Aquatic Ecology Report D

EASTERN LEASES PROJECT

Aquatic Ecology Assessment Report

For:

Hansen Bailey on behalf of South32 Pty Ltd

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Report No. Q14002RP2

The preparation of this report has been in accordance with the brief provided by the Client and has relied upon the data and results collected at or under the times and conditions specified in the report. All findings, conclusions or recommendations contained within the report are based only on the aforementioned circumstances. The report has been prepared for use by the Client and no responsibility for its use by other parties is accepted by Cumberland Ecology.

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Glossary of Terms

AEP	Annual Exceedence Probability
ALC	Anindilyakwa Land Council
Algae	Aquatic cellular plant-like organisms
ALRA	*Aboriginal Land Rights Act (Northern Territory) 1976*
ANOSIM	Analysis of Similarity: a statistical analysis that tests whether there are significant differences between datasets from two or more sample groups
ANZECC	Australian and New Zealand Environment Conservation Council
ARI	Average Recurrence Interval
ARMCANZ	Agricultural and Resource Management Council of Australia and New Zealand
AusRivAS	Australian River Assessment System
Biplot	A type of exploratory graph used in statistics that allows information on a data matrix to be displayed graphically
bloom	Dense, uncontrolled growth of plants, algae, or bacteria
BOM	Bureau of Meteorology
Cyanobacteria	A phylum of bacteria that obtain energy via photosynthesis
disturbance footprint	The area of land proposed to be disturbed by the project
DO	Dissolved Oxygen. Relative measure of the amount of oxygen that is dissolved in water.
DotE	Commonwealth Department of the Environment
EA Act	*Environmental Assessment Act*
Eastern Leases	ELR28161 and ELR28162
EC	Electrical Conductivity
EIS	Environmental Impact Statement
ELR	Exploration Licence in Retention
EPT ratio	A measure used to determine the presence of pollution sensitive invertebrate fauna. EPT includes Ephemeroptera (mayflies), Plecoptera (stoneflies) and Trichoptera (caddisflies)
Ephemeral	A water body that exists for a limited period of time following precipitation
EPBC Act Environmental Offsets Policy	*EPBC Act Environmental Offsets Policy 2012*
EPBC Act	Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*
Family	One of the seven main ranks in the taxonomic hierarchy of biological classification, lying below Order and above Genus

Glossary of Terms

GEMCO	Groote Eylandt Mining Company Pty Ltd
GIS	Geographic Information System
GPS	Global Positioning System
Lentic	Non-flowing water
Locality	Area within 20 km radius of the project site
Lotic	Flowing water
Macroinvertebrate	Invertebrates large enough to be seen with the naked eye and retained by 0.595 mm sieve. An animal lacking a backbone
Macrophytes	Aquatic vascular plants with stems, leaves and roots. They grow in or near water and is either emergent, submerged or floating
MDS	Multidimensional Scaling. This is a graphical means of representing the level of similarity between two or more sample groups
microhabitat	Refers to very small, specialised habitats, such as a clump of algae or a space between submerged rocks
MNES	Matters of National Environmental Significance
Multi-parameter Water Quality Meter (90 FLT)	Water meter used to simultaneously record water quality variables *in situ.* The model number utilised is 90FLT
Native Title Act	Commonwealth *Native Title Act 1993*
Northern EL	Northern Eastern Lease (ELR28161)
NT EPA	Northern Territory Environment Protection Authority
NTU	Nephelometric Turbidity Unit
OE50 score	A ratio of observed to expected taxa used in AusRivAS modelling
Order	One of the seven main ranks in the taxonomic hierarchy of biological classification, lying below Class and above Family
Perennial	A stream or river that has continuous flow in its channel bed all year round during years of normal rainfall
Phylum	One of the seven main ranks in the taxonomic hierarchy of biological classification, lying below Kingdom and above Class
PMST	Protected Matters Search Tool
ppm	Parts per million
PRIMER	A statistical software package for analysing ecological data. Version 6 was utilised for the current study.
Project site	The area comprising the Eastern Leases and the haul road corridor
RNE	Register of National Estate
SEWPaC	Commonwealth Department of Sustainability, Environment, Water, Populations and Communities – now the DotE

Glossary of Terms

SIGNAL	Stream Invertebrate Grade Number – Average Level
SIMPER	Similarity Percentages: a statistical analysis that compares the contribution of species to an observed similarity between two or more sample groups
Southern EL	Southern Eastern Lease (ELR28162)
Stream order	A number that is assigned to a stream in order to designate its relative position in a drainage basin network and which is ranked from headwaters to river terminus
Taxon / Taxa	A group of one or more populations of an organism or organisms seen to form a biological unit.
TDS	Total Dissolved Solids
the project	The Eastern Leases Project
TOR	Terms of Reference
TPWC Act	*Territory Parks and Wildlife Conservation Act*
Tributary	A stream that flows to a larger stream or other body of water
TSMP	Threatened Species Management Plan
Threatened species	Aquatic flora and fauna species that are listed under the EPBC Act and TPWC Act and protected under the Fisheries Act.

CUMBERLAND ECOLOGY

Chapter ***1***

Introduction

Cumberland Ecology was commissioned by Hansen Bailey on behalf of BHP Billiton Manganese Australia Pty Ltd to undertake an aquatic ecology assessment report as part of the Environmental Impact Statement (EIS) for the Eastern Leases Project (the project).

An EIS is being prepared in accordance with the requirements of the Northern Territory *Environmental Assessment Act* (EA Act) and to support an application for approval from the Commonwealth Department of the Environment (DotE) under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). The Terms of Reference (TOR) for the EIS were issued by the Northern Territory Environment Protection Authority (NT EPA) in September 2014. The Northern Territory's EIS process for the project has been accredited under an agreement between the Commonwealth and the Northern Territory under section 45 of the EPBC Act, following determination of the project as a 'controlled action' (EPBC 2014/7228).

1.1 Purpose

This aquatic ecology assessment report provides ecological information for the EIS being prepared in order to support approval of the project. The purpose of this report is to document the findings of an aquatic ecology assessment of the project site (see **Figure 1**) and to assess the impacts of the project on the aquatic biodiversity values present. Aquatic biodiversity values include threatened species, populations and ecological communities protected under Territory and Commonwealth legislation.

Specifically, the objectives of this aquatic ecology assessment are to:

- Describe and map aquatic habitats of the project site;
- Identify and map the location of threatened aquatic flora and fauna species;
- Assess the likelihood as to whether threatened aquatic flora or fauna species could occur within the project site;
- Describe the presence or likely occurrence of introduced and invasive species;
- Describe the types and extent of potential impacts arising from the project; and
- Describe avoidance, mitigation and offset measures proposed to manage impacts.

A terrestrial ecology assessment has been undertaken separately and is presented in the EIS Terrestrial Ecology Report.

1.2 Project Description

The project proponent is the Groote Eylandt Mining Company Pty Ltd (GEMCO), which has two shareholders, namely South32 Pty Ltd (60%) and Anglo Operations (Australia) Pty Ltd (40%). BHP Billiton Manganese Australia Pty Ltd was previously a shareholder in GEMCO, however its interest is now represented by South32.

The project involves the development of a number of open cut mining areas to the east of the existing GEMCO manganese mine on Groote Eylandt in the Gulf of Carpentaria, approximately 650 km south-east of Darwin (**Figure 1**). The proposed additional mining areas are located on the Eastern Leases, which are two Exploration Licences in Retention (ELRs). ELR28161 is termed the Northern Eastern Lease (Northern EL) and ELR28162 is termed the Southern Eastern Lease (Southern EL).

The Eastern Leases are located 2 km east of the existing GEMCO mine at the closest point. The township of Angurugu is located approximately 6 km to the north-west of the Eastern Leases, and is the closest residential community (**Figure 2**). The Eastern Leases are located on Aboriginal land, scheduled under the *Aboriginal Land Rights (Northern Territory) Act 1976*. The land within the Eastern Leases comprises natural bushland, with the Emerald River and a small section of the Amagula River traversing the Northern EL and Southern EL respectively.

The project involves:

- Developing a number of open cut mining areas (termed “quarries”) within the Eastern Leases and mining manganese ore by the same mining methods that are in use at the existing GEMCO mine;
- Constructing limited mine related infrastructure in the Eastern Leases (dams, water fill points, crib hut, truck park up areas and laydown storage areas); and
- Transporting the ore by truck on a new haul road to be constructed between the existing GEMCO mine and the Eastern Leases.

Ore will be processed at the concentrator at the existing GEMCO mine and the concentrate would be transported to market via the existing port (**Figure 2**). No changes or upgrades to the existing GEMCO mine facilities are required as a result of the project. Ore mined from the Eastern Leases will supplement production from the existing GEMCO mine, but the project will not increase GEMCO’s annual production rate of approximately 5 Million tonnes per annum of product manganese. The EIS does not include any assessment of operations within the existing GEMCO mine, given that these operations are subject to existing environmental approvals, and will not be altered by the project.

The project site for the purposes of the EIS is the Northern and Southern ELs and the new section of haul road linking the Eastern Leases to the existing GEMCO mine. The project site is approximately 4,600 ha.

Mining in the Eastern Leases would take place concurrently with the operation of the existing GEMCO mine. According to current planning, construction in the Northern EL would commence in 2017 and mining activities would commence in 2018. Construction in the Southern EL is scheduled to commence approximately 4 years later in 2022 and mining would then take place in both of the tenements until approximately 2031. This equates to a total of 13 years of mining operations (i.e. mining of ore).

1.3 Island and Regional Context

The project site is located on Groote Eylandt, the third largest island off the Australian mainland. It is part of an archipelago to the east of Arnhem Land (**Figure 3**).

Groote Eylandt is located in the Groote Sub-region of the Arnhem Coast Bioregion (DLRM, 2014). The Arnhem Coast Bioregion comprises a coastal strip extending east of the Cobourg Peninsula to north of the township of Numbulwar in south eastern Arnhem Land, and includes many offshore islands including Groote Eylandt (**Figure 3**). The Arnhem Coast Bioregion has a tropical monsoonal climate with a distinct wet and dry season, and experiences high temperatures throughout the year (DEWHA, 2008). The bioregion is located entirely within Aboriginal land (DEWHA, 2008). Land uses within the bioregion include bauxite and manganese mining, as well as tourism (DEWHA, 2008). No national parks occur within the bioregion (DLRM, 2014).

The central areas of Groote Eylandt are characterised by elevated rocky outcrops that form hills and escarpments with limited vegetation and soil cover. The rocky outcrops limit the vegetation and soil cover within this centre portion of the island. Between these hills and escarpments, the low-lying topography forms densely vegetated, gently sloping valleys that open into flat coastal plains. These hills and escarpments define the surface water catchments across the majority of the island. The relief of the landscape in the area surrounding the project site is shown in **Figure 4**.

Regionally, the surface geology is naturally enriched in metals and depleted in minerals, and exhibits low soil erosion rates. This results in naturally low suspended sediment loads and elevated concentrations of metals in watercourses.

1.4 Drainage Setting

There are three main river systems in the southern half of Groote Eylandt, these being the Amagula, Emerald and Angurugu Rivers. These rivers typically flow in a west or south-westerly direction, draining into the sea. The river systems are largely undisturbed by human activities.

Each of these rivers typically experience significantly high flows during the monsoonal wet season which occurs from November to April. During the dry season, the upper reaches of these rivers experience low to no flows, with isolated pools often forming along the course of the rivers. However, all three rivers sustain continuous flow throughout the year in their lower reaches (downstream of the project site) due to groundwater inflows, which assist in maintaining flows during the dry season.

1.4.1 Drainage of the Project Site

The project site is located in the upper catchments of the Amagula, Emerald and Angurugu Rivers (**Figure 4**). The Emerald River and its tributary watercourses drain the majority of the Northern EL and the western area of the Southern EL. The Amagula River drains the eastern area of the Southern EL via the main channel and two tributary watercourses. The main channel of the Angurugu River does not traverse the project site.

The majority of the project site drains towards the coast from elevated rock outcrops located at the periphery of the project site. Minor drainage features include a network of minor gullies in the steeper topography associated with elevated outcrops, and overland flow paths in the lower lying areas. These drainage features coalesce to form regionally significant watercourses in the flatter areas of the project site. The main watercourses are typically channelised through the project site and characterised by narrow, rocky channels and chains of pools. Site drainage is highly ephemeral through the majority of the project site.

There are no lakes, dams or permanent wetlands occurring within the project site.

i. Amagula River

The Amagula River rises in the eastern part of Groote Eylandt and flows in a south-westerly direction. It discharges to the sea on the southern coast of the island, approximately 21 km south of the Southern EL (**Figure 4**). The Amagula River has a catchment area of 24,300 ha.

A small section of the Amagula River – Main Channel intersects the south-eastern corner of the Southern EL (**Figure 5**). The Amagula River has the following two tributaries which traverse parts of the project site, namely:

- Amagula River – Tributary 1 traverses the centre of the Southern EL, flowing toward the south and draining into the Amagula River – Main Channel approximately 0.8 km to the south of the Southern EL; and
- Amagula River – Tributary 2 traverses the eastern portion of the Southern EL, flowing toward the south and draining into the Amagula River – Main Channel where the main channel crosses the boundary of the Southern EL.

The eastern half of the Southern EL falls within the Amagula River Catchment (**Figure 4**).

ii. Emerald River

The Emerald River rises in the central area of Groote Eylandt and flows in a westward direction toward the south-western coast of the island. It discharges into the sea approximately 12.6 km downstream of the Northern EL and 7 km downstream of the Southern EL (**Figure 4**). The Emerald River has a catchment area of 9,500 ha.

The Emerald River – Main Channel traverses the middle of the Northern EL and is crossed by the proposed haul road corridor at one location to the west of the Northern EL (**Figure 5**). The Emerald River has the following three tributaries which traverse parts of the project site:

- Emerald River – Tributary 1 traverses the southern section of the Northern EL, and drains into the Emerald River – Main Channel approximately 2.3 km to the west of the Northern EL;
- Emerald River – Tributary 2 traverses the western section of the Southern EL; and drains into the Emerald River – Main Channel approximately 8.1 km downstream of the Northern EL and 2.5 km to the west of the Southern EL; and
- Emerald River – Tributary 3 flows south into the Emerald River – Main Channel approximately 3.4 km downstream of the Northern EL. The Emerald River – Tributary 3 is crossed by a section of the haul road corridor approximately 0.7 km upstream of this confluence.

The majority of the Northern EL, the western half of the Southern EL, and the entire haul road corridor lie within the Emerald River Catchment (**Figure 4**).

iii. Angurugu River

The Angurugu River rises in the central area of Groote Eylandt and flows in a westward direction toward the western coast of the island (**Figure 4**). The Amagula River has a catchment area of 16,300 ha. An area of 181 ha in the north-east of the Northern EL drains to the Angurugu River via minor drainage lines and overland sheetflow (**Figure 5**).

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Chapter **2**

Regulatory Framework

2.1 Commonwealth Legislation and Policies

2.1.1 Environment Protection and Biodiversity Conservation Act 1999

The EPBC Act is the Australian Government's principal piece of environmental legislation and is administered by DotE. It is designed to protect national environmental assets, known as Matters of National Environmental Significance (MNES), which include threatened species of flora and fauna, endangered ecological communities, migratory species as well as other protected matters. Among other things, it defines the categories of threat for threatened flora and fauna, identifies key threatening processes and provides for the preparation of recovery plans for threatened flora, fauna and communities.

Under the EPBC Act, any action (which includes a development, project or activity) that is considered likely to have a significant impact on MNES (including nationally threatened ecological communities and species, and listed migratory species) is termed a Controlled Action and is subject to assessment and approval under the EPBC Act.

The project was deemed a Controlled Action on 1 July 2014 with the controlling provisions for the project being listed threatened species and communities (Section 18 and 18A) and listed migratory species (Sections 20 and 20A). The project will be assessed through an accredited assessment process under the EA Act.

2.1.2 EPBC Act Environmental Offsets Policy

Under the *EPBC Act Environmental Offsets Policy 2012* (EPBC Act Environmental Offsets Policy), environmental offsets are actions taken to counterbalance significant residual impacts on MNES. Offsets are used as a last resort in instances where an action will give rise to residual impacts, even after the application of management measures.

The EPBC Act Environmental Offsets Policy came into force in October 2012 and provides guidance on the role of offsets in environmental impact assessments and how DotE considers the suitability of a proposed offset package (SEWPAC, 2012).

According to the policy, an offsets package is a "*suite of actions that a proponent undertakes in order to compensate for the residual significant impact of a project"* (SEWPAC, 2012). It can comprise a combination of direct offsets and other compensatory measures.

Direct offsets are those actions that provide a measurable conservation gain for an impacted protected matter. Direct offsets are an essential component of a suitable offsets package. A minimum of 90% of the offset requirements for any given impact must be met through direct offsets. Other compensatory measures are those actions that do not directly offset the impacts on the protected matter, but are anticipated to lead to benefits for the impacted protected matter, for example funding for research or educational programs (SEWPAC, 2012).

Deviation from the 90% direct offset requirement will only be considered by DotE in circumstances where it can be demonstrated that a greater benefit to the protected matter is likely to be achieved through increasing the proportion of other compensatory measures in an offsets package, or scientific uncertainty is so high that it isn't possible to determine a direct offset that is likely to benefit the protected matter (SEWPAC, 2012).

