ii) Cut stump			
Triclopyr (Garlon 600®)	1 L/60 L diesel	Any time. Best results when actively growing	(i) Apply to lower 40 cm of every stem. Must ensure complete coverage around stem (ii) Cut close to ground level. Immediately apply herbicide
2,4-D ester (AF Rubber Vine Spray®)	2.5 L/100 L diesel	Any time. Best results when actively growing	As above
Picloram + Triclopyr (Access®)	1 L/60 L diesel	Any time. Best results when actively growing	As above
Picloram (Vigilant® Herbicide Gel)	3 mm to 5 mm gel	Any time. Best results when actively growing	(ii) If diameter of stump is › 20 mm, use a minimum of 5 mm gel thickness
Glyphosate (Roundup®, Weedmaster Duo®)	Neat	Any time. Best results when actively growing	Off-label permit
Splatter gun			
Glyphosate (Roundup® 360)	1:9 glyphosate +water	October to April	2 x 2 ml dose per 0.5 m height of lantana
Metsulfuron methyl (Brushkiller® 600, Lynx® 600)	2 g/L water	March to May	As above
Aerial			
Picloram + triclopyr + 2,4-D (Grazon® DS + 2,4-D amine 625 g/L)	1.5 L + 6 L/ha or 10 L/ha (Grazon®)	When plant actively growing	Helicopter only. Minimum of 200 L water per hectare. Follow-up re-spray will be required. Do not burn within six months of treatment
Dichlorprop(Lantana® 600)	6 L to 8 L L/ha	When plant actively growing	As above

a Only some common trade names provided.
b Optimum times are only a guide. Lantana must be actively growing for the herbicide to work.
® = Registered trade name.
Labels often recommend the additional use of a wetting agent or surfactant within the mix. Herbicides types vary in their selectivity against other species and soil residual.

PR11–5584

Fact sheet
PEST PLANT

Noogoora burr

Xanthium pungens

Noogoora burr is found along river and creek flats, on roadsides and in pasture land following seasonal rain or floods.

The burrs readily contaminate wool, significantly reducing the value of the wool due to increased processing costs. Thick patches of noogoora burr may deny sheep access to watering points. This plant is also a serious competitor in pastures and summer crops.

Seedlings are poisonous to domestic stock, causing death if eaten in sufficient quantities.

Declaration details

Noogoora burr is not declared under the *Land Protection (Pest and Stock Route Management) Act 2002*; however, it may be declared under local government law and be reflected in the local government area pest management plan.

Landholders are required to control declared pests on the land and waters under their control. A local government may serve a notice upon a landholder requiring control of declared pests.

PP17 September 2009

Queensland Government

Description and general information

This plant is an erect, annual herb that can grow up to 2.5 m high. It has blotched purple stems. Leaves are dark green on the upper surface, similar in shape to grape leaves, 15 cm in diameter and roughly textured with minute bristles. Flowers are inconspicuous—both male and female occurring in leaf axils towards the end of the branches. Flowers develop into hard, woody, spiny burrs, 1.2–2 cm long, with numerous hooked spines.

Habitat and distribution

Noogoora burr is widespread in Queensland, occurring in tropical regions and the central and western regions (where it prefers alluvial flood plains).

Control

As this plant is an annual, infestations will be reduced if seeding can be prevented.

Biological control

Some level of control has been achieved with biological control agents including stem-boring and stem-galling insects, and a rust fungus (*Puccinia xanthii*). This form of control has been more effective in tropical areas where temperatures and moisture conditions are favourable.

Mechanical control

Cultivation or hand pulling isolated plants is effective if performed before flowering or burr formation.

Herbicide control

Before using any herbicide always read the label carefully. All herbicides must be applied strictly in accordance with the directions on the label. Details of herbicides registered for the control of noogoora burr are listed in Table 1.

Spraying with 2,4-D or MCPA before flowering will give favourable results. As plants mature, higher rates are necessary.

Further information

Further information is available from your local government office, or from your local primary industries and fisheries biosecurity officer: contact details are available through 13 25 23.

Table 1 Herbicides registered for the control of noogoora burr

Situation	Herbicide	Rate	Comments
Winter cereals	2,4-D Amine 500	1 L/ha	Boom spray when young
Cotton	Fluometuron 500	1.3–7.2 L/ha	Boom spray when young
Fields/fallow	Glyphosate 450	0.8–1.2 L/ha	Boom spray when young
Fallow crop lands, headlands and drains	Ametryn	720 ml/100 L	Hand spraying for plants up to 60 cm and actively growing
Sorghum	2,4-D Amine 500	0.5–1 L/ha	Boom spray when young
Pastures (grass)	MCPA 500 (Amine)	0.7–4 L/ha	Boom spray when young
Turf, ovals/parks	2,4-D Amine 500	2–4 ml/1 L	Spot spray when young

PR09_4541K

Fact sheet

DECLARED CLASS 2 PEST PLANT

Parthenium weed

Parthenium hysterophorus

Parthenium costs the beef industry a total of $16.5 million per year and cropping industries several million dollars per year.

Declaration details

In Queensland, Parthenium is a Class 2 declared plant.

Under the *Land Protection (Pest and Stock Route Management) Act 2002*, Class 2 declaration requires landholders to control pests on the land and waters under their control. A local government may serve a notice upon a landholder requiring control of declared pests.

PP2 January 2011

Description and general information

Size

Parthenium weed is an annual herb with a deep tap root and an erect stem that becomes woody with age. As it matures, the plant develops many branches in its top half and may eventually reach a height of two metres.

Leaves

Its leaves are pale green, deeply lobed and covered with fine soft hairs.

Flowers

Small creamy white flowers occur on the tips of the numerous stems. Each flower contains four to five black seeds that are wedge-shaped, two millimetres long with two thin, white scales.

Lifecycle

Parthenium weed normally germinates in spring and early summer, produces flowers and seed throughout its life and dies around late autumn. However, with suitable conditions (rain, available moisture, mild temperatures), parthenium weed can grow and produce flowers at any time of the year. In summer, plants can flower and set seed within four weeks of germination, particularly if stressed.

Potential damage

Parthenium weed is a vigorous species that colonises weak pastures with sparse ground cover. It will readily colonise disturbed, bare areas along roadsides and heavily stocked areas around yards and watering points. Parthenium weed can also colonise brigalow, gidgee and softwood scrub soils. Its presence reduces the reliability of improved pasture establishment and reduces pasture production potential.

Parthenium weed is also a health problem as contact with the plant or the pollen can cause serious allergic reactions such as dermatitis and hay fever.

Habitat and distribution

Parthenium weed is capable of growing in most soil types but becomes most dominant in alkaline, clay loam soils.

The plant is well established in Central Queensland and present in isolated infestations west to Longreach and in northern and southern Queensland.

Infestations have also been found in northern and central parts of New South Wales and it is capable of growing in most states of Australia.

Control

Prevention and weed seed spread

As with most weeds, prevention is much cheaper and easier than cure. Pastures maintained in good condition, with high levels of grass crown cover, will limit parthenium weed colonisation. Drought, and the subsequent reduced pasture cover, creates the ideal window of opportunity for parthenium weed colonisation when good conditions return.

Parthenium seeds can spread via water, vehicles, machinery, stock, feral and native animals and in feed and seed. Drought conditions aid the spread of seed with increased movements of stock fodder and transports.

Vehicles and implements passing through parthenium weed infested areas should be washed down with water. Wash down facilities are located in Alpha, Biloela, Charters Towers, Emerald, Gracemere, lnjune, Monto, Moura, Rolleston, Springsure and Taroom. Particular care should be taken with earthmoving machinery and harvesting equipment. The wash down procedure should be confined to one area, so that plants that establish from dislodged seed can be destroyed before they set seed.

Extreme caution should be taken when moving cattle from infested to clean areas. Avoid movement during wet periods as cattle readily transport seed in muddy soil. On arrival, cattle should be held in yards or small paddocks until seed has dropped from their coats and tails prior to their release into large paddocks. Infestations around yards can be easily spotted and controlled whereas infestations can develop unnoticed in large paddocks.

Particular care should be taken when purchasing seed, hay and other fodder materials. Always keep a close watch on areas where hay has been fed out for the emergence of parthenium or other weeds.

Property hygiene is important. Owners of clean properties should ensure that visitors from infested areas do not drive through their properties. If your property has parthenium weed on it, ensure that it is not spread beyond the boundary or further within the property.

Pasture management

Grazing management is the most useful method of controlling large-scale parthenium weed infestations. Maintain pastures in good condition with high levels of ground and grass crown cover. This may require rehabilitation of poor pastures, followed by a sound grazing maintenance program.

Sown pasture establishment—Poor establishment of sown pastures can allow parthenium weed colonisation. pasture agronomist Aerial seeding prior to scrub pulling is normally beneficial.

Overgrazing—High grazing pressure caused by drought or high stock numbers decreases the vigour and competitiveness of pastures and allows the entry and spread of parthenium weed. Maintenance of correct stock numbers is most important in controlling parthenium weed. pasture agronomist

Pastures spelling—In situations of serious infestation, pasture spelling is essential for rehabilitation. Total spelling is much more effective than simply reducing the

stocking rate. However, overgrazing of the remainder of the property must be avoided.

The most appropriate time for pasture spelling is the spring–summer growing period, with the first 6–8 weeks being particularly important. If the condition of perennial grasses (native or sown) is low, spelling for the entire growing season may be required or introduced grasses may need to be re-sown. Herbicide treatment can hasten the rehabilitation process by removing a generation of parthenium seedlings and allowing grass seedlings to establish without competition. In the presence of parthenium weed, grass establishment is poor.

Grazing during winter should not increase the parthenium weed risk. Most tropical grasses are dormant and can tolerate moderate grazing during this period. However, parthenium weed may germinate and grow at this time.

Fencing—One of the main problems in controlling parthenium weed is the large paddock size and the variability of country within paddocks. The resulting uneven grazing pressures encourage parthenium weed to colonise the heavily grazed country. Ideally, similar land types should be fenced as single units. Fencing can be used to great effect to break up large paddocks, allowing more flexible management such as pasture spelling or herbicide application, options not available previously.

Burning—Burning is not promoted as a control strategy for parthenium weed. However, research suggests that burning for pasture management (e.g. woody weed control) should not result in an increased infestation if the pasture is allowed to recover prior to the resumption of grazing. Stocking of recently burnt areas known or suspected to contain parthenium decreases pasture competition and favours parthenium, ultimately creating a more serious infestation.

Herbicide control

Non-crop areas—Parthenium weed should be sprayed early before it can set seed. A close watch should be kept on treated areas for at least two years.

Small and/or isolated infestations should be treated immediately. Herbicide control will involve a knockdown herbicide to kill plants that are present and a residual herbicide to control future germinations. Repeated spraying may be required even within the one growing season to prevent further seed production.

Extensive infestations will require herbicide treatment in conjunction with pasture management. Timing of spraying is critical so that parthenium weed is removed when plants are small and before seeding has occurred. Grasses should be actively growing and seeding so that they can recolonise the infested area.

Table 1 shows the herbicides registered for parthenium weed control and application rates. Before using any herbicide always read the label carefully. All herbicides must be applied strictly in accordance with the directions on the label.

Cropping areas—Controlling parthenium weed in cropland requires selective herbicide use and/or crop rotations. For further information on parthenium weed control in crops consult your nearest Primary Industries and Fisheries extension agronomist.

Biological control

The combined effects of biological control agents reduced the density and vigour of parthenium weed and increased grass production.

There are currently a number of insect species and two rust pathogens that have been introduced to control parthenium weed—a selection of these are outlined below.

Epiblema strenuana is a moth introduced from Mexico established in all parthenium weed areas. The moth's larvae feed inside the stem, forming galls that stunt the plant's growth, reduce competitiveness and seed production.

Listronotus setosipennis is a stem-boring weevil from Argentina but is of limited success in reducing parthenium weed infestations.

Zygogramma bicolorata is a defoliating beetle from Mexico which is highly effective where present. It emerges in late spring and is active until autumn.

Smicronyx lutulentus (Mexico) lays eggs in the flower buds where the larvae feed on the seed heads.

Conotrachelus albocinereus (stem-galling weevil from Argentina) produces small galls and is still becoming established in Queensland.

Bucculatrix parthenica (leaf mining moth from Mexico) larvae feed on leaves, leaving clear windows in the leaf.

Carmentia ithacae is a stem boring moth from Mexico which is becoming established at favourable sites in the northern Central Highlands.

Puccinia abrupta is a winter rust from Mexico that infects and damages leaves and stems. It is currently established over a wide area from Clermont south. It requires a night temperature of less than 16 degrees and 5–6 hours of leaf wetness (dew). Sporadic outbreaks occur where weather conditions are suitable.

Puccinia melampodii is a summer rust from Mexico that weakens the plant by damaging the leaves over the summer growing season. It is currently established and spreading at a number of sites from north of Charters Towers to Injune in the south.

Manual control

Hand pulling of small areas is not recommended. There is a health hazard from allergic reactions and a danger that mature seeds will drop off and increase the area of infestation.

Further information

Further information is available from your local government office, or by contacting Biosecurity Queensland (call 13 25 23 or visit our website at www.biosecurity.qld.gov.au).

Table 1 Herbicides registered for parthenium weed.