2.1.3 Ramsar Wetlands and Nationally Important Wetlands

The Convention on Wetlands of International Importance (i.e. the Ramsar Convention), is an international cooperative designed to conserve wetlands. It involves an intergovernmental treaty that provides the framework for national action and international cooperation for the conservation and wise use of wetlands and their resources. Ramsar wetlands are those that are representative, rare or unique wetlands, or are important for conserving biological diversity. Although Ramsar wetlands are recognised as a MNES under the EPBC Act, they are not a controlling provision for this project.

The Directory of Important Wetlands is managed by DotE and is an online database that lists Nationally Important Wetlands. Nationally Important Wetlands, although listed on a database managed by DotE, are not MNES and are not protected under the EPBC Act.

Ramsar wetlands and Nationally Important Wetlands are considered in **Section 4.1**.

2.2 Northern Territory Legislation and Guidelines

2.2.1 Mining Management Act

The *Mining Management Act* (MM Act) is an Act established to ensure the development of the Northern Territory's mineral resources in accordance with environmental standards consistent with best practice in the mining industry (MM Act, Section 3(a)). The MM Act aims to protect the environment through establishing a system that provides for the authorisation of mining activities, the management of mining sites, the provision of economic and social benefits to communities affected by mining activities, and for related purposes. Any company that proposes to undertake works that would cause "substantial disturbance" is required to have an Authorisation. The Mining Environmental Compliance Group in the Northern Territory Department of Mines and Energy is responsible for issuing Authorisations for operational activities on mining tenements. The group is also responsible for ensuring there is a transparent system in place for remediation securities (i.e. closure and decommissioning provisions involving the rehabilitation of mining leases or to rectify environmental harm caused by mining activities) and ensuring operators comply with

approved mining management plans. The project will require an Authorisation under the MM Act, and this Authorisation can only be granted once the EIS process under the EA Act has been completed.

2.2.2 Environmental Assessment Act

The environmental assessment process is administered under the Northern Territory EA Act and its subordinate *Environmental Assessment Administrative Procedures*. The Act and Procedures establish the framework for the assessment of potential or anticipated environmental impacts of development. The object of the Act is to ensure that matters affecting the environment to a significant extent are fully examined and taken into account in decisions by the Northern Territory Government. In the Northern Territory, the NT EPA is responsible for the implementation of the environmental assessment process.

The scale and complexity of a proposed development and the significance of potential impacts will determine if assessment is at the level of a Public Environmental Report or EIS. In addition to assessing the potential impacts, the assessment process also evaluates the effectiveness of the proposed safeguards to mitigate these impacts and recommends actions to ensure the construction and operational phases of a project can be managed in an environmentally sound manner. The NT EPA has determined that an EIS is the required level of assessment for the project.

2.2.3 Territory Parks and Wildlife Conservation Act

The *Territory Parks and Wildlife Conservation Act* (TPWC Act) is the primary piece of legislation for managing the protection and conservation of biodiversity, and the sustainable use of wild populations in the Northern Territory. The Act is administered by the Northern Territory Department of Land Resource Management (NT DLRM).

The TPWC Act makes provision for the study, protection, conservation and sustainable utilisation of wildlife throughout the Northern Territory. This legislation covers the classification and management of wildlife; classification and control of feral animals; permits for taking wildlife and entering land; designation and management of protected areas, including joint management with Traditional Owners and mining; and private sanctuaries.

The management of wildlife under the TPWC Act is to be carried out in accordance with the Principles of Management (Section 31 of the TPWC Act), which promote:

> *(a) the survival of wildlife in its natural habitat;*
>
> *(b) the conservation of biological diversity within the Territory;*
>
> *(c) the management of identified areas of habitat, vegetation, ecosystem or landscape to ensure the survival of populations of wildlife within those areas;*
>
> *(d) the control or prohibition of:*
>
> > *(i) the introduction or release of prohibited entrants into the Territory; and*

(ii) any other act, omission or thing that adversely affects, or will or is likely to adversely affect, the capacity of wildlife to sustain its natural processes; and

(e) the sustainable use of wildlife and its habitat.

Under the TPWC Act, threatened flora and fauna species in the Northern Territory are classified under the following conservation categories:

- Extinct;
- Extinct in the Wild;
- Critically Endangered;
- Endangered;
- Vulnerable;
- Near Threatened;
- Least Concern;
- Data Deficient; and
- Not Evaluated.

These categories and associated assessment criteria are aligned with the classification system and criteria developed by the International Union for the Conservation of Nature for determining the conservation status of species.

Under the TPWC Act, species are considered as 'threatened' wildlife if they are classified as Extinct in the Wild, Critically Endangered, Endangered or Vulnerable and are assigned protected wildlife status. The categories utilised under the TPWC Act are independent of the listing of wildlife under the EPBC Act as they relate only to their occurrence within the Northern Territory.

2.2.4 Fisheries Act

The *Fisheries Act* which is administered by the Department of Primary Industry and Fisheries is the primary legislation that provides for the protection, conservation and management of fish, fish habitat and aquatic life in the Northern Territory.

The purpose of the *Fisheries Act* is to provide for the regulation, conservation and management of fisheries and fishery resources so as to maintain their sustainable utilisation, to regulate the sale and processing of fish and aquatic life, and for related purposes. This includes overseeing licensing, permits, and offences related to fisheries.

Although threatened fish species in the Northern Territory are listed in the conservation categories as described in the TPWC Act (shown in **Section 2.2.3**), they are protected under regulations of the *Fisheries Act*.

2.2.5 Water Act

The Northern Territory *Water Act* and subordinate *Water Regulation* provides the legislative framework for water planning and entitlements for most water resources in the Northern Territory. The DLRM is responsible for administering and enforcing the *Water Act*. The *Water Act* provides for the investigation, allocation, use, control, protection, management and administration of water resources. It also defines the beneficial uses of both surface water and groundwater. Water extraction for most purposes must be licensed under the *Water Act*. The Act provides rights to take water from watercourses and groundwater for stock and domestic uses.

The water licensing provisions of the Act do not apply to the take of water for mining, given that these activities are managed under the *Mining Management Act*.

The *Water Act* provides a framework for the protection of environmental values. Under this framework, environmental values can be formalised through a process of statutory declaration. Environmental values formalised under the *Water Act* are known as beneficial uses. Beneficial uses have been declared for the Emerald River, Angurugu River and their receiving coastal waters west of Groote Eylandt. The declared beneficial uses for these waters are aquatic ecosystem protection and recreational water quality and aesthetics.

2.2.6 Northern Territory Guidelines on Environmental Offsets and Associated Approval Conditions

The objective of the *Northern Territory Guidelines on Environmental Offsets and Associated Approval Conditions* (NTEPA, 2013) is to foster coordination of offsets and the conditioning of approval requirements that may be imposed under Commonwealth and Northern Territory legislation. The guidelines note the potential requirement for an environmental offset under the EPBC Act, EA Act, ALRA and the Commonwealth *Native Title Act 1993* (Native Title Act). The offset requirements under the EPBC Act are outlined within the EPBC Act Environmental Offsets Policy. At present, the EA Act contains no requirements for the provision of environment offsets or social or other community benefits as part of an assessment or approval process. The NT EPA has no role in requiring, developing or managing environmental offsets, however the ALRA and the Native Title Act contain provision for negotiation with Land Councils regarding the use of Aboriginal lands or lands with Aboriginal interests which may entail the provision of environmental offsets.

As there is no formal offsetting policy under the EA Act, any offsets required for project-related impacts will be provided under the EPBC Act Environmental Offsets Policy.

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Chapter **3**

Methodology

The methodology utilised in the aquatic ecology assessment included a desktop study comprising a database analysis and literature review of the various ecological studies conducted in the Eastern Leases and nearby areas of Groote Eylandt, field surveys and an assessment of the findings. The methods used for each component are explained in more detail below.

Due to the size of the project site, the approach was to conduct field surveys in strategic locations and extrapolate using high resolution aerial photography, geological maps and topographic maps. Prior to undertaking field surveys, appropriate permits were obtained from the Northern Territory Government. These included:

- A Permit to Interfere with Protected Wildlife (Permit number 51161);
- A Licence to Use Premises for Teaching or Research involving Wild Animals (Licence number 058); and
- An Animal Ethics Approval consistent with the Northern Territory *Animal Welfare Act*.

Permission to access the project site for the purpose of undertaking field surveys was obtained from the Anindilyakwa Land Council (ALC).

3.1 Desktop Study

3.1.1 Database Analysis

Prior to the fieldwork, database searches were conducted, and government mapping was consulted. This included the following:

- EPBC Act Protected Matters Search Tool (PMST), accessed on 1 July 2014 (20 km search from the centre of the study area);
- Northern Territory NRM InfoNet database (InfoNet), accessed on 17 October 2014 (20 km search radius from the boundary of Groote Eylandt; and
- Searches for Nationally Important Wetlands using the DotE website.

3.1.2 Literature Review

Available literature on the project site and the locality was reviewed, including available Northern Territory Government data and in-house reports as available from GEMCO. Several aquatic ecology studies have been conducted in the locality and the subsequent reports were reviewed. These included the following studies:

- URS Australia Pty Ltd (2012): Flora and Fauna Surveys of Western Groote Eylandt; and
- G. Webb Pty Limited (1992): Flora and Fauna Surveys on the Western Side of Groote Eylandt, N.T. (1991-92).

Various other reports were also reviewed, and details of these reports are provided in the References section.

In 1992, GEMCO engaged G. Webb Pty Ltd to undertake a baseline survey of the flora and fauna of the GEMCO mineral leases and adjoining areas in order to fulfil rehabilitation obligations and to provide definitive data for use in the future. The terrestrial environment was the focus of the surveys conducted by Webb (1992); however some surveys for fish were undertaken in the Angurugu and Emerald Rivers. A total of five survey sites were surveyed in the Angurugu River (two sites in the dry season and three sites in the wet season), and three sites were sampled in the Emerald River (one in the dry season and three in the wet season). All sites were located downstream of the project site. **Figure 5** shows the sections of the Angurugu and Emerald Rivers that were surveyed by Webb (1992).

In 2012, GEMCO engaged URS to undertake a flora and fauna survey of western Groote Eylandt to update the baseline flora and fauna studies undertaken by Webb in 1992, review the conservation status of species identified, and discuss the implications of the results relative to rehabilitation practices. The project site was not included in this assessment. **Figure 5** shows the sections of the Angurugu and Emerald Rivers that were surveyed by URS (2012). In common with Webb (1992), the focus of the URS studies was on the terrestrial environment; however some aquatic surveys were conducted. A total of 21 aquatic sites were surveyed for fish and turtles in July and August 2010 (dry season) comprising 12 sites along the Angurugu River and nine sites along the Emerald River.

Macroinvertebrate surveys were conducted in July 2010 at six sites; three on the Angurugu River and three on the Emerald River. All of the survey sites on the Emerald River were conducted within an area approximately 4.5 km upstream of the mouth of the river. These sites are not in the project site and are located a considerable distance downstream of the sites surveyed for this Aquatic Ecology Assessment and therefore comprise different habitat types. Accordingly the results of the URS assessment are not directly comparable with this most recent assessment undertaken for the Eastern Leases. Nevertheless, the URS report provides a useful reference on the biodiversity that occurs in this river downstream of the project site.

3.1.3 Review of Aerial Photography

The most recent available aerial photography (flown by GEMCO in July 2013, September 2013 and March 2014) was reviewed to identify features for ground-truthing during the field survey, to identify appropriate survey locations, and for determining and characterising potential aquatic habitats.

3.2 Field Surveys

Aquatic flora and fauna surveys were undertaken in the watercourses that traverse the project site, including the Emerald River, the Amagula River and their tributaries. The purpose of the field surveys was to provide a comprehensive baseline aquatic ecology assessment of existing aquatic conditions in the project site.

Aquatic surveys were conducted in accordance with the *Australia-wide Assessment of River Health: Northern Territory AusRivAS Sampling and Processing Manual* (NT AusRivAS Manual) (Lloyd and Cook, 2002). This approach involves undertaking habitat assessments, *in-situ* water quality measurements and macroinvertebrate samples to provide an indication of the current condition of the aquatic survey locations. The aquatic survey also included sampling for fish. GPS coordinates were taken at each aquatic survey location and observations and water quality measurements were recorded to assess habitat potential.

3.2.1 Survey Timing

Aquatic field surveys were conducted in the project site in two survey periods; between 20 May and 3 June 2014 (early dry season), and between 2 October and 5 October 2014 (late dry season). Personnel from Cumberland Ecology were accompanied by ALC rangers for two days during the October survey period.

The first survey commenced in May 2014, immediately following the wet season, when all of the rivers and their tributaries still contained significant volumes of water, and the natural resources for aquatic fauna were expected to be at their peak. The majority of watercourses present within the project site were flowing, while in other locations the water present consisted of non-flowing pools.

The second survey period occurred toward the end of the dry season in October 2014, when conditions were much drier in comparison to the first survey period. Water was far more limited, and the majority of the watercourses were observed to be dry. The exception to this was the main channel of the Amagula River which was flowing, as well as some isolated pools in the Emerald River, and the tributaries of both rivers. With the exception of one survey site from the May survey (in the Emerald River – Tributary 2), all other survey sites from the May survey were found to be dry in the October survey. No sampling for macroinvertebrates, fish or water quality could therefore be duplicated in the second survey period at these original sites. Consequently, alternative aquatic survey sites were selected for the October survey.

3.2.2 Meteorology During Survey Periods

For each of the survey periods the meteorological conditions (temperature and rainfall) recorded at the Bureau of Meteorology (BoM) weather station at Groote Eylandt Airport (approximately 7 km from the project site) are presented below in **Table 3.1**. The data from this weather station is considered to be broadly representative of the conditions in the project site.

The weather conditions during the May 2014 survey period were characterised by clear, warm days and cool to cold nights. Some small amounts of patchy rainfall occurred during the beginning of the field survey, however for the majority of the period it was dry.

The weather conditions during the October 2014 survey period were characterised by warm to hot days, and cool to moderately warm nights. The entire survey period was dry and whilst no rainfall was recorded at the closest weather station; isolated showers were observed at two of the detailed fauna survey sites on 10 October 2014.

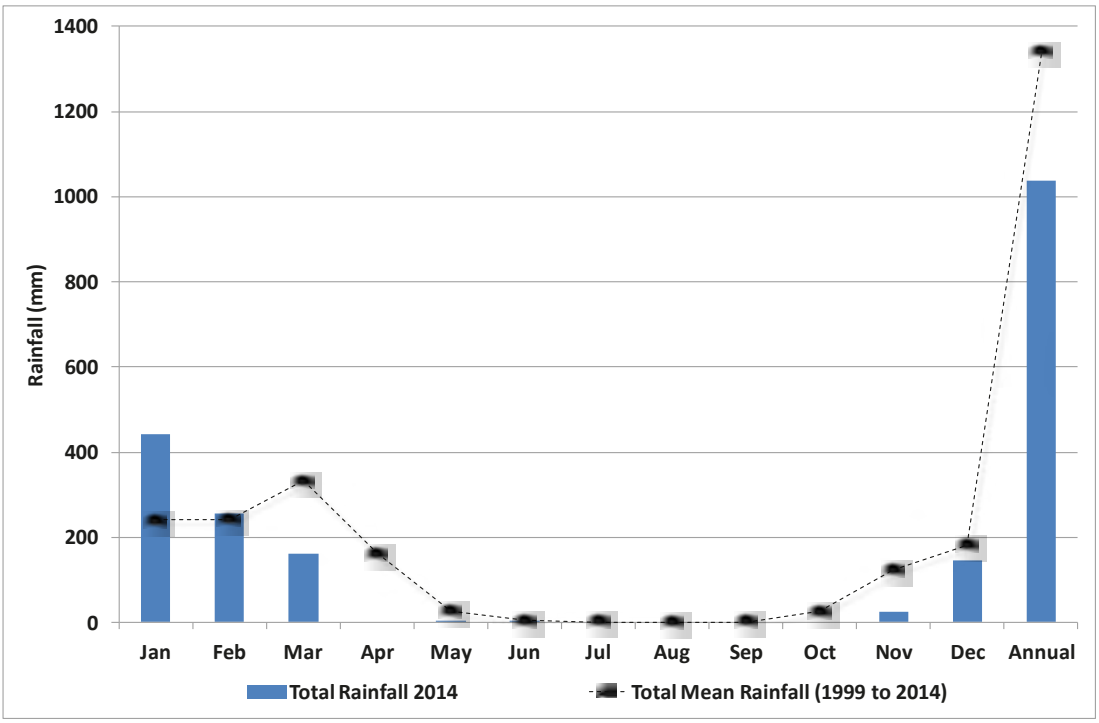
Table 3.1 Meteorological Conditions Recorded During Field Surveys at the Groote Eylandt Airport BoM Weather Station

Date	Minimum Temperature (°C)	Maximum Temperature (°C)	Rainfall (mm)
First Survey Period			
20/05/2014	20.9	29.6	0.0
21/05/2014	21.5	30.0	2.6
22/05/2014	20.7	31.6	0.0
23/05/2014	21.0	32.2	1.6
24/05/2014	17.7	32.5	0.2
25/05/2014	20.6	32.9	0.0
26/05/2014	19.1	32.2	0.2
27/05/2014	18.6	31.1	0.0
28/05/2014	18.2	32.0	0.0
29/05/2014	19.6	32.1	0.0
30/05/2014	19.1	32.4	0.0
31/05/2014	20.8	32.0	0.0
1/06/2014	21.4	31.2	0.0
2/06/2014	23.3	30.1	0.6
3/06/2014	21.0	29.8	0.0
Average	20.2	31.4	
Total			5.2
Second Survey Period			
2/10/2014	17.1	32.5	0.0
3/10/2014	16.3	32.9	0.0
4/10/2014	17.8	33.1	0.0

Date	Minimum Temperature (°C)	Maximum Temperature (°C)	Rainfall (mm)
5/10/2014	17.6	32.2	0.0
Average	17.2	32.7	
Total			0.0

Data obtained from the Groote Eylandt Airport (Station 014518) (BOM, 2014)

Graph 1 shows the monthly rainfall in 2014 compared to the historic mean monthly rainfall recorded at the BoM Groote Eylandt Weather Station. As can be seen from **Graph 1**, rainfall in January 2014 was higher than the historic average, however subsequent months in 2014 experienced lower or on average rainfall.



Graph 1 Comparison of the Historic Average Rainfall to the Rainfall Recorded in 2014 at the Groote Eylandt Airport BoM Weather Station

3.2.3 Site Selection

Aquatic survey sites were selected based on the different habitat types present (e.g. permanent river, ephemeral watercourses and groundwater fed watercourses), the proportion of lentic and lotic bodies in the project site, their relative size and accessibility for sampling during wet season flows. Potential survey sites within the project site were determined through an assessment of aerial photographs and available site information. Detailed review of the aerial photographs resulted in the identification of key habitat types that were then assessed (ground-truthed) during the field assessment.

A total of 17 survey sites were sampled for aquatic ecology in accordance with the NT AusRivAS Manual (Lloyd and Cook, 2002). This comprised nine sites during the May 2014

field survey period, and eight sites during the October 2014 field survey period, at the following locations (see **Figure 6**):

- Emerald River - Main Channel (three sites);
- Emerald River - Tributary 2 (five sites);
- Emerald River - Tributary 3 (one site);
- Amagula River - Main Channel (one site);
- Amagula River - Tributary 1 (five sites); and
- Amagula River - Tributary 2 (two sites).

No survey sites were undertaken in the Emerald River – Tributary 1 as this area was dry during both survey periods. Waterbodies near Emerald River – Tributary 1 were limited to seasonal wetlands to the north of the tributary.

The seasonal wetlands were not surveyed as part of the aquatic assessments as they predominantly consist of swamps with waterlogged soils and generally lack sufficient surface water for adequate aquatic sampling. These seasonal wetlands are discussed in the EIS Terrestrial Ecology Report.

Aquatic survey sites are shown on **Figure 6** and are listed below in **Table 3.2**. Note that sites A8 and A16 were sampled at the same location. Photographs of the sites are presented in **Section 4.2** of this report.

Table 3.2 Location of Survey Sites and Timing of Survey

Location	Survey Site	Timing	Easting	Northing
Emerald River – Main Channel	**A1**	May	664070	8447629
	A2	May	660842	8446022
	A17	October	664318	8447691
Emerald River – Tributary 2	**A8***	May	660682	8444283
	A9	May	662374	8443378
	A10	October	661542	8443755
	A15	October	659717	8444223
	A16*	October	660682	8444283
Emerald River – Tributary 3	**A3**	May	660193	8447116
Amagula River – Main Channel	**A11**	October	669376	8440060
Amagula River – Tributary 1	**A5**	May	665380	8440586
	A6	May	667013	8443010
	A12	October	666072	8439811
	A13	October	665455	8440462
	A14	October	665899	8439938
Amagula River – Tributary 2	**A4**	May	668810	8441052
	A7	May	669012	8442152

(* A8 and A16 were sampled at the same location)

3.2.4 Aquatic Habitat Assessment

Aquatic habitat assessments were conducted at each of the 17 aquatic sampling locations in accordance with the NT AusRivAS Manual (Lloyd and Cook, 2002). Habitat assessments were conducted along a 100 m reach of the watercourse, where possible, or a subset that included the bed and banks. The assessment considered the habitats within the survey site in terms of habitat diversity and extent, suitability for aquatic fauna groups, existing disturbances/modifications, riparian condition and flow characteristics.

The following general features were noted at each survey site:

- Flow regime;
- Nature of watercourse;
- Vegetation;
- Substrate; and
- Water clarity.

A photograph was taken at each sampling location, both upstream and downstream to provide a visual indication of the habitat at each location, and to form a baseline record of current conditions.

Further details of particular habitat features were recorded specifically for the purposes of the AusRivAS modelling (See **Section 3.2.6 v**). These include:

- Composition and percentage cover of substrate (e.g., bedrock, boulder, cobble, pebble, gravel, sand or silt/clay);
- Habitat attributes (e.g., algae, macrophytes, bank overhang vegetation, trailing bank vegetation);
- Variety of habitat (e.g., sand/silt bed, gravel/rock bed, riffle, macrophytes, snags, pool/edge);
- Width of the riparian zone and levee banks;
- Flow level;
- Vegetation cover;
- Presence of erosion;
- Local land use;
- Channel alteration;

- Bottom scouring and deposition;
- Pool/riffle and run/bend ratio;
- Bank stability;
- Bank vegetative stability; and
- Streamside cover.

The majority of freshwater habitats in the project site were accessed and surveyed, including all habitats in proximity to the project disturbance footprint. The survey data collected within the project site for the current surveys was assessed in conjunction with data collected by Webb (1992) and URS (2012) from nearby parts of the Emerald and Amagula Rivers. The data available is considered to be suitable and adequate to assess the likely impacts of the project on aquatic flora and fauna.

3.2.5 Water Quality

At each of the 17 survey locations, a range of water quality measurements were recorded *in situ* using a 90 FLT Multi-parameter Water Quality Meter. The following *in-situ* parameters were recorded:

- Alkalinity (as mg/L of $CaCO_3$): Measure of the buffering capacity of the water;
- Electrical Conductivity (EC) (µS/cm): Measure of the total concentration of inorganic ions (salts) in the water;
- Dissolved oxygen (DO) (ppm): Reflects the equilibrium between oxygen consuming processes (e.g. respiration) and oxygen releasing processes (e.g. photosynthesis);
- Temperature (°C): Temperature of the water at the time of sampling;
- pH: Measure of the acidity or alkalinity of the water;
- Total Dissolved Solids (TDS) (ppm): total amount of mobile charged ions, including minerals, salts or metals dissolved in a given volume of water; and
- Turbidity (NTU): Measures the presence of suspended particulate and colloidal matter such as suspended clay, silt, phytoplankton and detritus.

Water quality data were analysed, tabulated and compared to the relevant guideline values, including the *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZECC and ARMCANZ, 2000), in particular, Volume 1, *Water Quality Guidelines for Aquatic Ecosystems*. DO was recorded in the field in parts per million (ppm), and converted to percent saturation to allow for comparison with relevant water quality guidelines.

Additional water quality data has been collected from within the project site as part of the EIS surface water assessment. This data is presented in the EIS Baseline Surface Water Monitoring Report. This data was reviewed as part of this aquatic ecology assessment.

3.2.6 Aquatic Flora Assessment

An aquatic flora assessment was undertaken in conjunction with aquatic habitat assessments, noting any aquatic flora species present and their relative abundance. This assessment targeted aquatic macrophytes and water dependent flora species only.

Aquatic flora can have many different forms, including:

- Submerged macrophytes: Usually rooted in the substrate with the vegetative parts predominantly beneath the water surface,;
- Floating macrophytes: Can be either attached to the substrate or free floating (Sainty and Jacobs, 2003). For example, waterlilies are rooted to the substrate and the mature leaves and flowers are emergent, whereas water hyacinths free float on the water surface; and
- Emergent macrophytes: Generally found in shallower waters and are rooted to the substrate with the majority of the plant (stems, flowers and leaves) protruding above the surface of the water (Sainty and Jacobs, 2003).

Details of the riparian vegetation community present at each survey site were recorded as part of the standard AusRivAS habitat assessment of each survey site. Further assessment of riparian vegetation was conducted for the terrestrial ecology assessment and is presented in the EIS Terrestrial Ecology Report.

3.2.7 Aquatic Macroinvertebrate Communities

i. Quantitative Samples

At each of the 17 survey sites, macroinvertebrate samples were collected according to the methods in the NT AusRivAS sampling manual (Lloyd and Cook, 2002) from bed habitat and or edge habitat where possible. For sites where sampling of the two distinct habitats was not possible, a single pooled sample was collected. Limitations for collection of two distinct habitat samples from all sites was based on the potential presence of crocodiles in large, deep waterbodies and the small size of the remnant waterbodies (pools) during the October 2014 survey period.

A maximum of 10 m of habitat was surveyed along a 100 m stretch at each location, where possible. The entire length any remnant pools was sampled during the October 2014 survey period. Bed samples were collected by disturbing the sediment within the 10 m section and the sample was then collected by sweeping a standard macroinvertebrate sampling net, with a 250 micron mesh, through the water. Edge samples were collected by agitating submerged root matter to a water depth of 30 cm from the surface and vigorously sweeping the net through any suspended material.

The samples were washed through nested sieves, including a 10 mm coarse sieve to remove the large organic fraction, and a 250 micron fine sieve. Components of the organic fraction were washed and checked for macroinvertebrates prior to being discarded, and the sample from the 250 micron sieve was stored in a solution of 70% ethanol for transport to the laboratory for identification. ALC rangers assisted with checking the organic fraction for macroinvertebrates during the October 2014 survey period.

Photograph 3.1 Sorting of organic fraction for macroinvertebrates

Macroinvertebrate identification was undertaken by Dr Gitanjali Katrak of Cumberland Ecology. Macroinvertebrate analysis involved identification using taxonomic keys and aquatic invertebrate guides. Most taxa were identified to family level, however the Mites (Order Acarina), were left at order level because it is particularly difficult to identify this group down to family level.

The macroinvertebrate data collected from each site was analysed using standard statistical methods as well as AusRivAS and Stream Invertebrate Grade Number – Average Level (SIGNAL) Analyses. AusRivAS and SIGNAL are two macroinvertebrate scoring methods that can provide an indication of the water quality and therefore aquatic health at the sample collection sites. These analysis methods are described in the following sections.

ii. Statistical Analyses

Macroinvertebrate data was analysed using the statistical software package PRIMER Version 6 (Clarke and Gorley, 2006). The primary analyses conducted were non-parametric Multidimensional Scaling (MDS), Analysis of Similarity (ANOSIM) and Similarity Percentages (SIMPER).

An MDS analysis incorporates all relevant data and displays outputs on a two-dimensional graph. This method is useful for analysing sets of data with multiple variables (e.g. invertebrate families) between sites, as the data is interpreted visually, with sites that are more similar being placed closer together. The program also outputs a stress number, which indicates the goodness of fit of the data in the two-dimensional space, whereby the lower the stress number the better the fit. A standard stress level of ≤ 0.2 is considered to be acceptable for an MDS plot.

ANOSIM tests were undertaken to determine differences between the sampling groups using the Global R statistic. The Global R statistic ranges in value from 0 – 1, where large values (close to 1) are suggestive of complete separation of groups, whilst small values (close to 0) indicate little separation between groups. The SIMPER procedure calculates levels of similarity between samples and determines the contribution of each factor (in these cases – the different invertebrate taxa) to the similarity and/or dissimilarity between samples.

All invertebrate abundance data was pre-treated and transformed (square root and presence/absence) prior to analyses. PRIMER analyses were focused on determining differences between sampling periods (May and October) and between the two main rivers (Emerald River and Amagula River) based on taxon richness (presence/absence data) and taxon composition (square-root abundance data).

As several sites had only edge samples, data from sites with edge and bed samples were pooled for the purposes of the PRIMER analyses.

iii. EPT Taxa Richness

The “EPT” group of macroinvertebrates are three orders of insects that are known to be especially sensitive to disturbance and are typically found in very low numbers in degraded water bodies or water bodies with naturally high stressors (e.g. low oxygen content or acidic waters). The three orders are; Ephemeroptera (mayflies), Plecoptera (stoneflies) and Trichoptera (caddisflies). These particular macroinvertebrate orders are known to be sensitive to changes within their environment and therefore the species richness and numbers of species found at a site are considered good indicators of disturbance and/or stressors. An EPT ratio is derived as the percentage of EPT taxa representation within the whole invertebrate community at each site. High EPT ratios indicate a greater prevalence of taxa that are less tolerant to disturbance (and can reflect higher habitat values).

iv. SIGNAL Analysis

The SIGNAL index was initially developed by Chessman (1995) to assist in the bioassessment of water quality in Australia. Chessman (1995) determined sensitivity grade numbers (between 1 and 10) for most freshwater macroinvertebrate families in Australia based on how sensitive each was to various pollutants and other physical and chemical factors. In 2003, Chessman devised an updated weighted system for analysing SIGNAL indices to provide an overall SIGNAL 2 score for sampled sites (Chessman, 2003). This weighted system of analysis takes into consideration relative family abundance and therefore community composition.

The SIGNAL scoring was conducted in accordance with Version 2 of the scoring system (SIGNAL 2) which allows for identification at family level as well as order-class-phylum level. The SIGNAL 2 scoring was conducted at the family level for most taxa. However, for taxa such as the mites, the order-class-phylum grades were used consistently across the samples (Chessman, 2003). The overall SIGNAL 2 score was calculated using the following steps:

- Determine SIGNAL grade for each different taxon present;
- Determine weighting of each taxon present based on the number of individuals collected using the categories outlined in Chessman (2003);
- Multiply the weight value by the SIGNAL grade for each taxon; and
- Divide the total weight determined for a site (add up all the weights) by the total SIGNAL grade x weight determined (add up all the values determined in the previous step) to provide an overall SIGNAL 2 score for the site.

SIGNAL 2 scores were then interpreted using biplots and compared against the number of families recorded at each site. The biplots are then divided into quadrants with each separate quadrant identifying the particular conditions occurring within a site (Diagram 1).

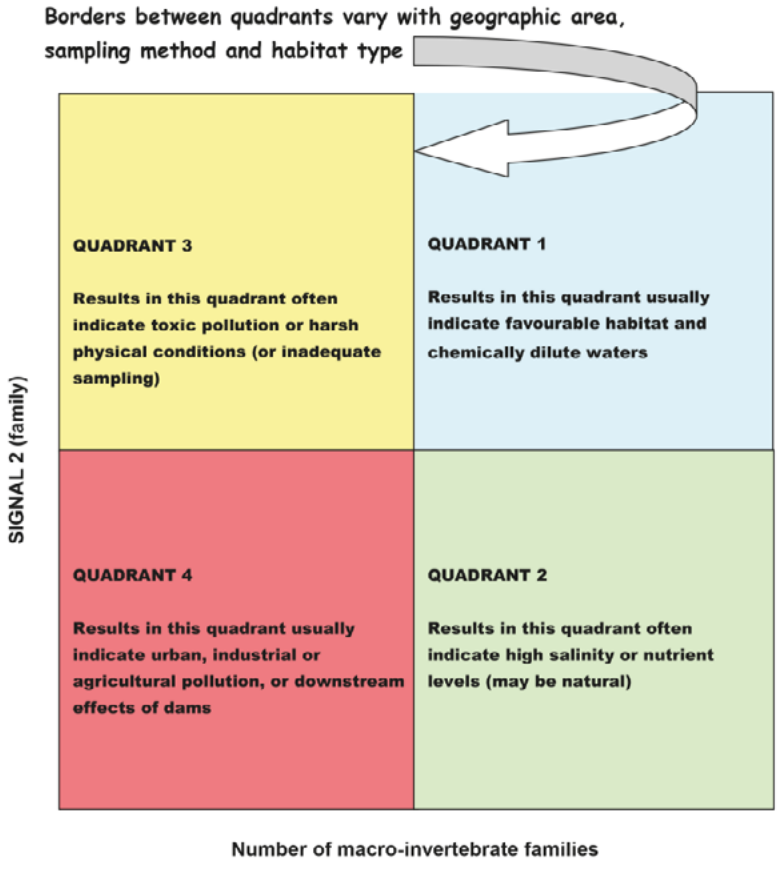


Diagram 1 Habitat Condition Represented by Each Quadrant of the SIGNAL 2/Family Biplot (extracted from Chessman 2003)

The boundaries of the quadrants are set individually to suit each study region and the sampling methods. Accordingly, they differ between geographic regions of Australia because of natural variation in macroinvertebrate assemblages.

Relatively pristine sites would be expected to have high macroinvertebrate diversity, including taxa that are sensitive to pollution, and therefore a high SIGNAL score. It should be noted that although scores range from 1 to 10 (with Site SIGNAL score >6 being healthy habitat, and scores <4 indicating severe pollution), SIGNAL was originally developed for 'normal' streams with typical freshwater habitats. Streams with unusual water chemistry, wetlands and/or ephemeral streams can produce SIGNAL scores which may not be representative. In these cases, judgment has to be used to set appropriate biplot quadrat boundaries to fit the appropriate definitions of the biplot quadrants.

v. AusRivAS Analysis

AusRivAS compares the abundance and identity of macroinvertebrates collected from a sample site, with a database from a large number of defined reference sites throughout Australia (the reference sites are those believed to be least altered by human activity). The AusRivAS model then matches the sample site to reference sites for similar types of streams in the same State/Territory or region, and classifies the site into one of five Ecological Integrity Bands (X, A, B, C or D) (described in **Table 3.3**). The band describes the level of biological impairment.