Herbicide	Rate	Situation	Comments
2,4-D amine 500 g/L	0.4 L/100 L	Land—industrial, pastures; rights-of-way	Spot spray
atrazine 500 g/L	3.6–6 L/ha	Fields and fallow	Boom spray
max 3 kg/ha/yr	6 L/ha	Land—industrial, commercial, non-agricultural, roadside, right-of-way	Boom spray
atrazine 900 g/kg	2–3.3 kg/ha	Fields and fallow	Boom spray
max 3 kg/ha/yr	3.3 kg/ha	Land—non-agricultural, commercial, industrial	Boom spray
2,4-D + picloram (Tordon 75-D)	125 ml/100 L	Land—commercial, industrial, pastures, right-of-way	Spot spray
	3 L/ha	Land—commercial, industrial, pastures, right-of-way	Boom spray
2,4-D ester[1]	.025 L/10 L	Land—non-agricultural, pastures	Rosette stage
glyphosate (450 g/L)	0.8–1.2 L/ha	Fields and fallow	Spot spray
metsulfuron methyl	5–7 g/ha	Fields and fallow	Seedlings only
	5 g/100 L	Land—commercial, industrial, pastures, rights-of-way	Spot spray
hexazinone	3.5 L/ha or 7 L/10 L/20 m^2	Land—commercial, industrial, pastures, rights-of-way	Boom spray or spot spray
dicamba (200 g/L)	0.7–2.8 L/ha or 0.1–0.19 L/100L	Grass pastures	Boom spray or spot spray
(500 g/L)	0.28–1.1 L/ha or 0.40–0.76 L/100L	Grass pastures	Boom spray or spot spray
(700 g/kg)	200–800 g/ha or 30–60 g/100 L	Grass pastures	Boom spray or spot spray

[1]Use restricted in some areas of Central Queensland

Notes The registered rates are for non-crop uses. Consult label for in-crop recommendations.
For power hand spray or knapsack use, spray plants to the point of runoff.

PR11–5578

Prickly pear

Opuntia, Nopalea and Acanthocereus spp.

The introduction and spread of prickly pears into Queensland and New South Wales is one of the greatest environmental invasions of modern times.

Prickly pears were introduced into pastoral districts in the 1840s. By 1900, over 4 million hectares in Queensland and New South Wales was infested by prickly pear. By 1925, the pest had invaded over 24 million hectares. Control costs were prohibitive and the only effective herbicide at the time was hazardous. This resulted in landholders abandoning large tracts of land.

Research for biological control agents commenced in 1912, and in 1914 cochineal insects were released to control one of the minor prickly pear species. Control of this minor prickly pear species by these introduced insects occurred within a few years.

The success of the cochineal insects led to renewed efforts against other types of prickly pear in the 1920s. These efforts resulted in the control of the major pest prickly pear by the moth *Cactoblastis cactorum*; by the mid-1930s, prickly pear was no longer a major problem.

Several prickly pear species have since remained as minor weeds.

PP29 September 2009

Declaration details

Prickly pear (*Opuntia* spp.) is a declared Class 1 plant under the *Land Protection (Pest and Stock Route Management) Act 2002*. *O. ficus-indica* is not declared. *O. Stricta, O. aurantiaca, O. monacantha, O. tomentosa* and *O. streptacantha* species are Class 2 declared pest plants and all other species are declared Class 1.

Description and general information

'Prickly pear' is a general term used to describe some plants of the Cactaceae family. The term includes species of *Opuntia, Nopalea* and *Acanthocereus*. All of these plants originate in the Americas. The term 'prickly pear' relates to the fruit that is often spiny and pear-shaped. Plants are normally leafless succulent shrubs. Stems are divided into segments (pads or joints) that are flat and often incorrectly called leaves.

Young shoots have true leaves resembling small fleshy scales that fall off as the shoot matures.

Flowers are large, normally seen during spring and can be yellow, orange, red, pink, purple or white depending on the species. Prickly pear fruits vary between species and can be red, purple, orange, yellow or green.

Areoles (spots with clusters of spines) are found on both the pads (joints, segments) and fruit. In addition to spines, areoles often have clusters of sharp bristles (glochids) and tufts of fibre ('wool'). Each areole contains a growing point that can produce roots or shoots.

Life cycle

Prickly pears have several features that enable them to compete and become pests.

Prickly pears are drought resistant because of their succulent nature, their lack of leaves and their thick, tough skins. These features result in plants that use the majority of their internal tissues for water storage and their outer parts to reduce water loss and damage by grazing and browsing animals. They can remain vigorous in hot, dry conditions that cause most other plants to lose vigour or even die. Some species develop underground bulbs that enable the plant to resist fire and mechanical damage.

Prickly pears reproduce both sexually and asexually. Birds and other animals readily eat the many seeded fruits and deposit seeds in their droppings. Seeds have hard seed coats that allow them to survive heat and lack of water. Asexual reproduction (cloning) of prickly pears occurs when pads (joints, segments) or fruits located on the ground take root and produce shoots. Animals and floods move broken pads long distances. These pads can survive long periods of drought before weather conditions allow them to set roots.

Habitat and distribution

Prickly pears considered pests in Queensland are:

- Common pest pear — *Opuntia stricta* var. *stricta* (= *O. inermis*)
- Spiny pest pear — *Opuntia stricta* var. *dillenii* (= *O. stricta*)
- Tiger pear — *Opuntia aurantiaca*
- Drooping tree pear — *Opuntia vulgaris* (= *O. monacantha*)
- Velvety tree pear — *Opuntia tomentosa*
- Westwood pear — *Opuntia streptacantha*
- Devil's rope pear — *Opuntia imbricata*
- Coral cactus — *Opuntia cylindrica*
- Snake cactus — *Opuntia fulgida* X *O. imbricate*
- Sword pear — *Acanthocereus pentagonus*

Common pest pear (*Opuntia stricta* var. *stricta*)

This bushy, spreading plant grows up to 1.5 m high and forms large clumps. The stems are divided into oval, blue-green spineless pads 20 cm long and 10 cm wide. Areoles are in diagonal lines along the pads 2.5 cm to 5 cm apart and have a cushion of brown wool containing bristles but usually no spines. When spines occur they are stout, yellow and up to 4 cm long.

Common pest pear produces flowers that are 7.5 cm wide, bright lemon yellow and green at the base. The fruit is oval-shaped, has a deep cavity on one end and tapers at the other. Fruit is purple, 6 cm long and 3 cm wide, with carmine-coloured (dark red) seeds and a fleshy pulp.

Common pest pear is found as small to large clumps of varying density. The clumps are usually broken up by the action of *Cactoblastis cactorum*. Common pest pear occurs throughout most of central and southern Queensland and is still spreading westwards. It is often found along beaches and on offshore islands.

Spiny pest pear (*Opuntia stricta* var. *dillenii*)

This succulent shrub grows 1–2 m high. The stems are hairless and bluish-green or dull green. The stems are divided into pads up to 30 cm long, 15 cm wide and 1–2 cm thick. The areoles have tufts of short and finely barbed bristles accompanied by one or two yellow spines between 2 cm and 4 cm long. Small scale-like leaves are found on areoles of immature pads.

Spiny pest pear produces 6–8 cm wide flowers that are lemon yellow with green or pink markings on the back. The fruit is pear-shaped and about 4–6 cm long with a red-purple skin. The areoles located on fruits have fine, barbed bristles. The red flesh of fruits contains rounded seeds that are yellow or pale brown.

While this prickly pear once formed large-scale dense infestations, it is now found as small clumps or as scattered plants. These clumps are usually broken by the action of *Cactoblastis cactorum*. It is found in eastern central Queensland, the Burnett district, the Darling Downs and south-eastern Queensland.

Tiger pear (*Opuntia aurantiaca*)

This succulent low shrub with underground tubers usually grows 30–60 cm high. The stems are divided into very spiny, slightly flattened pads that are 1–30 cm long and 1–5 cm wide. The stems are dark green to purple and red in colour. The areoles have 3–7 brown barbed spines up to 4 cm long surrounded by tufts of short, fine bristles. The pads detach easily and are transported on the skins of animals. Small and scale-like leaves are found on areoles of immature pads.

Tiger pear produces 6 cm wide yellow flowers. The rarely formed fruits are pear-shaped and about 2.5 cm long. When ripe, they are red with purple markings.

Dense tiger pear forms an impenetrable spiny groundcover and is prevalent in southern Queensland but extends into central Queensland.

Drooping tree pear (*Opuntia vulgaris*)

This erect succulent shrub with fibrous roots grows up to 5 m high but is usually 2–3 m high. The branches are divided into glossy light green pads up to 45 cm long, 15 cm wide and 1.5 cm thick. The dark grey trunk grows up to 25 cm in diameter. Drooping tree pear gets its name because the upper segments tend to droop. The areoles on the older pads have 1–5 sharp spines about 5 cm long.

Small, scale-like leaves are found on areoles of very young pads that are quickly shed as the pad grows. Drooping tree pear produces yellow flowers that are 6 cm wide and have red markings on the back. The fruit is pear-shaped and 4–7 cm long with a green skin. The flesh of the fruit is red, pulpy and contains round seeds that are yellow or pale brown. The fruits have areoles with tufts of fine, barbed bristles.

Dense thickets result when drooping tree pear is allowed to grow freely. Small scattered infestations occur in the south-east corner of Queensland and in coastal northern Queensland.

Velvety tree pear (*Opuntia tomentosa*)

This tree-like plant forms a central woody trunk over 40 cm wide and grows up to 5 m high. The stems are divided into oblong pads that are dull green and velvety to touch due to the dense covering of short fine hairs. The pads are 15–35 cm long, 8–12 cm wide and 1.5–2 cm thick.

Young plants have 2–4 white or pale yellow spines located in the areoles with one spine reaching a length of 2.5 cm. The areoles usually become spineless as the plant matures. A more spiny variety does exist and has more than 50 spines in each areole on the trunk.

The flowers are a deep orange. The fruit is egg-shaped, about 5 cm long and 3 cm wide, and dull red. The top of the fruit is saucer-shaped with circular lines that meet in the centre and give the fruit a shrivelled appearance. The fruit produces many seeds within a reddish pulp.

Velvety tree pear is found predominantly throughout the brigalow belt of Queensland and is still extending its range. It is occasionally found as dense shrubs, but more usually as small clumps of trees or as trees scattered over the landscape.

Westwood pear, Cardona (*Opuntia streptacantha*)

Westwood pears are shrub-like or tree-like plants that form clumps by branching from the base. They are usually 2–4 m high. The stems are divided into almost circular dull green pads, 25–30 cm long and 15–20 cm wide. The areoles have white spines that vary in number and size when the plant matures.

Young pads have 2–5 white spines 1–2 cm long, accompanied by two hair-like spines 0.5 cm long in the lower part of the areole. Spines increase in number (up to 20) and size (5 cm long) in areoles along the trunk of the plant.

The flowers are yellow and fruits are barrel-shaped, 6 cm long and 5 cm wide with a flat top. The fruit has a purple skin and a rind that is 1 cm thick. Fruits contain red seeds buried in a dark red (carmine) pulp.

Westwood pear is found in eastern central Queensland as small clumps or as plants scattered over the landscape.

Devil's rope pear (*Opuntia imbricata*)

This open branching shrub grows 1.5–3 m high. The stems are divided into hairless, dull green, cylindrical pads that vary up to 37 cm in length and are 3.5–5 cm thick. The pads have a series of short raised ridges that give them a twined, rope-like appearance. The areoles are found on these ridges and produce 3–11 pale yellow or white spines, with the longest being 2.5 cm long. Papery sheaths cover these spines.

The flowers are a dull, red-purple colour and found at the ends of pads. The yellow fruit resembles a small, 5 cm wide custard apple and has a spineless areole at the top.

Devil's rope pear occurs in Queensland as a small infestation at Gladfield.

Coral cactus (*Opuntia cylindrica*)

Coral cactus grows as a branching shrub 1–1.5 m in high. The stems of coral cactus are divided into green cylinder-like pads that are fist-like and obtuse at their apex. Mature coral cactus pads widen, become distorted and wavy, and resemble a piece of coral. Areoles along the pads have a number of short white spines.

Coral cactus produces small (1–2 mm wide) scarlet flowers. The fruit is yellow-green and 2–5 cm wide.

Coral cactus has been located near Mount Isa, Longreach, Wyandra, Eulo and Hungerford but its potential spread includes all of far western Queensland.

Snake cactus (*Opuntia fulgida* X *O. imbricata*)

This open branching shrub grows 1–2 m high. The stems are divided into hairless, dull green, cylindrical pads that vary up to 20 cm in length and are 3.5–5 cm thick. The pads have a series of short raised ridges that give them a twined rope-like appearance. The areoles are found on the bottom of these ridges and produce 5–10 pale yellow to brown spines, with the longest being 3 cm long.

The flowers are light red to dark rose and commonly 5–7 cm wide. Snake cactus produces fruit that is yellow and 2–5 cm wide.

Snake cactus has been located near Longreach but its potential spread includes all of north-western Queensland.

Sword pear (*Acanthocereus pentagonus*)

This elongated branching shrub grows in clumps up to 4 m high. The stems are erect, up to 1.5 m long, 3–8 cm wide and divided into many joints. Sword pear stems are three-, four- or five-angled and resemble star-picket posts. The areoles are found on the edges of the joints and produce many white spines 1–4 cm long.

The flowers are white, funnel-shaped and 14–20 cm long. The flowers open at night between spring and summer. Sword pear produces bright red sphere-shaped fruits that are 5 cm in diameter. The fruit has a red pulp and black seeds.