Table 3.3 AusRivAS Ecological Integrity Bands

AusRivAS Band	Description	Macroinvertebrate Biodiversity Status	Interpretation Guide
X	More biologically diverse than reference sites	Over 112% more biodiversity than reference sites	More macroinvertebrate families found than expected. Potential biodiversity 'hot spot'. Possible mild nutrient enrichment.
A	Reference condition	Similar levels of biodiversity to reference sites (i.e., natural or near-natural levels of biodiversity)	Presumed to be in a reference condition. Most or all of the expected macroinvertebrate families were found at the sample site. Water quality and/or habitat condition roughly equivalent to reference sites.
B	Significantly impaired	Approximately 16-45% of macroinvertebrate biodiversity has been lost	Several expected macroinvertebrate families not found. Water quality and/or habitat condition significantly impaired. Significant loss of macroinvertebrate biodiversity.
C	Severely impaired	Approximately 46-75% of macroinvertebrate biodiversity has been	Many expected macroinvertebrate families not found. Water quality and/or habitat condition severely

Table 3.3 AusRivAS Ecological Integrity Bands

AusRivAS Band	Description	Macroinvertebrate Biodiversity Status	Interpretation Guide
		lost	impaired. Severe loss of macroinvertebrate biodiversity.
D	Extremely impaired	Approximately 76-100% of macroinvertebrate biodiversity has been lost	Extremely few of the expected macroinvertebrate families found. Extremely poor water quality and/or habitat condition. Extreme loss of macroinvertebrate biodiversity. Highly degraded

Source: Gray (2004).

If the sample site is lacking the macroinvertebrate families that are expected to occur according to the reference site database, it is likely that the test site is more affected by human influences than the reference sites (Lloyd and Cook, 2002).

Current available AusRivAS models for the Northern Territory include the Darwin-Daly Regional (early season) Model, Early and Late Season Model and the Spring & Autumn Models which are designed for perennial water bodies on the mainland, primarily the north-west coast of the Northern Territory.

It should be noted that there are no AusRivAS reference sites available for the north-east coast of the Northern Territory (including Groote Eylandt). It is therefore currently unknown as to how the natural diversity of Groote Eylandt compares to the reference sites from the available models. Therefore the results of the AusRivAS models should be treated with caution, particularly, as for example, a site with naturally low diversity may get mis-banded if compared to a reference site with naturally high diversity.

The invertebrate data and the detailed habitat assessment data from each site were assessed to determine the AusRivAS bandings for each site, using the Early and Late Season Models of the AusRivAS modelling programme (*AUSRIVAS Macroinvertebrate Bioassessment Predictive Modelling Software V3.2.0*). These models are used to predict the condition of a site based on the invertebrate community present within the sample, and provide an indication of the level of biological impairment experienced at the targeted sites.

AusRivAS compares the expected (E) number of taxa to the actually observed (O) number of taxa at each site. AusRivAS only considers taxa that were calculated to have a probability of 50% or greater of occurring at a test site. The “OE50” score is therefore the ratio of the observed to the expected number of taxa with a probability of 50% or greater of occurring. Each OE50 score occurs within the range of one of the five Ecological Integrity Bands (**Table 3.2**), and therefore provides a measure of biological impairment for each habitat type

within a site. This OE50 score is the major output score used in the NT to assess the health of the macroinvertebrate community at the test site.

There are several limitations of the AusRivAS predictive models that currently have the potential to affect assessments of site condition. Reference sites must cover a wide range of river types to allow for accurate matching of test sites with reference site groups. The current available AusRivAS models for the Northern Territory are designed for perennial water bodies on the mainland, primarily the north-west coast of the Northern Territory. Therefore, these models would have limitations in predicting values for ephemeral water bodies on an island, off the north-eastern coast of the Northern Territory.

3.2.8 Fish and Other Aquatic Fauna

Fish communities were surveyed using a combination of seine netting and dip nets, depending on habitat type. Where sufficient water was present at a given survey location, a seine net with 1 cm mesh was dragged through the water by two people. The seine net was approximately 4 m long, and the bottom edge was weighted with lead to maximise the depth sampled. The length of the seine transects was determined by the habitat characteristics (i.e. depth, length and presence of woody debris) of the water body and generally did not exceed 10 m for each trawl. The seine transect was dragged twice; once in one direction, and then once from the other direction.

The macroinvertebrate dip net (with 250 micron mesh) was used to survey the smaller remnant pools and narrow streams where it was not feasible to use the seine net. The dip net was dragged through the water by one person.

These methods were also suitable for surveying macro-crustaceans, such as crabs.

Some locations were not surveyed for fish due to the potential presence of crocodiles. These were locations where crocodiles had either been recently sighted or were considered likely to occur due to the depth of the water or the size of the pool. In particular, large pools that were highly discoloured or turbid were not surveyed due to the inability to see what was below the surface of the water.

The survey effort used to survey for fish at each survey site is summarised below in **Table 3.4**.

Table 3.4 Fish Survey Effort Employed at each Survey Site

Survey Site	Survey Date	Average Sampling Depth (m)	Method	Total Survey Effort (minutes)
Emerald River – Main Channel				
A1	24/05/2014	0.6	Seine net	15
A2	25/05/2014	0.4	Seine net	30
A17	05/10/2014	0.2	Dip net	15

Table 3.4 Fish Survey Effort Employed at each Survey Site

Survey Site	Survey Date	Average Sampling Depth (m)	Method	Total Survey Effort (minutes)
Emerald River – Tributary 2				
A8	31/05/2014	0.6	Dip net	15
A9	31/05/2014	0.6	Seine net	30
A10	02/10/2014	-	NS	-
A15	04/10/2014	0.5	Dip net	15
A16	04/10/2014	0.5	Dip net	15
Emerald River - Tributary 3				
A3	25/05/2014	0.5	Seine net	30
Amagula River – Main Channel				
A11	03/10/2014	-	NS	-
Amagula River – Tributary 1				
A5	28/05/2014	0.45	Seine net	15
A6	29/05/2014	0.6	Seine net	15
A12	03/10/2014	-	NS	-
A13	03/10/2014	0.2	Dip net	15
A14	04/10/2014	-	NS	-
Amagula River – Tributary 2				
A4	28/05/2014	-	NS	-
A7	29/05/2014	0.6	Seine net	15

NS = Not Sampled due to the potential presence of crocodiles

After each trawl, if fish were caught, they were placed in a bucket of water for recovery. Fish were then counted, identified, measured (to determine life history stage) and photographed. Fish were then returned to the same body of water from which they were sampled.

The deeper waters in some sections of the Emerald River – Tributary 2 and the Amagula River (Main Channel Tributary 1 and Tributary 2) were not specifically surveyed for fish due to the presence of crocodiles. These include Sites A4 (Amagula River Tributary 2), A10 (Emerald River – Tributary 2), A11 (Amagula River Main Channel) and Sites A12 and A14 (Amagula River Tributary 1). Fish data for these sites (from the current surveys) was therefore limited to incidental captures from the macroinvertebrate dip-netting.

These sections are near the edges of the Southern EL, some distance from the project disturbance footprint. Aquatic fauna in the deeper water habitats of the Emerald and Amagula Rivers has been previously surveyed downstream of the project site by Webb (1992) and URS (2012) and so baseline data exists for these habitats. That data was

reviewed to identify those fish species having the potential to occur in the deeper pools of the project site. The aquatic fish fauna in the project site is well understood and the potential presence of threatened species has been adequately assessed.

No targeted surveys were undertaken for turtles, as only one species is known to occur on Groote Eylandt; the Northern Snake-necked Turtle (*Chelodina rugosa*), and this is not listed as threatened.

CUMBERLAND ECOLOGY

Chapter **4**

Results

This section provides a description of the aquatic biodiversity values present in the project site. It presents the results of the desktop study, aquatic habitat assessment, in-situ water quality, aquatic flora survey, macroinvertebrate and aquatic fauna results.

4.1 Desktop Study Results

4.1.1 Protected Matters Search Tool

No EPBC Act listed aquatic flora species were recorded from the Protected Matters Search Tool (PMST).

Several EPBC Act listed fauna species were recorded from the PMST as having been recorded from the locality or having the potential to occur (**Appendix A**), including the following aquatic species:

- Species that may be associated with the freshwater environment:
  - Merten's Water Monitor (*Varanus mertensi*); and
  - Salt-water Crocodile (*Crocodylus porosus*).

  These species inhabit riparian areas and are discussed in the EIS Terrestrial Ecology Report. They are not considered further in this assessment.
- Marine species that may make use of the estuarine environment for parts of their lifecycle:
  - Green Sawfish (*Pristis zijsron*);
  - Dwarf Sawfish (*Pristis clavata*); and
  - Dugong (*Dugong dugon*).

  As noted in Section 1.3, the project site is in the catchment of three rivers, namely the Amagula, Emerald and Angurugu Rivers. These species, if present, would be restricted to the estuarine reaches of these rivers. The project site is located in the headwaters of these rivers, at least 9 km upstream of the estuarine reaches of these rivers. The assessment of the watercourses in the project site area, which

are 9 km upstream of the nearest potential habitat for these species, determined that no potential habitat for these species occurs within the project site.

Previous surveys carried out by URS (2012) in the estuarine reaches of the Emerald and Amagula Rivers downstream of the project site did not record these species. As these species were not recorded within more suitable esturine habitats downstream of the project site, they are unlikely to occur within watercourses within the project site.

As is detailed in Section 5.1, the project has been specifically designed to minimise potential downstream impacts on these rivers and their catchments. The project is not predicted to give rise to any impacts on the downstream, estuarine reaches of the rivers. Issues such as water quality and sedimentation are considered in Section 5.1. Estuarine species are therefore not discussed further in this report.

- Marine species, such as whales, marine turtles and sharks.

  The whale, turtle and shark species listed in the PMST report (**Appendix A**) are all exclusively marine with no stage of their lifecycle being spent in freshwater or estuarine environments. Exclusively marine species are not relevant to the assessment, given the location of the project site and the lack of any feasible mechanism whereby the project would impact the marine environment.

The remaining fauna species listed in the PMST are terrestrial mammals, reptiles and birds, and are assessed in the EIS Terrestrial Ecology Report.

Appendix C describes the habitat requirements of the aquatic species listed above. This appendix does not include terrestrial species, as these are assessed in the EIS Terrestrial Ecology Report.

4.1.2 Northern Territory NRM InfoNet

No TPWC Act listed aquatic flora species were recorded from the InfoNet database.

Several TPWC Act listed fauna species were recorded from the InfoNet database as having been recorded from the locality or having the potential to occur (**Appendix B**). Of these, the only aquatic species were four threatened marine turtles. As discussed in **Section 4.1.1**, exclusive marine species are not considered further in this report.

The remaining species listed from the InfoNet database are terrestrial mammals, reptiles and birds, which are not relevant to this assessment, and are therefore assessed in the EIS Terrestrial Ecology Report.

4.1.3 Ramsar Wetlands and Nationally Important Wetlands

The PMST report indicates that there are no Nationally Important Wetlands or Wetlands of International Importance (i.e. Ramsar wetlands) in the locality. In addition, Ramsar wetlands are not a controlling provision for the project. Nationally Important Wetlands and Ramsar wetlands are therefore not considered further in this report.

4.2 Aquatic Habitat Assessment

The catchments of the project site are naturally vegetated with forest, woodland and sedgeland (these vegetation types are described in the EIS Terrestrial Ecology Report). The project site has not been subject to any land clearing or agricultural grazing practices. The majority of land is burnt annually or biennially and many fires are deliberately lit by the Traditional Owners. Aside from fire, human disturbances are limited to unsealed tracks and trails, most of which are located on well drained areas of the project site away from watercourses and seasonal wetlands. There are no known sources of pollution, nor any development close to the watercourses, and there are no domestic stock present which may pollute the water or erode the banks of watercourses. The watercourses and seasonal wetlands in the project site are quite undisturbed and in their natural state. The watercourses that are in the upper catchments of the Angurugu, Emerald and Amagula Rivers are generally small, higher order watercourses that are seasonally dry.

The majority of the aquatic habitat only receives surface water flows or has standing water during and immediately after the wet season. In the first survey period (May/June 2014) the watercourses within the project site contained water while the seasonal wetlands had water-logged soils with shallow surface pools (depth <10cm). However, in the second survey period (in October 2014), most of the watercourses and all seasonal wetlands within the project site were dry, and freshwater habitat was restricted mainly to remnant pools isolated by dry river or stream beds. Some sections of the Amagula River – Tributary 1 and the Emerald River – Tributary 2 are perennial due to groundwater inflows contributing to their baseflow. **Figure 7** shows the sections of the watercourses that have been mapped as perennial, based on the results of the aquatic ecology assessment, the geomorphology study (described in the EIS Baseline Surface Water Monitoring Report) and predictions from groundwater modelling (refer EIS Groundwater Report).

The quartzitic rocks that form low hills around the Eastern Leases have eroded to form a variety of sandy soils and consequently many of the streams have sandy beds and banks. Some also have rocky beds where the underlying geology is exposed.

Fire scars, including scars close to the base, were noted on the trunks of trees observed growing within the channels of the majority of the watercourses within the project site. This indicates that these sections of the watercourses dry out thereby exposing the full tree to fire.

Most watercourses and seasonal wetlands within the project site are bounded by narrow bands of paperbarks, including *Melaleuca viridiflora* (Swamp Tea Tree)*, M. cajuputi* (Cajuput tree) and *M. leucadendra* (Weeping Paperbark). Rainforest elements also occur along the larger watercourses and include trees such as *Canarium australianum* (Brown Cudgerie), *Dillenia alata* (Red Beech) and *Syzigium nervosum*. The riparian communities are described further in the EIS Terrestrial Ecology Report.

Emergent macrophytes comprising rushes, sedges and related plants typically occur along the main channels of the watercourses and in the seasonal wetlands. Submerged macrophytes were not well represented and were found mainly in the larger, perennial flowing sections of the Emerald River – Tributary 2 and Amagula River – Tributary 1. Floating macrophytes were largely absent from the first and second order streams. Different

forms of algae (e.g: plant-like forms, flat encrusting forms on submerbed rocks) were also present in the majority of the watercourses. There was no evidence of algal blooms or cyanobacterial blooms in any of the watercourses.

The aquatic habitats present in the watercourses of the project site are discussed in more detail below. **Photograph 4.1** shows the upstream and downstream view from each survey site.

Emerald River - Main Channel

Site A1 - upstream (May 2014)

Site A1 - downstream (May 2014)

Site A2 - upstream (May 2014)

Site A2 - downstream (May 2014)

Site A17 - upstream (October 2014)

Site A17 - downstream (October 2014)

Emerald River - Tributary 2

Site A8 - upstream (May 2014)

Site A8 - downstream (May 2014)

Emerald River - Tribuary 2 (cont.)

Site A9 - upstream (May 2014)

Site A9 - downstream (May 2014)

Site A10 - upstream (October 2014)

Site A10 - downstream (October 2014)

Site A15 - upstream (October 2014)

Site A15 - downstream (October 2014)

Site A16 - upstream (October 2014)

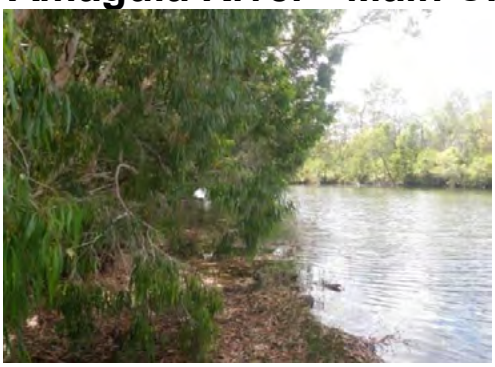
Site A16 - downstream (October 2014)

Emerald River - Tributary 3

Site A3 - upstream (May 2014)

Site A3 - downstream (May 2014)

Amagula River - Main Channel



Site A11 - upstream (October 2014)

Site A11 - downstream (October 2014)

Amagula River - Tributary 1

Site A5 - upstream (May 2014)

Site A5 - downstream (May 2014)

Site A6 - upstream (May 2014)

Site A6 - downstream (May 2014)

Amagula River - Tributary 1 (cont.)

Site A12 - upstream (October 2014)

Site A12 - downstream (October 2014)

Site A13 - upstream (October 2014)

Site A13 - downstream (October 2014)

Site A14 - upstream (October 2014)

Site A14 - downstream (October 2014)

Amagula River - Tributary 2

Site A4 - upstream (May 2014)

Site A4 - downstream (May 2014)

Amagula River - Tributary 2 (cont.)

Site A7 - upstream (May 2014)

Site A7 - downstream (May 2014)

Photograph 4.1 Upstream and Downstream Photographs of Aquatic Survey Sites

4.2.1 Emerald River – Main Channel

The Emerald River – Main Channel flows from east to west through the Northern EL and is fed by three ephemeral tributaries.