Sword pear occurs in the Gogango area west of Rockhampton.

Control

Biological control

Investigations into biological control agents against prickly pears began in 1912. Over 150 insect species were studied throughout the world, with 52 species selected for transport to Queensland. Following intensive host specificity testing, 18 insects and one mite were released in Queensland. Nine insects and the mite remain established in Queensland. These species are:

- *Cactoblastis cactorum*, a stem-boring moth
- *Dactylopius ceylonicus*, a cochineal mealybug
- *Dactylopius opuntiae*, a cochineal mealybug
- *Dactylopius confusus*, a cochineal mealybug
- *Dactylopius tomentosus*, a cochineal mealybug
- *Dactylopius austrinus*, a cochineal mealybug
- *Chelinidea tabulata*, a cell-sucking bug
- *Tucumania tapiacola*, a stem-boring moth
- *Archlagocheirus funestus*, a stem-boring beetle
- *Tetranychus opuntiae*, prickly pear red spider mite.

These biological control agents continue to keep several prickly pears under control. It is important to remember not all the agents attack all prickly pears.

The most successful of these species were the moth *Cactoblastis cactorum* and five cochineal mealybugs—*Dactylopius ceylonicus, D. opuntiae, D. confusus, D. tomentosus* and *D. austrinus*. The other agents are still around but not in sufficient numbers to provide control.

Cactoblastis cactorum (cactoblastis moth)

Larvae of this moth were introduced from Argentina in 1925. Cactoblastis proved to be the most effective agent against the common and spiny pest pears, destroying massive infestations in Australia. Larvae keeps these two pest pears controlled to an acceptable level most of the time, although it is less effective in some coastal and far western areas.

The larvae collectively eat out the contents of the pads leaving empty pad skins and piles of mushy droppings. The orange and black larvae are occasionally observed on the outsides of pads. Cactoblastis also attacks most types of prickly pear but is not effective against them.

Dactylopius spp. (cochineal insects)

All female cochineal insects are small, sessile mealy bugs that spend their adult lives permanently attached to their host plants sucking plant juices. They are covered by a fine, white, waxy secretion and when crushed yield a carmine colouring. The adult males are small, free-flying insects that do not feed.

Dactylopius ceylonicus (monacantha cochineal, Argentine cochineal)

This South American mealy bug was released in 1914 and 1915 to control drooping tree pear. It destroyed the dense infestations existing at that time. It is specific to drooping tree pear and today remains the only effective biological control agent for drooping tree pear. This insect needs to be distributed manually.

Dactylopius opuntiae (prickly pear cochineal)

This mealy bug was introduced from Mexico and southern United States between 1920 and 1922. It is effective against common pest pear, spiny pest pear, velvety tree pear and Westwood pear and remains the main biological control agent against velvety tree pear and Westwood pear. This insect spreads slowly in nature and can be assisted manually.

Dactylopius confusus (prickly pear cochineal)

This mealy bug was introduced from Florida and released in 1933 against spiny pest pear. It remains effective against spiny pest pear in central Queensland but spreads slowly. This insect can be spread manually.

Dactylopius tomentosus (devil's rope pear cochineal)

This mealy bug was introduced from southern United States in 1925 and 1926. It is effective against devil's rope pear but works slowly.

Dactylopius austrinus (tiger pear cochineal)

This mealy bug was introduced from Argentina in 1932. It is specific to and effective against tiger pear. It rapidly reduces tiger pear populations but dies out in a paddock after the destruction of tiger pear. It needs to be reintroduced after tiger pear regrows.

Chelinidea tabulata (prickly pear bug)

This plant-sucking bug was introduced from Texas in 1921. It was effective against dense common pest pear before *Cactoblastis cactorum* was but is now relatively ineffective. This insect also attacks most other prickly pears. The adult is a pale brown bug up to 20 mm long that leaves characteristic round bleached spots on the surface of the cactus.

Tucumania tapiacola (prickly pear moth-borer)

This moth was introduced from Argentina in 1934 against tiger pear. Its solitary larvae feed internally and eat out tiger pear pads with limited effect. It has been observed attacking common pest pear and harrisia cactus.

Archlagocheirus funestus (tree pear beetle)

This stem-boring beetle was introduced from Mexico in 1935. It was effective against velvety tree pear and Westwood pear but has become rare since the dense stands of these prickly pears have gone.

Tetranychus opuntiae (prickly pear spider mite)

This mite was introduced from southern United States and Mexico in 1922. It was effective against common pest pear but is now rare and difficult to find. It causes distinctive scar tissue formation around areoles.

Distributing biological control agents

Cactoblastis

Cactoblastis can be spread manually by distributing eggs or larvae. Cactoblastis moths lay chains of eggs (eggsticks) on prickly pear pads from January–February and September–November. The eggsticks are distinguished from spines by their curved appearance.

1. Collect the fragile eggsticks carefully.
2. Glue single eggsticks to small pieces of paper using a starch-based adhesive.
3. Pin the egg papers to prickly pear pads. (Eggs take up to one month to hatch.)
4. Collect pads or plants in which larvae are obviously still active.
5. At a release site place all the collected plant material in a small part of the infestation.
6. Subsequent generations of moths will disperse through the infestation.
7. Follow up the biological control with either herbicide or mechanical treatment.

Cochineals

Because several cochineal insects affect some prickly pears and not others, it is essential to know what prickly pear you wish to control.

1. Identify your prickly pear type.
2. Find the same prickly pear type which is being attacked by a cochineal.
3. Collect pads of the prickly pear with the insects.
4. Place affected pads against unaffected prickly pears at the release site.
5. Follow up the biological control with either herbicide or mechanical treatment.

Tiger pear cochineal

Tiger pear cochineal is easy to multiply quickly after collection.

1. Carefully collect a reasonable quantity of unaffected tiger pear in a container (box or bucket).
2. Place a few pieces of cochineal-affected tiger pear into the same container.
3. Cover the container with a cloth and store under cover for a few weeks.
4. Check the cactus occasionally.
5. When most of the tiger pear in the container has cochineal, it is ready to distribute.
6. At the release site place affected pads against unaffected prickly pears.
7. Follow up the biological control with either herbicide or mechanical treatment.

Note: It is best to multiply tiger pear cochineal before release.

Mechanical control

Mechanical control using machinery is difficult because prickly pear pads can easily re-establish. A hot fire is an effective control method for dense prickly pear infestations. Before burning, consult Queensland Primary Industries and Fisheries to see if this practice is suitable for your pasture and land management practices.

Herbicide control

Herbicide options available for the control of prickly pears in Queensland are shown in Table 1.

Landholders and contractors should check if the property is in a hazardous area as defined in the *Agricultural Chemicals Distribution Control Act 1966* prior to spraying.

Further information

Further information is available from your local government office, or from your local primary industries and fisheries biosecurity officer: contact details are available through 13 25 23.

Table 1 Herbicides registered for the control of prickly pears

Herbicide	Situation	Rate	Method	Comments
Triclopyr	Forest—timber production; land—commercial/ industrial, non-agricultural, pastures, rights of way	0.8 L/60 L diesel	Overall spray	For use against common prickly pear, drooping prickly pear, tiger pear
Triclopyr	Forest—timber production; land—commercial/ industrial, non-agriculture, pastures, rights of way	3 L/100 L water	Overall spray	For use against common prickly pear, drooping prickly pear and tiger pear
Picloram + Triclopyr	Agricultural land—non-crop; forest—timber production; land—commercial and industrial, pastures, rights of way	1 L/60 L diesel	Basal bark/ cut stump	For use against velvet tree pear, tree pears, tiger pear, common prickly pear, snake cactus
Amitrole	Land—around buildings, commercial/industrial, non-agricultural, rights of way	1 ml/3 cm	Inject	
		1 L/25 L	Overall spray	Small plants or regrowth

PR09_4541N

PESTSMART

European rabbit (*Oryctolagus cuniculus*)

Biology & ecology: Wild European rabbits typically have grey-brown back fur and a white-grey belly. Colour varies from sandy light brown, to ginger, black, and occasionally, white. Rabbits are characterised by their long ears, long hind legs, short fluffy tail and feet that are well furred beneath, with large straight claws. Males and females are similar in size and appearance; male rabbits may have a slightly broader head. Adults weigh 1–2.25 kg and range in length from 35 to 45 cm[1].

Habitat: In Australia, rabbits are widely distributed and occur in a variety of habitats, including urban and coastal areas. They prefer low vegetation, well-drained, deep sandy soils and refuge such as scrub, blackberries or fallen logs[1]. Rabbits construct large warrens up to 3 m deep and 45 m long. Warren complexes are generally larger in more open country. Warrens provide cover and protection from predators and extreme temperatures, and allow rabbits to live in open grasslands, grazed pasture and arid land. Where there is abundant surface cover, rabbits may live above the ground.

> “Rabbits prefer to eat soft, short, succulent plants such as grasses and herbs”

Nutrition: Rabbits are herbivores that eat a wide variety of plants, including crops, roots, pastures, young trees and vines[2]. They can graze plants to ground level and may eat up to one third of their own body weight daily, although their average daily intake is 100–150 g[2]. In arid areas rabbits need access to water, but elsewhere they get enough moisture from their food.

Reproduction & lifecycle: Females can breed at any time of the year if there is sufficient feed available. The main breeding season is determined by rainfall and the early growth of high-protein plants. During this time, wild rabbits form territorial groups containing 1–3 males and 7–10 females, led by a dominant pair. Wild rabbits can begin breeding at four months old and may produce five or more litters in a year, with up to five young per litter. In less favourable conditions they can still produce one or two litters each year[2].

Rabbits have a gestation time of 28–30 days. Young are born blind and hairless and open their eyes after 7–10 days. They emerge from the warren weaned at about 18 days and leave the nest at 23–25 days. Survival of young varies between years and with seasonal conditions, and also depends on the incidence of diseases. Wild rabbits rarely survive past six years of age[1].

Biological & behavioural weaknesses: Rabbits are dependent on warrens or other shelter so destruction of these will greatly reduce the local rabbit population[1]. Rabbits are also highly susceptible to predators and disease. In Australia, their most significant predators include feral cats, foxes and dingoes. Two of the most deadly diseases to rabbits are myxomatosis and rabbit haemorrhagic disease (RHD, formerly known as calicivirus). However, variable virulence of different virus strains and increased genetic resistance by rabbits to the diseases over time has lessened their effectiveness as biological controls[1].

Original distribution: European rabbits are native to the Iberian Peninsula (Spain & Portugal), France, Gibraltar and north-western Africa (Morocco & Algeria)[1].

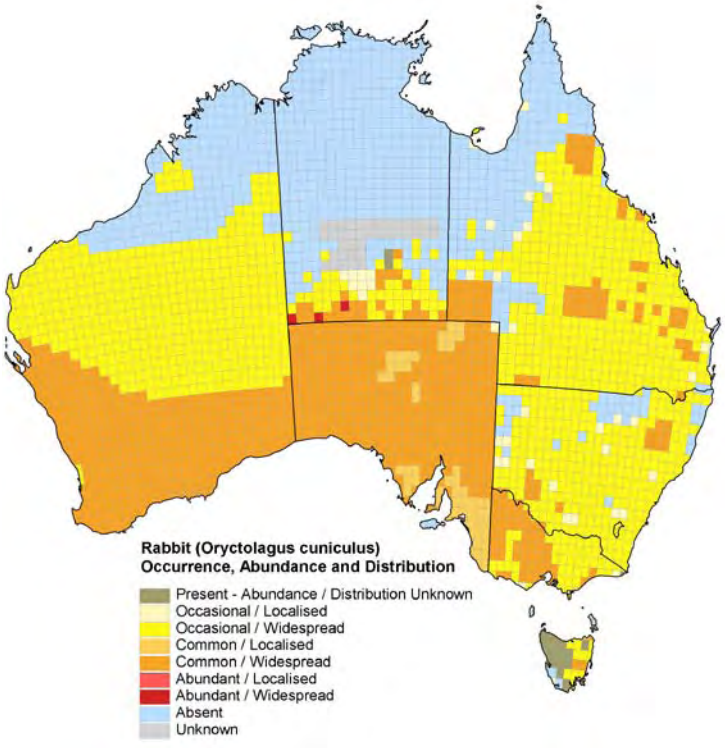
Current Australian distribution: The rate of spread of the rabbit in Australia is believed to be the fastest of any colonising mammal in the world[1]. Domesticated rabbits were first introduced to Australia in 1788. The first feral populations were observed in Tasmania in 1827. Thomas Austin introduced wild rabbits to his property in Geelong, Victoria, for hunting in 1859. By 1886, rabbits had spread north to New South Wales and Queensland. They were in Western Australia and the Northern Territory by 1900. Their colonisation was aided by existing native animal burrows and habitat modification for farming, and by further deliberate human introductions for meat and hunting. The construction of a 1700 km rabbit-proof fence in Western Australia failed to stop the spread of rabbits and they are now found across the continent, and on several offshore islands[1].

Economic impacts: Rabbits graze on native and introduced vegetation, crops and pastures. Rabbit grazing can prevent seedlings from regenerating and reduce crop yields, as well as increase competition for feed with livestock. This may affect the carrying capacity of livestock on a property, resulting in lower weight gain, lower wool production, reduced births and higher mortality during drought. Rabbit grazing of emerging crops can also result in high yield losses of up to 100%. Rabbits cost Australian agriculture $206 million in production losses each year[3].