During the May 2014 field surveys, the Emerald River – Main Channel was dry in the upstream eastern reaches of the Northern EL; however towards the west, several isolated water pools were present (e.g. survey site A1), and further west it formed a flowing stream towards the western boundary of the Northern EL. Where the haul road corridor intersects the Emerald River it was flowing relatively fast in a narrow channel (site A2; see **Photograph 4.1**). The substrate within the survey sites was dominated by sandy sediment with occurrences of silt/clay sediments and cobbles. Water clarity was very good. Generally, no distinct riparian zone was present, and the vegetation fringing the watercourse was typical of surrounding vegetation with the exception of *Melaleuca viridiflora* that was observed to be growing in close proximity to the water.

During the October 2014 field surveys, with the exception of some very small remnant pools (e.g. site A17 – see **Photograph 4.1**), the Emerald River – Main Channel was dry for its entire length in the Northern EL and also where the haul road corridor intersects the river to the west. **Photograph 4.2** shows the comparative conditions of the Emerald River – Main Channel in May and October 2014 at survey site A2, where the haul road corridor intersects the main channel. The vast majority of all the upstream pools in the project site had dried out and only very shallow puddles remained at some locations. The pools were not flowing and water clarity was very poor. These pools may dry out further towards the end of the dry season, depending on the rainfall regime of any given year. Accordingly (and consistent with the findings of the EIS Groundwater Report), it is not considered likely that the Emerald River – Main Channel, where it occurs within the project site, is augmented by groundwater. Downstream of the project site near Yedikba, the Emerald River was observed to still be flowing in October 2014; most likely due to the influence of springs, groundwater inflows and remnant inflows from minor water bodies downstream of the EL.

Photograph 4.2 Emerald River – Main Channel (Site A2 – May and October 2014)

4.2.2 Emerald River –Tributary 1

The Emerald River – Tributary 1 was dry during both survey periods. Semi-aquatic habitats in the form of small patches of seasonal wetlands were present to the north of Emerald River – Tributary 1 (**Photograph 4.3**). These seasonal wetlands mainly had water-logged soils and surface water was limited to shallow surface pools, generally with a depth <10cm.

Further assessments of the seasonal wetlands are provided in the EIS Terrestrial Ecology Report.

Photograph 4.3 Seasonal wetland area to the north of Emerald River – Tributary 1 (May 2014).

4.2.3 Emerald River –Tributary 2

The western half of the Southern EL is drained by the Emerald River – Tributary 2. The upstream (eastern) section of this tributary is ephemeral and during both survey periods, was found to be largely dry with the exception of remnant water pools (e.g. sites A9 and A10; see **Photograph 4.1**).

The western part of the Emerald River – Tributary 2 was characterised in both survey periods by a rapidly flowing narrow stream that was flanked by *Melaleuca leucadendra* closed forest with a dense sedge and fern understorey dominated by ferns such as *Blechnum indicum* (Swamp Water Fern) and *Lygodium flexuosum* (Climbing Maidenhair), and large herbs such as *Hanguana malayana* (see **Photograph 4.4**). This section of the tributary is perennial due to the surface expression of groundwater in this location. **Figure 7** identifies the section of Emerald River – Tributary 2 that is perennial.

The western section of the Emerald River – Tributary 2 that is groundwater fed, displayed noticeably different water characteristics (e.g, Alkalinity) between the two survey periods (see **Section 4.6**). Water clarity was very high in this area during both survey periods.

The substrate within the western parts of the Emerald River – Tributary 2 (Sites A8, A15 and A16) consisted of sand or silt/clay sediments. In contrast, substrates in the eastern parts (Sites A9 and A10) consisted largely of bedrock and boulders.

Photograph 4.4 *Melaleuca leucadendra* closed forest along a groundwater-fed section of the Emerald River - Tributary 2 (photograph taken at Site A15)

4.2.4 Emerald River –Tributary 3

The Emerald River - Tributary 3 intersects the western section of the haul road corridor (see **Figure 5**) and flows in a southerly direction.

During the May 2014 field surveys the Emerald River - Tributary 3 was flowing rapidly in a narrow channel (refer to site A3 –**Photograph 4.1**). The water was clear, and macrophytes such as *Eriocaulon setacum* (Water Pincushions) were present. No distinct riparian zone was present, and the vegetation fringing the watercourse was typical of surrounding vegetation with the exception of *Melaleuca viridiflora* that was observed to be growing in close proximity to the water. The substrate within the survey site (A3) was dominated by sand and silt/clay sediments with occasional occurrences of boulders.

During the October 2014 field surveys, the Emerald River - Tributary 3 was found to be dry at survey site A3 (see **Photograph 4.5**).

Photograph 4.5 Emerald River –Tributary 3 (Site A3 – May and October 2014)

4.2.5 Amagula River – Main Channel

The Amagula River – Main Channel flows from north-east to south-west across the south-eastern corner of the Southern EL.

The Amagula River – Main Channel was not surveyed in May 2014 because of access restrictions imposed by the ALC at that time. It was, however, surveyed in October 2014 and

was noted to be characterised by a wide, slow flowing river (refer to site A11; see **Photograph 4.1**).

At this survey site (A11), the Amagula River is approximately 20 m wide, and is fringed by a broad riparian zone dominated by *Melaleuca cajuputi*. Macrophytes, such as *Eriocaulon setacum* and *Nymphaea violacea* (Blue Waterlily) were present, as well as fringing sedges such as *Cyperus aquatilis* (Water Nutgrass) and *Eleocharis dulcis* (Water Chestnut). Some emergent reeds were also present.

The substrate at the survey site consisted of a mix of bedrock interspersed with patches of silt/clay sediments. Water clarity was relatively good at this location. As the Amagula River was still flowing (albeit slowly) in October 2014, there is potential that this river is augmented by groundwater. This is consistent with the findings of the EIS Groundwater Report.

4.2.6 Amagula River –Tributary 1

The Amagula River – Tributary 1 flows south through the centre of the Southern EL and flows into the main channel of the Amagula River approximately 900 m south of the southern border of the Southern EL (see **Figure 5**).

The Amagula River – Tributary 1 was flowing in May 2014 (see site A5; **Photograph 4.1**), and several large pools were present, particularly towards the south of the Southern EL. Water clarity was relatively good, despite being heavily stained from decaying organic material and leaf litter.

In October 2014, this tributary was noted to have largely dried up with the exception of some small, very shallow stagnant pools in the southern section of the tributary (e.g. sites A12 and A13 – see **Photograph 4.1**). These pools were noted to be highly turbid and stained, and water clarity was low, due to the presence of plumes and foam/scum on the surface, likely to be from fermentation of organic matter and anaerobic processes.

Towards the southern boundary of the Southern EL, where the Amagula River – Tributary 1 approaches the Amagula River – Main Channel, there appears to be a surface expression of groundwater where the elevation of the watercourse drops below the water table. Flows were observed in the tributary downstream from this area in October 2014 (refer to Figure 7). This EIS Groundwater Report identified potential groundwater inflows in this location. The riparian zone in this area, and downstream from it, is characterised by rainforest vegetation such as *Melaleca leucadendra*, *Dillenia alata*, *Canarium australianum* and *Syzigium nervosum* (see **Photograph 4.6**). This vegetation type only extends for approximately 3 m beyond the banks of the watercourse, where after the vegetation rapidly returns to the sclerophyll/eucalypt vegetation commonly found across most of the project site.

The substrate at all survey sites on the Amagula River – Tributary 1 was dominated by silt/clay sediments with occasional occurrences of bedrock and boulders.

Photograph 4.6 Amagula River - Tributary 1; Rainforest Vegetation downstream of A12

4.2.7 Amagula River –Tributary 2

The Amagula River – Tributary 2 flows in a southerly direction near the eastern boundary of the Southern EL, flowing into the Amagula River – Main Channel at the southern border of the Southern EL (see **Figure 5**). The Amagula River – Tributary 2 was observed to be flowing rapidly during the May 2014 field surveys (refer to Sites A4 and A7 of **Photograph 4.1**). The downstream section of this tributary was characterised by a wide, deep channel (i.e. at Site A4), whereas upstream sections were observed to be shallower and were faster flowing (i.e. at Site A7).

Water clarity was excellent in this watercourse in May 2014.

The substrate at the survey sites varied from sand and silty sediments (at Site A4) to bedrock and boulders (at Site A7). No distinct riparian zone was present, and the vegetation fringing the watercourse was typical of surrounding vegetation with the exception of *Melaleuca viridiflora* that was observed to be growing in close proximity to the water.

Despite the high volumes of water observed to be flowing through this tributary in May 2014; the tributary was entirely dry in October 2014, and no remnant pools were observed (see **Photograph 4.7**).

It is considered unlikely that any surface expression of groundwater is occurring in this tributary within the project site. This is consistent within the findings of the EIS Groundwater Report.

Photograph 4.7 Amagula River – Tributary 2 (Site A7 – May and October 2014)

4.3 Water Quality

4.3.1 Baseline Surface Water Quality

A program of monthly surface water quality monitoring was conducted in 2014 by EcOz Environmental Services (refer to the EIS Baseline Surface Water Monitoring Report) to establish the baseline water quality at the project site. The surface water quality monitoring program comprised 7 locations in the Emerald River catchment and 4 locations in the Amagula River catchment. Each location was sampled monthly in 2014 (i.e. each location was sampled 12 times). The monitoring locations were distributed along the main channels of both the Amagula and Emerald Rivers to capture upstream and downstream water quality, and any influence of tributaries and groundwater on these rivers. The locations and results of the surface water quality monitoring program are presented in the EIS Baseline Surface Water Monitoring Report.

The Emerald and Amagula catchments are characterised by rocky channels and limited hillslope erosion resulting in naturally low sediment loads within the river network. The stream geomorphology and flow characteristics also allow for settlement of any residual sediment loads in low energy reaches of these rivers. These are reflected by the low suspended sediment concentrations and low turbidity (and low particulate nutrients) recorded from the network of surface water monitoring locations.

Long-term salinity levels (as total dissolved solids) are generally consistent and fresh (i.e. non-saline) throughout the surface water drainage network, as expected for tropical freshwater streams. Water quality is characterised as slightly acidic due to the low pH and low alkalinity (and therefore limited buffering capacity).

Nutrient metabolism and breakdown of organic materials each typically exert an oxygen demand. The nutrient concentrations are typically low in the Emerald and Amagula Rivers, reflecting the lack of agriculture or grazing within the vicinity of the project site. Nonetheless, dissolved oxygen levels are variable within both river systems ranging from highly oxygenated to anaerobic. This reflects the variable flow conditions observed throughout the drainage network and the variable oxygen demand arising from the breakdown of detritus in slow moving sections of these rivers.

4.3.2 In Situ Water Quality at Survey Sites

Water quality parameters were measured *in-situ* during both rounds of aquatic field surveys including temperature, EC, pH, DO, turbidity, TDS and alkalinity. DO was recorded in the field as ppm, and converted to percent saturation to allow for comparison with the water quality guidelines.

Water quality measurements were compared to the water quality guidelines (ANZECC and ARMCANZ, 2000) for lowland rivers in tropical Australia. These guidelines provide a wide range of potential trigger values, outside which, there is a low risk that adverse biological effects will occur (von der Ohe and Liess, 2004). **Table 4.1** shows the *in-situ* water quality data collected, and the ANZECC trigger values. It should be noted that the *in-situ* water quality data provide a “snapshot” of water quality conditions at the time of the surveys and

are not indicative of long term trends in water quality. However they do allow for comparison of general water quality conditions between survey periods (May 2014 and October 2014). The comparison with these trigger values is included to provide context to the water quality data collected as part of this study. A full assessment of baseline water quality associated with surface water in the project site is provided in the EIS Surface Water Section.

Table 4.1 Water Quality Parameters Measured In situ Compared to the ANZECC Trigger Values for Tropical Lowland Rivers (ANZECC and ARMCANZ, 2000)

Site Number	Water Temp (°C)	EC (uS/cm)	pH	DO (%)	Turbidity (NTU)	TDS (ppm)	Total Alkalinity (ppm)
ANZECC Trigger Values:	***N/A***	***20 to 250***	***6 to 8***	***85 to 120***	***2 to 15***	***N/A***	***N/A***
Emerald River – Main Channel							
May 2014							
A1	23.5	234	5.36	65	1.7	41.1	6
A2	24.4	225	5.76	85	0.3	20.3	6
October 2014							
A17	25.8	118	5.80	20	24.9	70.1	16
Emerald River – Tributary 2							
May 2014							
A8	26.7	166	4.94	50	0.1	21.1	4
A9	26.2	282	5.47	88	0.1	21.5	4
October 2014							
A10	23.4	138	5.93	57	1.6	26.3	12
A15	25.9	370	4.62	45	0.2	23.3	12
A16	25.4	316	4.60	53	0.2	22.9	8
Emerald River – Tributary 3							
May 2014							
A3	26.2	230	5.27	75	1.3	15.8	6
Amagula River – Main Channel							
October 2014							
A11	24.7	157	5.38	82	1.8	32.6	8
Amagula River – Tributary 1							
May 2014							
A5	23.2	198	5.47	80	1.4	18.7	6
A6	23.0	196	5.44	56	1.4	32.3	6
October 2014							
A12	21.7	189	6.20	15	5.2	36.7	16
A13	28.4	212	6.22	120	3.7	53.1	10
A14	23.9	165	5.94	50	7.6	35.7	12
Amagula River – Tributary 2							
May 2014							
A4	22.7	200	5.20	75	1.8	13.2	6
A7	24.7	262	5.17	95	0.3	12.3	6

i. Temperature

The water temperature at the survey sites varied between 22.7°C and 26.7°C during the May 2014 survey period, and between 21.7°C and 28.4°C in the October 2014 survey period (**Table 4.1**).

In general, there was no consistent trend in the temperatures between survey sites and, despite the higher ambient air temperatures experienced in October, the minimum water temperature (21.7°C) was recorded from a site surveyed in October (A12 at the Amagula River – Tributary 1). The highest water temperature (28.4°C) was recorded in a very small remnant pool (site A13 at the Amagula River – Tributary 1) in October.

The water temperatures that were recorded are considered typical of a tropical environment, and the fauna and flora species found at the survey sites would be adapted to these temperatures.

ii. EC

EC levels in the survey sites were variable, ranging between 118 µS/cm (at survey site A17 at the Emerald River – Main Channel) and 370 µS/cm (at survey site A15 at the Emerald River – Tributary 2) (**Table 4.1**). All recorded EC values are classed as fresh water (i.e. non-saline). The recorded EC levels were not considered to be a limiting factor for the aquatic flora and fauna found at the survey sites. No clear pattern of EC varying with season was evident. The variability of inorganic ions (salts) in the water at the survey sites is likely to be the result of a combination of factors such as flow regime, evaporation, runoff and the minerals within the underlying geology, groundwater and soil.

iii. pH

The pH levels were noted to be acidic across all survey sites, ranging from a pH of 4.60 at site A16 (Emerald River – Tributary 2) to a pH of 6.22 at site A13 (Amagula River – Tributary 1) (**Table 4.1**). No significant difference in pH was noted between seasons.

Although the pH values for the majority of the survey sites are low, there are a number of areas in Australia that have naturally acidic water, caused by several factors such as the geology which affects baseflow and surrounding soils. Low pH values, including naturally acidic waters, are known to have physiological effects on aquatic organisms, resulting in lower abundance and diversity of aquatic organisms.

iv. Total Alkalinity

Total alkalinity levels at all survey sites were relatively low, consistent with the low pH values that were measured. A maximum alkalinity level of 16 ppm was measured at two survey sites (A12 at the Amagula River – Tributary 1 and A17 at the Emerald River – Main Channel) (**Table 4.1**), but the majority of sites had alkalinity values of <10 ppm.

A strong difference in results, attributable to season, is apparent in the survey data, with values recorded in May 2014 being significantly lower than in October 2014 for all sites

sampled. Alkalinity values recorded in May 2014 ranged between 4 ppm and 6 ppm, and the values in October 2014 ranged between 8 ppm and 16 ppm.

Very low alkalinity levels can reduce the ability of this parameter to buffer any changes in pH, meaning that pH can fluctuate quite strongly. The resultant variability in pH can impact species diversity and abundance.

v. DO

DO levels varied greatly between monitoring sites, ranging from 15% (at site A12 at the Amagula River – Tributary 1) to 120% (at site A13 at the Amagula River – Tributary 1) (**Table 4.1**).

DO levels can fluctuate depending on factors such as time of day, temperature, photosynthetic activity, amount of decaying organic matter, aeration and flow regime which may account for variances in survey results. There was no clear pattern between levels of DO and the type of watercourse or the season.

vi. Turbidity

Turbidity levels (i.e. suspended particulate matter) ranged from 0.1 NTU (at sites A8 and A9 at the Emerald River – Tributary 2) to 24.9 NTU (at site A17 at the Emerald River – Main Channel) (**Table 4.1**). Levels of turbidity were generally very low for the majority of surveys sites (<2 NTU), consistent with the observation of very good water clarity at the majority of sites. The only survey site with significantly higher turbidity levels was A17 at the Emerald River – Main Channel, which is a very small remnant pool surveyed in October 2014. The high turbidity levels may be due to the high amount of leaf litter and organic materials found at this site (refer to Photograph 4.1). With the exception of A17, turbidity is not likely to be a limiting factor for the aquatic flora and fauna. High turbidity levels can impact aquatic flora species, as the turbidity reduces the light available for photosynthesis. This in turn impacts food sources for the aquatic fauna.

vii. Total Dissolved Solids

TDS levels at the survey sites were typically low, ranging between 12.3 ppm (at survey site A7 at the Amagula River – Tributary 2) and 70.1 ppm (at survey site A17 at the Emerald River – Main Channel) (**Table 4.1**).