Environmental impacts: Rabbits directly compete with native wildlife for food and shelter. They also impact on native plants by ringbarking, grazing and browsing, and preventing regeneration of seedlings. Their digging and browsing leads to a loss of vegetation cover, which in turn can result in slope instability and soil erosion. There are at least 156 threatened species that may be adversely affected by competition and land degradation by rabbits, which is listed as a key threatening process under Commonwealth legislation[4].

Social impacts: Harvesting wild rabbits can benefit regional employment and provides a recreational opportunity for local shooting clubs and hunters[5]. However, the monetary value of this industry is small[1]. Rabbits can also damage lawns, gardens, golf courses, sportsgrounds and regional parkland reserves, and may undermine buildings, garages and sheds, causing human-wildlife conflict in urban areas. Indirect costs of rabbits include disease transmission, which can present human and animal health concerns[1,5]. The social cost of rabbits includes psychological impacts, as landholders may suffer from loss or damage to their livelihoods, or distress related to other rabbit impacts[3].

Map: Occurrence, abundance and distribution of rabbits in Australia[6]



References & links:

1. Williams K, Parer I, Coman B, Burley J, Braysher M (1995). *Managing Vertebrate Pests: Rabbits*. Bureau of Resource Sciences and CSIRO Division of Wildlife and Ecology. Australian Government Publishing Service, Canberra.
2. NSW Department of Primary Industries (2007). *Vertebrate Pest Control Manual: Rabbit Biology and Control*. Vertebrate Pest Research Unit, NSW Department of Primary Industries, Orange, NSW.
3. Gong W, Sinden J, Braysher M, Jones R (2009). *The Economic Impacts of Vertebrate Pests in Australia*. Invasive Animals Cooperative Research Centre, Canberra.
4. Department of the Environment, Water, Heritage and the Arts (DEWHA, 2008). *Threat Abatement Plan for Competition and Land Degredation by Rabbits*. DEWHA, Canberra.
5. McLeod R (2004). *Counting the Cost: Impact of Invasive Animals in Australia, 2004*. Cooperative Research Centre for Pest Animal Control, Canberra.
6. National Land and Water Resources Audit (NLWRA) and Invasive Animals Cooperative Research Centre (2008). *Assessing Invasive Animals in Australia 2008*. NLWRA, Canberra.

Appendix F: Macro-invertebrate Identification Results

Table 21 Macro-invertebrate Identification Results

CLASS/ORDER	ORDER	GENUS	WET SEASON														DRY SEASON							
			AQ17	AQ31	AQ3	AQ19	AQ6	AQ9	AQ5	AQ1	AQ28	AQ4	AQ23	AQ18	AQ29	AQ2	AQ04	AQ05	AQ06	AQ09	AQ25_A	AQ28	AQ31	AQ49
Annelida	Oligochaeta			1		2				1	1	1					1		14	10				
Copepoda	Copepoda		2																					
Conchostraca	Conchostraca															2								
Cladocera	Cladocera				1																			
Crustacea	Ostracoda																	2			2			
	Family/Sub family																							
Hirudinea	Glossiphonidae			1											2									
Gastropoda	Lymnaeidae														4						1		1	
	Planorbidae				1				1	2					4	4								
	Viviparidae														4									
	Ancylidae				2																			
Hyriidae		Alathryia spp.								1														
Decapoda	Atyidae								6								1		1	11				
	Palaemonidae				1							2							6	7				1
	Parastacidae									1			1			3	1							
Acarina	Acarina																2			11	6	5	14	
	Hydracarina							31			2		5		3									

Table 21 (cont) Macro-invertebrate Identification Results

CLASS/ORDER	ORDER	GENUS	WET SEASON														DRY SEASON							
			AQ17	AQ31	AQ3	AQ19	AQ6	AQ9	AQ5	AQ1	AQ28	AQ4	AQ23	AQ18	AQ29	AQ2	AQ04	AQ05	AQ06	AQ09	AQ25_A	AQ28	AQ31	AQ49
Bivalvia	Hyriidae																	1						
Coleoptera	Dytiscidae	Undiff Adult/Larvae						5	2		2					3		5		1	16	29	11	11
		Necterosoma spp.	2	2	1	9	2		2				5											
		Hyphydrus spp.	1				2								4									
		Copelatus spp.		2		3			5						4									
	Elmidae																1							
	Hydraenidae	Hydraena spp.	5		8	1			4	1	3		1		2			1					4	
	Hydrophilidae	Hydrophilidae unid.																			1	2		2
		Berosus spp.							2		1													
		Hydrophilus spp.								1			2											
		Hydrochus spp.	4		1	2		3		1	1		3		2									
	Hydrochidae																			1			1	
	Haliplidae	Haliplus spp.						1				1			3									
	Curculionidae								1															
	Georyssidae										1				1									
	Gyrinidae																3							
	Staphylinidae												1											
Diptera/Chironomidae	Tanypodiinae			11	3	4	3	19	2	9	8	13	3			3	1	25	4	37	35	31	12	25

Table 21 (cont) Macro-invertebrate Identification Results

CLASS/ORDER	ORDER	GENUS	WET SEASON														DRY SEASON							
			AQ17	AQ31	AQ3	AQ19	AQ6	AQ9	AQ5	AQ1	AQ28	AQ4	AQ23	AQ18	AQ29	AQ2	AQ04	AQ05	AQ06	AQ09	AQ25_A	AQ28	AQ31	AQ49
	Chironominae		1	6	12	1				13	5	1	3	2	1	11	4	108	23	91	29	39	6	168
	UI Pupa			1	1									1										
Diptera	Ceratopogoninae										1		1	1				3	1		2	1	13	1
	Culicidae	Culicinae						1							2						1			
	Chaoborinae													2							1			
	Orthocladiinae																7			1	1			5
	Simuliidae																98	2						
	Tabanidae																2							
	Tipulidae																							1
Ephemeroptera	Baetidae				1		8		4	1	7	2	3		8		5	3		1	4	5		
	Caenidae				1		1					3		1		1	6	2	6	2	3	7		
	Leptophlebiidae						1										1					1		
Hemiptera	Pleidae	Plea spp.	3				1	1	1						10		3	1		5	2	2	16	1
	Belostomatidae																	1					3	1
	Veliidae	Microvelia spp.			1										2							1		
	Corixidae	Micronecta spp.	24	23	6	12	4	6			1		6		2	5		10			28	1	2	
	Notonectidae	Anisops spp.	3			9	2								20			1			14		1	3
	Gerridae						2			1				1						2				

Table 21 (cont) Macro-invertebrate Identification Results

CLASS/ORDER	ORDER	GENUS	WET SEASON														DRY SEASON							
			AQ17	AQ31	AQ3	AQ19	AQ6	AQ9	AQ5	AQ1	AQ28	AQ4	AQ23	AQ18	AQ29	AQ2	AQ04	AQ05	AQ06	AQ09	AQ25_A	AQ28	AQ31	AQ49
	Nepidae	Ranatra spp.	1												2									
		Laccotrephes spp.	1																					
	Naucoridae	Naucoris spp.									6		1		10									
	Mesoveliidae	Mesovelia spp.												1										
Anisoptera	Libellulidae	Libellulidae undiff.			1						1		1		7	2		1		1	1		1	
	Aeshnidae														2								1	
	Gomphidae				1		1		1		1								1	1				
	Undiff HUL (Hemicorduliidae, Urothemistidae, Libellulidae)									1	1				1									
	Isostictidae																		1	2		1		
Zygoptera	Coenogrionidae								1		1				7			4		1	1		3	
Trichoptera	Leptoceridae								2		3		1				4	49		5	4	15	26	3
	Ecnomidae	Ecnomus spp.					3										1		4	2	1	4		
	Hydrobiosidae																4							
	Hydroptilidae																						1	
	Hydropsychidae						2										91							
Lepidoptera	Pyralidae										1				1									
	Crambidae																						1	1

Appendix G: Aquatic Vertebrate Trapping Results

Table 22 Wet Season Aquatic Vertebrate Trapping Results

	AQ1	AQ3	AQ4	AQ5	AQ6	AQ9	AQ17	AQ18	AQ23	AQ25	AQ28	AQ31	AQ36	AQ37	AQ38	AQ39
Species																
Glass Perch *Ambassis agassizi*	X		X	X			X		X		X					X
Purple-spotted Gudgeon *Mogurnda adspersa*	X	X		X	X		X	X	X		X		X			
Carp Gudgeon *Hypseleotris compressa*	X		X				X				X					
Rainbowfish *Melanotaenia splendida*	X		X	X	X		X	X	X		X	X	X			
Spangled Perch *Leiopotherapon unicolor*		X	X	X		X		X	X		X	X	X		X	X
Bony Bream *Nematalosa erebi*			X	X								X				
Hyrtl's Tandan *Neosilurus hyrtlii*					X						X		X			

Table 23 Dry Season Aquatic Vertebrate Trapping Results

	AQ04	AQ05	AQ25A	AQ28	AQ31	AQ49
Species						
Glass Perch *Ambassis agassizi*		X	X	X	X	X
Purple-spotted Gudgeon *Mogurnda adspersa*	X	X		X	X	
Barred grunter *Amniataba percoides*		X		X		X
Rainbowfish *Melanotaenia splendida*	X	X	X			
Spangled Perch *Leiopotherapon unicolor*	X	X		X	X	
Hyrtl's Tandan *Neosilurus hyrtlii*		X		X		
Prawn (Palaemonidae sp.)		X				
Yabby *Cherax destructor*		X	X			X
Red claw *Cherax quadricarinatus*		X				

Appendix H: Vertebrate Fauna Species List

Table 24 Vertebrate Fauna Species List

	Status	AQ1	AQ3	AQ4	AQ5	AQ6	AQ9	AQ17	AQ18	AQ23	AQ25	AQ28	AQ31	AQ36	AQ37	AQ38	AQ39	AQ49
Mammals																		
Feral Pig *Sus scrofa*	*		✳										◆					
Water Rat *Hydromys chrysogaster*												◆						
Reptiles																		
Common Tree Snake *Dendrelaphis punctulata*												◆						
Eastern Snake-necked Turtle *Chelodina longicollis*												✳						
Birds																		
Australian Maned Duck *Chenonetta jubata*											◆	◆	✳◆			✳		
Australian pelican *Pelecanus conspicillatus*													✳◆					
Black Swan *Cygnus atratus*													◆					

Table 24 (cont) Vertebrate Fauna Species List

	Status	AQ1	AQ3	AQ4	AQ5	AQ6	AQ9	AQ17	AQ18	AQ23	AQ25	AQ28	AQ31	AQ36	AQ37	AQ38	AQ39	AQ49
Masked Lapwing *Vanellus miles*				◆			✳				✳◆	✳◆	◆					
Black-winged Stilt *Himantopus himantopus*												◆						
Black-fronted Dotterel *Charadrius melanops*							✳						✳◆					
White-necked Heron *Ardea pacifica*				◆	◆		✳				✳	✳◆		✳		✳		
White-faced Heron *Egretta novaehollandia*												◆						◆
Intermediate Egret *Ardea intermedia*													◆					
Straw-necked Ibis *Threskiornis spinicollis*												◆	◆					
Australian White Ibis *Threskiornis molucca*												◆						
Yellow spoonbill *Platalea flavipes*													◆					
Pacific Black Duck *Anas superciliosa*				✳	✳							✳◆	◆	✳				

Table 24 (cont) Vertebrate Fauna Species List

	Status	AQ1	AQ3	AQ4	AQ5	AQ6	AQ9	AQ17	AQ18	AQ23	AQ25	AQ28	AQ31	AQ36	AQ37	AQ38	AQ39	AQ49
Grey Teal *Anas gracilis*					✳													
Hardhead *Aytha australis*												✳						
Black Bittern *Ixobrychus flavicollis*										✳								
Darter *Anhinga melanogaster*												✳◆		✳		✳		
Pied Cormorant *Phalacrocorax varius*												◆						
Black-necked Stork *Ephippiorhynchus asiaticus*													◆					
White-eyed Duck *Aythya australis*												✳	◆					
Brolga *Grus rubicunda*												✳						
Laughing Kookaburra *Dacelo novaeguineae*					◆						◆							◆
Blue-winged Kookaburra *Dacelo leachii*						◆												

Table 24 (cont) Vertebrate Fauna Species List

	Status	AQ1	AQ3	AQ4	AQ5	AQ6	AQ9	AQ17	AQ18	AQ23	AQ25	AQ28	AQ31	AQ36	AQ37	AQ38	AQ39	AQ49
Rainbow Bee-eater *Merops ornatus*																		◆
Sacred kingfisher *Todiramphis sancta*												✳◆				✳		
Amphibian																		
Broad-palmed Frog *Litoria latopalmata*						✳												
Striped Burrowing Frog *Litoria alboguttata*					✳							✳						
Ornate Burrowing Frog *Opisthodon ornatus*					✳			✳				✳		✳		✳		
Little Red Tree Frog *Litoria rubella*												✳		✳		✳		
Cane Toad *Rhinella marina*					✳	✳				✳◆		✳	◆	✳		✳		

Legend: * = Naturalized

1 = Class 1 Declared Pest Species (Land Protection (Pest and Stock Route Management) Act 2002))

2 = Class 2 Declared Pest Species (Land Protection (Pest and Stock Route Management) Act 2002))

3 = Class 3 Declared Pest Species (Land Protection (Pest and Stock Route Management) Act 2002))

✳ = Recorded during Wet Season Surveys

◆ = Recorded during Dry Season Surveys