TDS levels were generally higher in the October 2014 survey period in all the watercourses in the project site. This is likely due to the slower flowing or stagnant waters experienced at the sample sites during the October survey.

viii. Summary

Measured EC values were generally low, and all survey sites have fresh (non-saline) water. The water at the majority of survey sites was measured as having a pH <6 (i.e. is slightly acidic), with low total alkalinity. Most sites experienced relatively low DO levels, with low turbidity and low TDS.

The *in situ* water quality parameters measured within the project site were generally in accordance with the ANZECC and ARMCANZ (2000) water quality guidelines. However pH was consistently lower than the range provided in the water quality guidelines and some sites recorded very low levels of DO. No industrial development or agricultural activity is present in the catchment and pollutants are expected to be very low to non-existent; therefore any deviation from the guideline values is not expected to be anthropogenic in origin.

4.4 Aquatic Flora

Macrophytes recorded at the survey sites consisted largely of emergent sedges and rushes, with occasional floating macrophytes such as *Nymphaea violacea* and emergent forbs such as *Eriocaulon setacum* and *Eriocaulon longifolium* (a Pipewort).

Dominant sedges recorded included:

- *Cyperus aquatilis (Flat sedge),*
- *Philydrum lanuginosum* (Frogsmouth)*,*
- *Xyris complanata* (Hatpins)*,*
- *Eleocharis dulcis (Water chestnut),*
- *Eleocharis spiralis* and
- *Typha orientalis* (Cumbungi).

Vegetation in rainforest areas was dominated by ferns such as *Blechnum indicum* (Swamp Water Fern) and *Lygodium microphyllum* (Climbing Maidenhair) as well as large herbs such as *Hanguana malayana*. No protected aquatic flora were observed and, based on database searches (**Section 4.1**), none are expected to occur.

Submerged macrophytes were not well represented and were found mainly in the larger, perennial flowing sections of the Emerald River – Tributary 2 and Amagula River – Tributary 1. Floating macrophytes were largely absent from the first and second order streams.

The absence of aquatic flora communities within the watercourses of Groote Eylandt is expected due to the highly ephemeral nature of the watercourses, as well as the relatively fast flow regime of the watercourses during the wet season. The wet season flow shifts large volumes of sediment down the bed of the watercourses which reduces substrate stability and impacts the ability of macrophyte species to establish and grow.

4.5 Macroinvertebrates

Aquatic macroinvertebrates are typically used as biological indicators of freshwater ecosystem health due to their sensitivity to changes in water quality, flow regime and general habitat condition (Ohne and Liess, 2004). The presence or absence of particular species, diversity, composition and abundance of communities provide general measures of health which can be used to assess impacts on aquatic systems (Maher and Norris, 1990).

4.5.1 Macroinvertebrate Diversity

Within the project site, a total of 629 macroinvertebrate specimens were collected comprising 29 different families from 8 orders (see **Appendix D**), with an average diversity of approximately 7 macroinvertebrate taxa per survey site.

Common taxa recorded across most sites included:

- Chironomidae (non-biting midges), Corduliidae (dragonflies), Coenagrionidae (damselflies), Dytiscidae (diving beetles), Elmidae (riffle beetles), Atyidae (shrimp), and Baetidae (mayflies).

While the Atyidae (shrimp) were recorded at only half the survey sites, this taxon had the highest number of individuals recorded.

Taxa observed in fewer samples and in lower abundances included:

- Leptoceridae (caddisflies), Ceratopogonidae (biting midges), Hydrometridae (water measurers) and Hydrophilidae (scavenger beetles).

- Single individuals were recorded for Notonectidae (backswimmers), Chaoboridae (phantom midges), Hydropsychidae (caddisflies), and Curculionidae (aquatic weevils).

Notably absent in all samples were the stoneflies (Order Plecoptera) and snails (Phylum Mollusca).

The number of recorded taxa was similar between the Emerald River and Amagula River catchments with 24 taxa being recorded for each river catchment.

Recorded taxa that were absent from the Emerald River catchment samples include:

- Caenidae (mayflies), Ceratopogonidae (biting midges), Notonectidae (backswimmers), Chaoboridae (phantom midges) and Curculionidae (aquatic weevils).

Recorded taxa that were absent from the Amagula River catchment samples include:

- Hydropsychidae (caddisflies), Hydrometridae (water measurers), Pleidae (pygmy backswimmers), Scirtidae (marsh beetles) and Acarina (mites).

The number of recorded taxa was similar between the May and October 2014 sampling periods with 24 taxa being recorded in each season. The total number of individuals caught was generally higher during the October 2014 surveys; however this is likely to be a sampling artefact as concentrations of invertebrates were higher due to the reduced size of the waterbodies present.

Recorded taxa that were absent from the May 2014 samples include:

- Hydropsychidae (caddisflies), Leptoceridae (caddisflies), Pleidae (pygmy backswimmers), Scirtidae (marsh beetles) and Curculionidae (aquatic weevils).

Recorded taxa that were absent from the October 2014 samples include:

- Chaoboridae (phantom midges), Notonectidae (backswimmers), Hydrophilidae (scavenger beetles), Veliidae (small water striders) and Haliplidae (crawling water beetles).

Sites A6 (upstream at the Amagula River – Tributary 1) and A15 (downstream at the Emerald River – Tributary 2) had the greatest diversity (12 taxa each) while sites A12 and A13 (both downstream at the Amagula River – Tributary 1) had highest number of recorded individuals (87 and 60 respectively), mostly of Atyidae (shrimp).

The lowest diversity was observed at Sites A7 and A4 (both upstream at the Amagula River – Tributary 2) (6 and 7 taxa respectively). These sites, together with Site A16 (downstream at the Emerald River – Tributary 2) had the lowest abundances with less than twenty individuals being recorded at each site.

The relatively low number of taxa and individuals recorded across the survey sites is likely to be due to the ephemeral nature of watercourses within the project site, as species richness and abundance can decrease with reduction in flow and increase in pool desiccation (Thomas *et al.*, 2001; Clarke *et al.*, 2010). The relative paucity of aquatic microhabitats and acidic nature of the water (refer to Section 4.3) are also likely contributing factors to the low numbers of taxa and individuals recorded.

4.5.2 EPT Richness

The "EPT" group of macroinvertebrates are three orders of insects that are used as indicators of disturbance due to their sensitivity to disturbance. The three orders are; Ephemeroptera (mayflies), Plecoptera (stoneflies) and Trichoptera (caddisflies).

Of the three EPT taxa, only two, Ephemeroptera (mayflies) and Tricoptera (caddisflies), were recorded (refer to Appendix D). No Plecoptera (stoneflies) were recorded.

The Ephemeroptera (mayflies) were represented by three families: Baetidae, Caenidae and Leptophlebiidae.

The Tricoptera (caddisflies) were also represented by three families: Ecnomidae, Hydropsychidae and Leptoceridae.

Overall, the EPT ratio for the project site was around 20% indicating a relative lack of disturbance-sensitive taxa on the project site. Given the relatively pristine nature of the project site, this low EPT ratio is potentially misleading and is not indicative of any anthropogenic disturbance. As the EPT taxa are also sensitive to natural stressors (eg acidic waters, high variabiliy in pH), the low EPT ratio is likely due to a range of naturally occurring stressors and environmental factors including the ephemeral nature of the watercourses, relative lack of in-stream vegetation and the relatively acidic nature of the water (refer to Section 4.3).

It is also noted that Leptophlebiidae is present on the project site, a taxon that is considered to be highly sensitive to anthropogenic disturbance and stressors. The presence of this species therefore indicates that, despite the presence of natural stressors, the conditions in the watercourses are in a relatively good to moderate condition for macroinvertebrates.

i. Other Sensitive Taxa

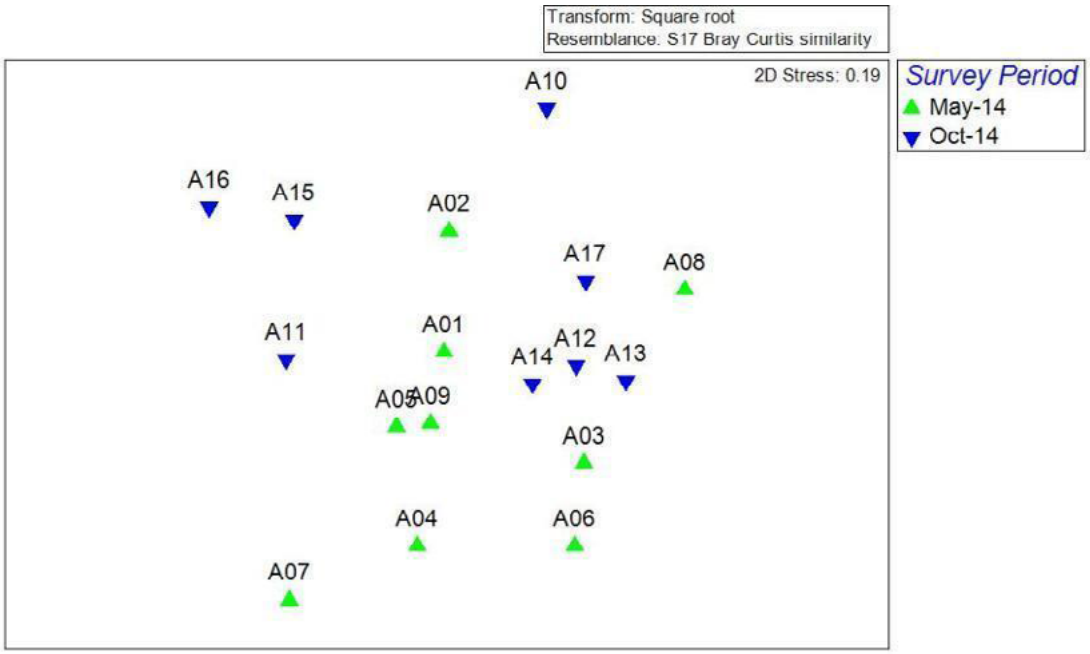
Other sensitive macroinvertebrate taxa, other than EPT taxa, that were found on the project site include Elmidae (riffle beetles) and Scirtidae (marsh beetles). While the Scirtidae were recorded only from two sites, the Elmidae were recorded at most of the sampled sites. The presence of these sensitive taxa, in addition to EPT taxa, further supports the finding that conditions in the watercourses are in a good to moderate condition for macroinvertebrates.

4.5.3 Community Composition

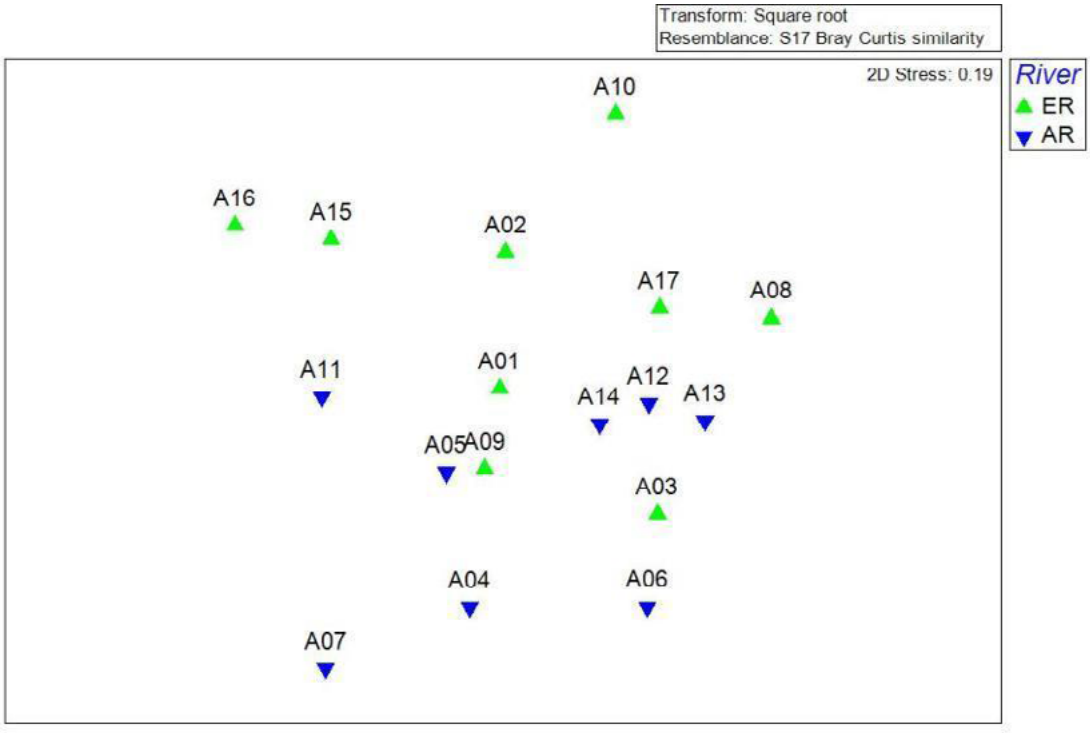
ANOSIM tests on the abundance data determined no significant difference in community composition between survey periods (Global R = 0.22, p = 0.05) or between river catchments (Global R = 0.18, p = 0.08). The low Global R values indicate a high level of overlap in species recorded between survey periods and between river catchments which supports the previous observations of similar numbers of recorded taxa.

Graphs 2 and 3 show the results of MDS analysis conducted on the samples for the different survey seasons (**Graph 2**) and the different river catchments (**Graph 3**). There is no clear separation of samples based on survey season (Graph 2) or river catchment (Graph 3). As samples that are more similar are placed closer together in the 2-dimensional space of the graph, the graphs indicate that there is a distinct similarity in the macroinvertebrate composition between survey seasons and the river catchments.

The lack of a clear visual separation between groups supports the ANOSIM results of high overlap between survey seasons and river catchments. The lack of clear separation between sites with high diversity (A6) from those with low diversity (sites A4 and A7) is due to similar taxa such as Chironomidae (non-biting midges) and Corduliidae (dragonflies) being recorded across all sites.



Graph 2 **MDS Ordination Plot of Community Composition Among Survey Periods**



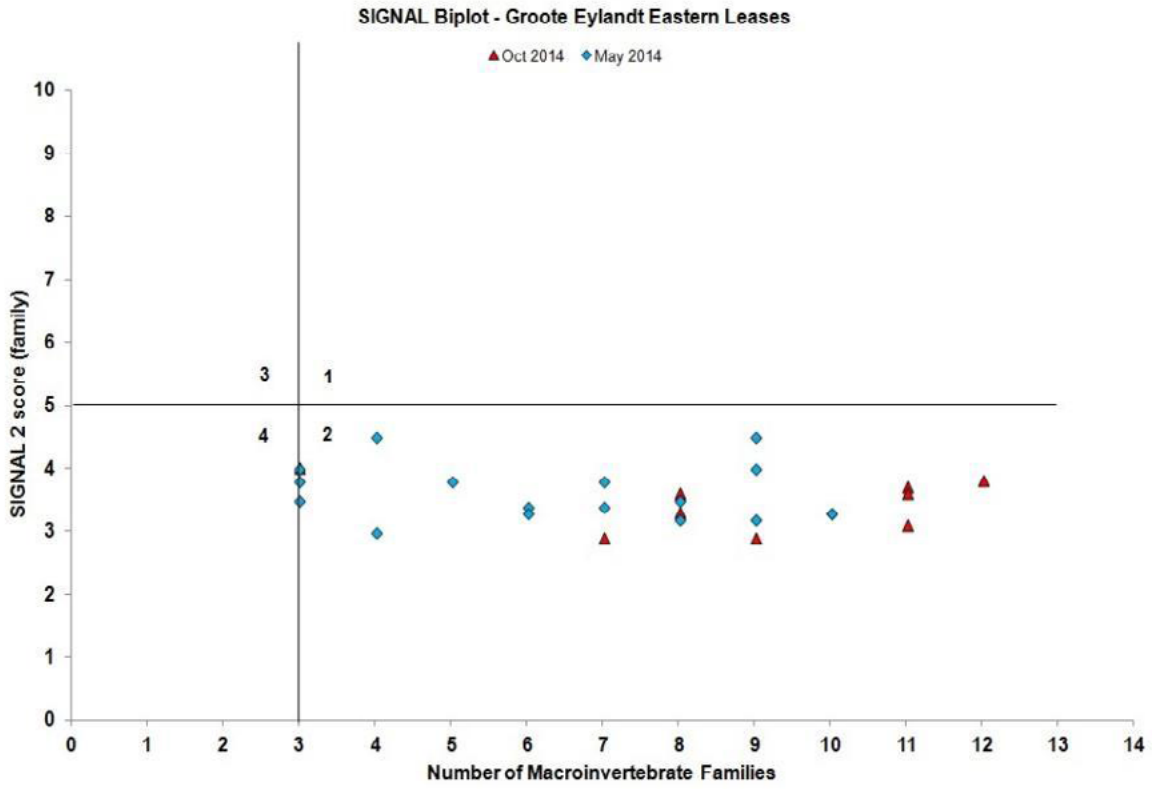
Graph 3 **MDS Ordination Plot of Community Composition Among River Catchments (ER – Emerald River, AR – Amagula River)**

4.5.4 SIGNAL Analysis

SIGNAL scores for the sites have been plotted in a basic quadrant diagram, displayed in **Graph 4**. SIGNAL scores for the sites ranged from a minimum of 2.9 to a maximum of 4.5. Sites with a score of <4 are generally considered to be severely polluted. However as SIGNAL was originally developed for 'normal' streams with typical freshwater habitats, streams with unusual water chemistry, wetlands, and/or ephemeral streams can produce SIGNAL scores which may not be representative of the health of the waterbody.

Although scores observed from the project site are relatively low, this is more likely a result of the relatively low abundances of the taxa observed rather than a lack of species richness. As suggested, quadrant boundaries for waterbodies on the eastern coast of Northern Territory are not available, therefore the biplot quadrats have been adjusted to fit in with the quadrant definitions provided in Chessman (2003) (refer to Section 3.2.6). This results in all sampling sites falling into Quadrant 2 which represents lower SIGNAL scores relative to high numbers of macroinvertebrate taxa. The higher numbers of taxa suggest that a good diversity of physical habitats is present but that the habitat contains higher stress factor levels which are likely to be natural, given the undisturbed nature of the environment.

As discussed previously, the waters that flow through the project site are naturally acidic. In general, acidic waters have less invertebrate biomass and/or species richness and only a few clearly dominant taxa, which results in lower SIGNAL scores compared to neutral or alkaline waters. While sensitive taxa are able to adapt and tolerate naturally low pH, this capability varies among taxonomic groups (Petrin *et al.*, 2007). The pattern of high numbers of tolerant taxa with occurrences of sensitive taxa seen in the watercourses of the project site is consistent with that of naturally acidic waters. The presence of EPT taxa in particular, is likely due to these groups adapting to the naturally acidic conditions over time.



Graph 4 SIGNAL/Family Biplot for each Survey Site

4.5.5 AusRivAS Analysis

Based on the diversity and abundance of invertebrates, under the AusRivAS Ecological Integrity Bands classification system (see Table 3.3) the majority of aquatic survey locations (nine bed and 14 edge sites) were classified as Band D (extremely impaired) with four edge sites classified as B and C (severely impaired) (**Table 4.2**).

The finding that the sites are severely to extremely impaired would not appear to be valid for the watercourses of the project site. The AusRivAS results largely contradict the field observations, habitat assessments and macroinvertebrate data and it is highly likely that available AusRivAS models are not a good fit for the project site.

Furthermore, given the seasonal nature of the majority of the watercourses sampled, they are likely to only conform with the conditions of the AusRivAS model for a limited period during the wet season only. Therefore, the results from the AusRivAS analysis were not utilised further.

Table 4.2 AusRivAS Bands for each Sampling Location

Emerald River Survey Site		AusRivAS Band*
Main Channel	A1 Bed	D
	A1 Edge	D
	A2 Bed	D
	A2 Edge	D
	A17 Edge	C
Tributary 2	A8 Bed	D
	A8 Edge	D
	A9 Edge	D
	A10 Bed	D
	A10 Edge	D
	A15 Edge	C
	A16 Edge	D
Tributary 3	A3 Bed	D
	A3 Edge	D

Amagula River Survey Site		AusRivAS Band*
Main Channel	A11 Edge	D
Tributary 1	A5 Bed	D
	A5 Edge	D
	A6 Bed	D
	A6 Edge	D
	A12 Edge	D
	A13 Edge	C
	A14 Edge	C
Tributary 2	A4 Bed	D
	A4 Edge	D
	A7 Bed	D
	A7 Edge	D

*- Refer to Table 3.3

4.6 Vertebrate Fauna

4.6.1 Fish

A total of 5 species of fish were recorded from the project site:

- *Denariusa australis* (Pennyfish);
- *Ambassis agrammus* (Sailfin Glassfish);
- *Mogurnda mogurnda* (Northern Purplespotted Gudgeon);
- *Melanotaenia nigrans* (Blackbanded Rainbow fish); and
- *Oxyeleotris sp* (likely *O. nullipora* [Poreless Gudgeon] or *O fimbriatus* [Fimbriate gudgeon]

The recorded species were caught during the October 2014 surveys when large concentrations of these species were present in the scattered pools along the watercourses. No species were caught during the May 2014 survey, which is likely due to the fast flowing waters and relatively large waterbodies present at that time.

Table 4.3 Fish Species Recorded at each Survey Site

Site	Pennyfish (*Denariusa australis*)	Sailfin Glassfish (*Ambassis agrammus*)	Northern Purplespotted Gudgeon (*Mogurnda mogurnda*)	Blackbanded Rainbowfish (*Melanotaenia nigrans*)	*Oxyeleotris* species
A17			2	2	1
A10	1	1			
A15			1	3	
A11		1			
A13		8	5	25	1
A14			1		

Note: The number indicates the number of individuals recorded.

Fish species were caught in the Emerald River - Main channel (3 species) and Emerald River - Tributary 2 (4 species) and in the Amagula River - Main channel (1 species) and Amagula River - Tributary 1 (4 species) .

The *Oxyeleotris* species is likely either *O. nullipora* (Poreless Gudgeon) or *O. fimbriatus* (Fimbriate gudgeon). Both species are common in tropical freshwaters in Northern Australia and are often used as aquarium fish. The Pennyfish, Sailfin Glassfish, Northern Purplespotted Gudgeon and Blackbanded Rainbow fish are also common freshwater species in tropical waters of Northern Australia.

Photograph 4.8 Blackbanded Rainbowfish Recorded from the Project Site

Photograph 4.9 Northern Purplespotted Gudgeon Recorded from the Project Site

Photograph 4.10 Sailfin Glassfish Recorded from the Project Site

Photograph 4.11 Pennyfish Recorded from the Project Site

Photograph 4.12 *Oxyeleotris* species from the Project Site

With the exception of the *Oxyeleotris* species, the fish species found on the project site were also recorded from the Emerald River by URS in 2012. In that study, a total of 11 freshwater fish species were recorded from the Emerald River; however the sampling sites were all located near the mouth of the river where diversity and abundance is expected to be higher due to the permanent nature of the river at that point. As discussed in **Section 4**; further downstream from the project site, the Emerald River receives groundwater contributions, and the river flows throughout the year.

The Emerald River was considered to have a low diversity of fishes by URS (2012), due to its small catchment size, limited habitat diversity, lack of rock or sediment movement into the system, and geographical isolation from other freshwater systems of the mainland and Groote Eylandt itself. The Emerald River is generally shallow (< 1m) for much of its length and lacks the large, deep water holes present on mainland systems, which tend to favour diverse groups such as the Fork-tailed catfishes (Family Ariidae) and Grunters (Family Terapontidae) (URS, 2012). Sand substrates also lack large quantities of depositing organic matter. This is likely to be a function of the small catchment and shallow nature of the Emerald River whereby monsoonal flooding during the wet season effectively flushes detritus from the system (URS, 2012). Organic detritus is an important source of nutrients that support trophic webs in aquatic systems.

4.6.2 Sawfish

The EIS TOR requires consideration of the Largetooth Sawfish (*Pristis pristis*) (also known as the Freshwater Sawfish – *Pristis microdon*) despite this species not being listed on database searches for the area (i.e. the PMTS or InfoNet searches).

The Largetooth Sawfish is listed as Vulnerable under the EPBC Act and the TPWC Act.

This species was not found during the field surveys of the project site. It is also not recorded as potentially present from the PMST report (within the 20km search radius of the project site) (see **Appendix A**) or the InfoNet database (within the 20km search radius of Groote Eylandt) (see **Appendix B**). A review of the literature has provided no records of this species from Groote Eylandt.

Although this species is known to occur in freshwater, it is primarily a marine/estuarine species. The preferred habitat of this species is mud/sand bottoms of river embankments and estuaries where the water is greater than 1 m depth (DotE, 2014). Sawfishes feed on slow-moving shoaling fish, which are stunned by sideswipes of the snout, and molluscs and crustaceans that are swept out of the mud by its saw (DotE, 2014).

Habitat assessments determined that these habitat characteristics or prey resources are largely absent in the watercourses of the project site. However, these habitat characteristics or prey resources are potentially available in the main channel of the Amagula River in the project site as this river is relatively wide (approximately 20 m) with a sandy or muddy substrate. However, compared to other rivers where this species is known (e.g. the Fitzroy River in the Kimberley region of Western Australia), the Amagula River is relatively small, and even the perennial lower reaches and estuaries of this river would probably only provide very limited habitat and feeding resources for this species.

The SPRAT profile (DotE, 2014) states that the Largetooth Sawfish has been recorded up to 400 km inland in isolated pools where it has travelled during flood conditions, and then become trapped as waters receded. However no evidence of the potential presence of the trapped Largetooth Sawfish was found within the project site during the surveys. Detailed surveys conducted by URS in 2012 included estuarine and near coastal reaches of the Emerald River, which would potentially be more favourable to the sawfish, however URS did not record the species. Furthermore, as there are no records of this species in the locality, it is unlikely that are any individuals that could potentially move into the project site during any flood events.

The Largetooth Sawfish has therefore been assessed as having a low potential to occur on the project site.

CUMBERLAND ECOLOGY

Chapter **5**

Impact Assessment

This section presents an assessment of the potential impacts of the project to the aquatic environment. It includes consideration of potential impacts arising from the construction of the open cut mine and mine infrastructure (Section 5.1). It also considers potential impacts on water quality (Section 5.2), as well as issues associated with changes in groundwater levels (Section 5.3); erosion and sedimentation (Section 5.4) and the potential introduction of weeds and pest animals (Section 5.5).

5.1 Open Cut Mining and Construction of Mine Infrastructure

5.1.1 Open Cut Mining

Figure 8 shows the disturbance footprint of the project, including open cut mining areas, haul roads and surface infrastructure. This figure shows the total disturbance footprint over the life of the project. However, mined areas will be progressively rehabilitated and so the disturbance footprint at any particular point in time is expected to be less than the total disturbance footprint shown on Figure 8. Mined areas will be rehabilitated to create self-sustaining open woodland ecosystems, similar to pre-mining undisturbed land. There will be no final voids at the end of the mine life.

The project planning process highlighted that the Emerald and Amagula Rivers, and their tributaries are considered culturally and environmentally sensitive. Mine planning was cognisant of these sensitivities and the project has been designed to ensure that mining will not encroach on any of the watercourses described in this report (and shown on Figure 8). In particular, buffers have been defined around the main channels of the Emerald River, Amagula River and their tributaries. The buffers were delineated by the 1% Annual Exceedence Probability (AEP) (1 in 100 year) flood extents. The mine plan and quarry extents were then designed to ensure alignment with the buffers, and restrict mining to areas beyond the defined drainage channels and associated buffers. The EIS Surface Water Section provides detail on the flood modelling that was undertaken to delineate the buffers. As determined by flood modelling, no diversions or levees are therefore required as a result of the project and open cut mining is not anticipated to have any direct impact on the aquatic environment. The key potential impact of the project on the aquatic environment is therefore limited to erosion and sedimentation. Erosion and sedimentation is discussed in Section 5.4.

5.1.2 Haul Road Crossings

As shown on Figure 8, haul roads are proposed to cross watercourses in the following locations:

- The haul road linking the Northern EL and the Southern EL with the existing GEMCO operations will cross the Emerald River – Main Channel and the Emerald River – Tributary 3.
- There are two haul road crossings of the Emerald River – Main Channel in Northern EL.
- There will be a haul road crossing of the Amagula River – Tributary 1 in the Southern EL.

Road crossings will be installed as low flow drainage culverts. Culverts will be designed to allow unimpeded drainage of the 2 year ARI flood flow. Floods larger than the design event will be allowed to flow over the culvert or haul road itself in order to maintain drainage within these watercourses. These crossings will be constructed progressively as the operations expand over the life of the mine and once constructed will remain operational for the life of the mine. The crossings will be removed at the end of the mine life (at the discretion of the traditional owners and ALC). The conceptual road crossing design is described in the EIS Surface Water Section. The culverts will be designed in a manner that does not impede fish passage.

Sediment collection and control measures will be implemented to manage runoff during the construction and operation of road crossings, and to mitigate potential downstream sedimentation effects. These measures will be undertaken and managed in accordance with an Erosion and Sediment Control Plan. Monitoring will be undertaken to confirm the success of these measures and identify any necessary remedial actions. Further detail on erosion and sedimentation is provided in Section 5.4.

5.2 Potential Impacts on Water Quality

5.2.1 Release of Mine Affected Water

Given the cultural and environmental sensitivities associated with the watercourses on the project site, the project has been designed to avoid the need for the release of mine affected water. In particular, water storages (i.e. dams) will be constructed to store the mine affected water generated during mining activities (i.e. water captured in quarries). The mine affected water will then be used for purposes such as dust suppression. Water balance modelling has been undertaken to confirm that the storages have sufficient capacity, even during the wet season. Long-term water balance modelling was undertaken, using all available historical climate data (a total of 124 years of data). Based on the historical climate data, the modelling demonstrates that there would be sufficient storage capacity to contain mine affected water, with a low potential for release.

Although no routine discharges of mine affected water are proposed, the proponent will request that discharge conditions are included in its Authorisation under the *Mining Management Act*. These discharge conditions are intended as a contingency measure only and the potential discharge water quality limits will be designed to ensure that discharges will not impact downstream water quality or aquatic environments. The proposed discharge water quality limits are discussed in the EIS Surface Water Section.

5.2.2 Bunding and Storage of Hazardous Materials

The project is an additional mining area that will be operated as part of the existing mine, rather than an independent mine. There will consequently be very limited infrastructure on the project site and storage of diesel and chemicals will be limited to small scale, portable containers. Storage and use of diesel and chemicals will be in accordance with relevant Australian Standards. The EIS Hazard and Risk Section details the procedures that will be adopted.

Given the strategies and management measures described above, the project is not predicted to impact water quality in any of the watercourses that traverse the project site.

5.3 Changes in Groundwater Levels

As noted in Section 4.2, the majority of the watercourses within the project site are dependent on surface water, and are consequently ephemeral. There are, however, a number of areas where watercourses receive groundwater inflows, leading to watercourses being perennial. In particular, the western part of the Emerald River – Tributary 2 is perennial, as is the southern part of the Amagula River – Tributary 1 and the Amagula River – Main Channel. The perennial reaches of the watercourses are shown in Figure 7. The EIS Groundwater Report documents the groundwater investigations undertaken for the project (including 3D numerical groundwater modelling). This report includes an assessment of the potential for drawdown of aquifers, as a result of mining activities, to impact on groundwater inflows to watercourses.

There are two aquifers within the project site, namely the shallow laterite aquifer and the deeper Cretaceous sandstone aquifer. The project is not predicted to depressurise the Cretaceous sandstone aquifer.

Modelling predictions show that drawdown of the water table within the laterite aquifer does not extend to the perennial reaches of the Emerald, Amagula or Angurugu rivers. Groundwater drawdown in the laterite is predicted to extend to the ephemeral reach of Emerald River – Tributary 2 and the ephemeral reach of Amagula River – Tributary 1. This drawdown will result in small changes in baseflow. However, the predicted drawdown typically represents less than 0.02% change from the existing flow within these reaches of the rivers and any change in flow rate or stream level would be imperceptible at downstream locations.

There is predicted to be a negligible increase (up to 1%) in baseflow to the Amagula River – Main Channel post mining. However, the predicted increase is negligible in terms of total

surface water flows, and any change in flow rate or stream level would be imperceptible at downstream locations.

5.4 Erosion and Sedimentation

The project has the potential to increase the amount of erosion occurring in the project site through the construction of the open cut mine, haul roads, light vehicle access tracks, and infrastructure. This potential to cause an increase in sedimentation is as a direct result of vegetation clearing associated within these activities. The project site is located in a tropical climate, and during the wet season heavy rainfall can erode and wash away any disturbed soils. This has the potential to result in sedimentation and turbidity of surrounding watercourses.

As noted in Section 5.1, the project has been designed to ensure that there will be no mining activities within the main channel of watercourses or within the 1% AEP (1 in 100 year) flood extents of the watercourses. This design principle will significantly reduce the potential for the project to give rise to erosion and sedimentation impacts on watercourses.

Active mining areas and recently rehabilitated areas may be subject to erosion, potentially leading to runoff with elevated levels of suspended sediment. An Erosion and Sediment Control Plan (ESCP) will be developed prior to commencement of construction to address erosion and the control of suspended sediment in drainage from these areas. Runoff from disturbed areas will be captured in collection drains and directed through sediment traps and sediment dams for control of suspended sediment prior to discharge from site. Sediment collected in sediment dams will be excavated at regular intervals and disposed of in the overburden emplacement areas. Diversion drains will be installed to divert overland flow from upstream areas around disturbed areas. All works will be designed and constructed in accordance with an ESCP. Monitoring will be undertaken to confirm the success of these measures and identify and necessary remedial actions.

It is considered that, with the implementation of appropriate measures, as described above, it is unlikely that erosion or sedimentation will significantly affect the aquatic ecology of the project site or downstream areas.

5.5 Spread of Weeds and Pest Animals

During the construction and operations phases of the project, environmental management measures will be required to prevent the transportation of introduced noxious weeds; prevent the introduction of additional pest species; and manage and reduce the area of occupancy of weeds on the site. All weed management activities will be conducted in compliance with the proponent's existing weed management procedures.

A Threatened Species Management Plan has been developed and is currently in operation across all GEMCO leases. It includes specifications for the monitoring and management of feral animals and weeds, which shall be implemented for the Eastern Leases. It is described further in the EIS Terrestrial Ecology Report.

A Cane Toad Management Plan is also in operation across all GEMCO leases and across the island. This will continue to operate and remains applicable for the Eastern Leases.

CUMBERLAND ECOLOGY

Chapter **6**

Impact Mitigation

Table 6.1 provides a summary of measures that have been adopted to avoid impacts, as well as mitigation measures that will implemented for the project.

Table 6.1 Summary of Mitigation Measures

Activity/Impact	Summary of Mitigation Measures and/or Measures to Avoid Impacts	EIS Section Reference
Open Cut Mining and Construction of Mine Infrastructure	The project has been designed to ensure that there will be no mining activities within the main channel of watercourses or within the 1% AEP (1 in 100 year) flood extents of the watercourses.	Further detail on this project design principle is provided in the EIS Surface Water Section.
	Clearing will be undertaken in accordance with a clearing procedure that restricts the area of vegetation to be cleared to that required for the safe construction and operation of facilities. Particular care will be taken in relation to any work in or adjacent to watercourses, with mitigation measures including application of appropriate erosion and sediment controls. Work will be undertaken in accordance with the requirements of an ESCP. • Application of appropriate drainage and erosion control measures (including design criteria) which shall provide for a manageable level of sediment runoff that can be contained within the active mine footprint. Any necessary sediment control works will be implemented, particularly if remnant pools or perennial watercourses are located adjacent to construction activities; and • Work will be undertaken in accordance with the requirements of an ESCP.	The clearing procedure is described in the EIS Terrestrial Ecology Report.
	Haul road crossings of watercourses (culverts) will be inspected throughout the construction phase. The inspections will confirm that appropriate erosion and sediment controls are in place and that external batter slopes have been designed in accordance with engineering design criteria and are stable and	

CUMBERLAND ECOLOGY

Table 6.1 Summary of Mitigation Measures

Activity/Impact	Summary of Mitigation Measures and/or Measures to Avoid Impacts	EIS Section Reference
	revegetated. Periodic inspections (i.e. monthly during the wet season) will be undertaken following construction to confirm that all culverts are operating effectively and not causing sedimentation.	
	Culverts will be designed to ensure that they do not lead to sedimentation or provide a barrier to fish passage.	
Water Quality Impacts	The mine water management system has been designed to avoid the need for the release of mine affected water. Monthly monitoring of the mine water management system will be undertaken, including monitoring of the water level of water quality in all storages.	Further detail on project's mine water management system, including monitoring of the system, is provided in the EIS Surface Water Section.
	Project water storages have been designed to avoid the need for any routine discharges of quarry water. Modelling has demonstrated that there would be sufficient total storage capacity to contain quarry water during the range of historical climate conditions over the life of the mine without the need for regular discharges. Modelling of the proposed water management system indicates that there would be no requirement to discharge quarry water based on the 124 years of modelled climate data, including all extreme wet periods. However, it is possible, with a very low likelihood, that a sequence of prolonged rainfall could occur that is more extreme than any within the modelled 124 years of rainfall data. The proponent will therefore request authorisation for discharge of quarry water, as a contingency measure. The nominated discharge criteria have been calculated using the method contained in the ANZECC guidelines for pristine, high conservation value settings. Discharge criteria calculated using this method are based on monitored baseline water quality and are designed to ensure there is no detectable change in the ecosystem, beyond natural variability.	EIS Surface Water Section.
	An ongoing water quality monitoring program will be implemented, comprising quarterly monitoring of surface water quality based on select suite of analytical parameters.	EIS Surface Water Section.
	Management measures in relation to the transport and	EIS Hazard and Risk

Table 6.1 Summary of Mitigation Measures

Activity/Impact	Summary of Mitigation Measures and/or Measures to Avoid Impacts	EIS Section Reference
	use of hazardous materials (including diesel) will be adopted to minimise and avoid the potential for spills and associated impacts on water quality.	Section.
Changes in Groundwater Levels	No impacts on watercourses are predicted as a result of the project's predicted impacts on groundwater levels. During the life of the project, groundwater levels will be recorded from the existing monitoring bores to confirm that impacts on groundwater levels are in accordance with the predictions in the EIS Groundwater Report.	EIS Groundwater Section.
Erosion and Sedimentation	An ESCP will be implemented to account for both construction and operational phases of the project. It will include mitigation measures that aim to minimise erosion and the release of sediment to receiving waters and the contamination of stormwater. These may include measures such as revegetating topsoil stockpiles, appropriate timing for soil disturbance activities, and the installation of erosion, drainage and sediment control measures.	
Spread of Weed and Pest Animals	GEMCO has various procedures designed to control the spread of weeds and pest animals. These procedures will be adopted for the project site.	EIS Terrestrial Ecology Report.

A Biodiversity Offset Strategy will be developed for the project to address the project's significant, residual impacts on MNES. However, given that no aquatic MNES are predicted to be impacted by the project, no offsets relevant to aquatic biology are required for the project. Further detail is provided in the EIS Biodiversity Offset Strategy.

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Chapter **7**

Figures

- Figure 1: Project Location
- Figure 2: Project Layout
- Figure 3: Bioregion Setting
- Figure 4: Regional Catchment Setting
- Figure 5: Local Catchment Setting
- Figure 6: Aquatic Survey Sites within the Project Site
- Figure 7: Aquatic Habitat within the Project Site
- Figure 8: Aquatic Habitat within the Disturbance Footprint

Figure 1. Project Location

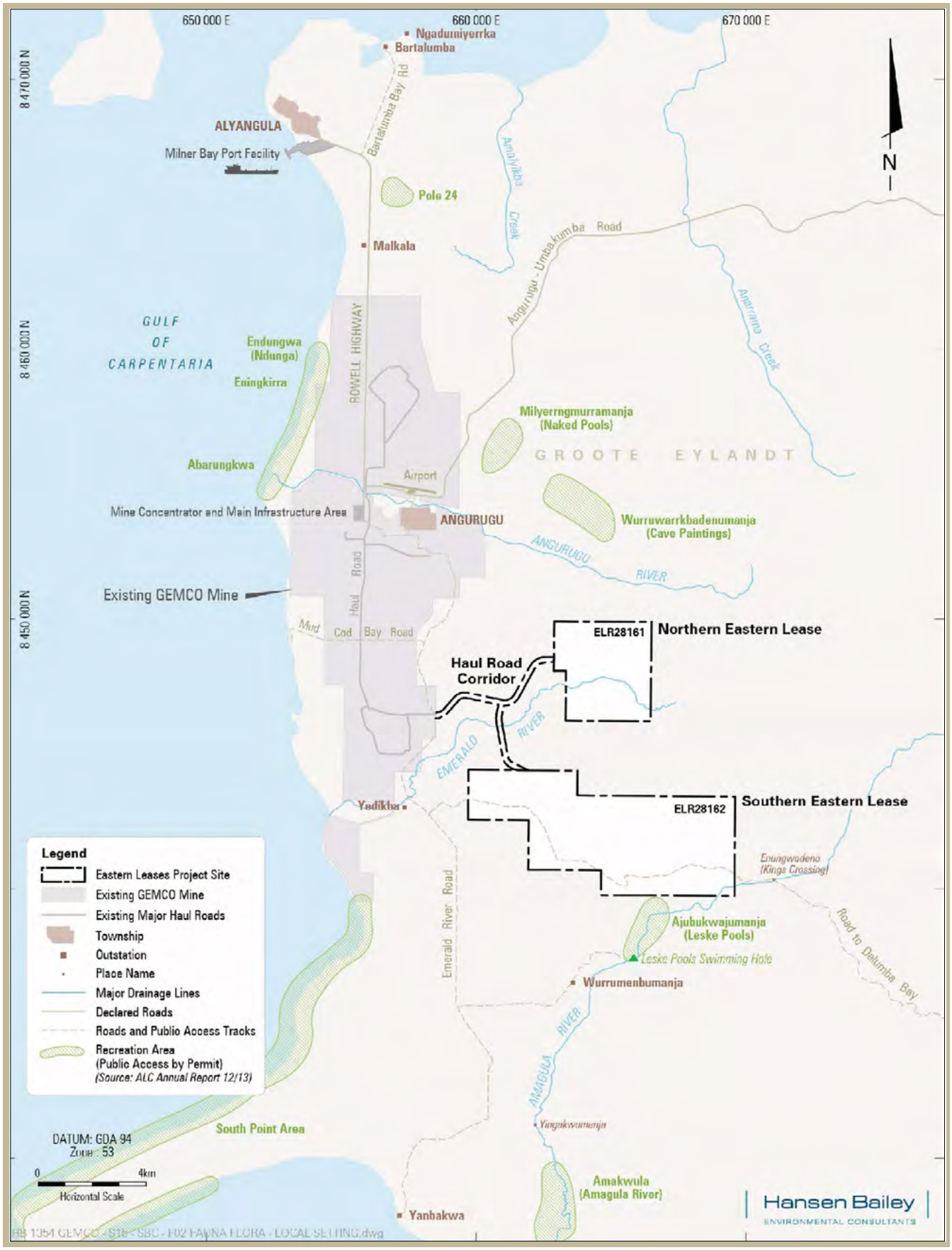

Figure 2. Project Layout

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Figure 3. Bioregion Setting

Figure 4. Regional Catchment Setting

Figure 5. Local Catchment Setting

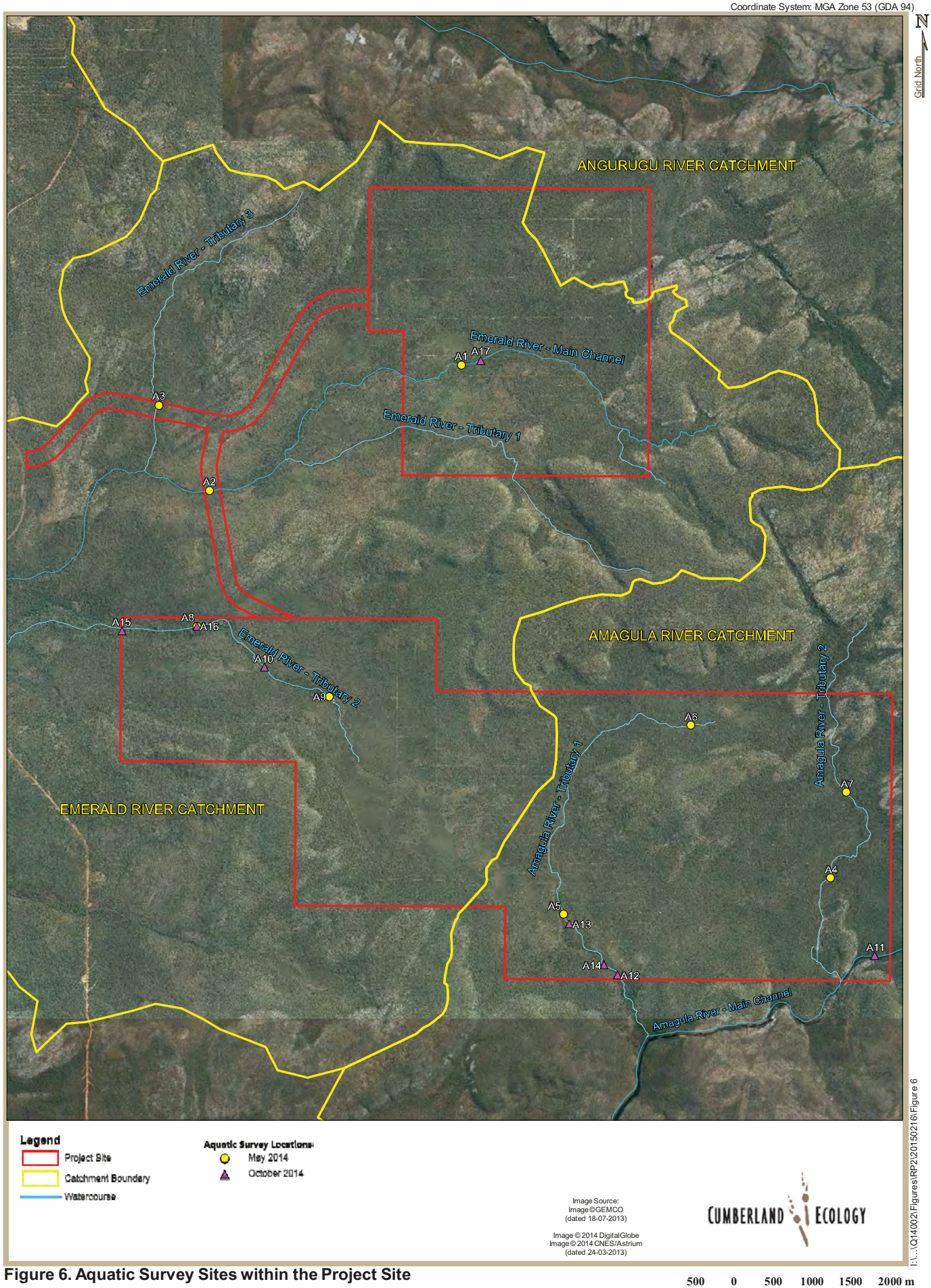

Figure 6. Aquatic Survey Sites within the Project Site

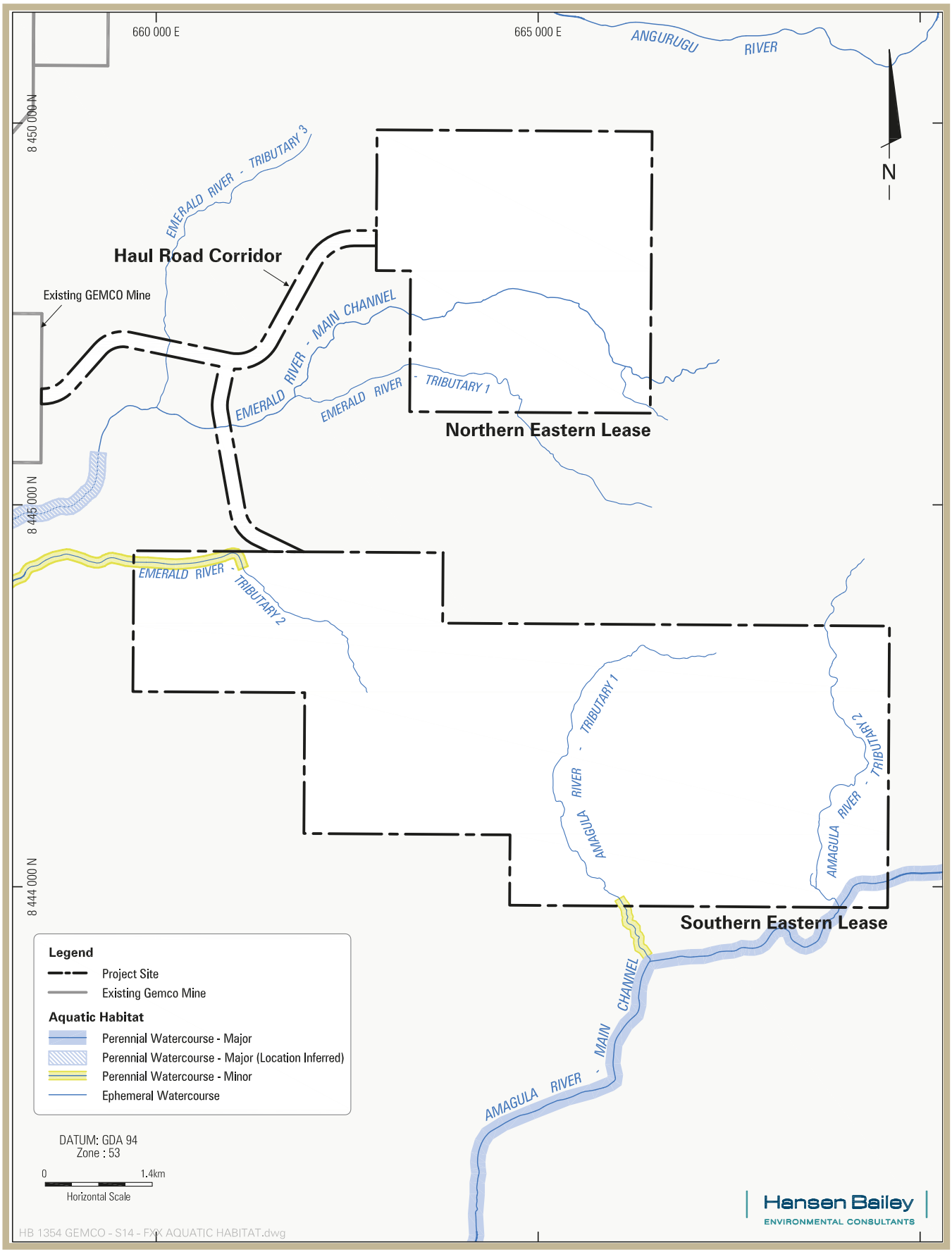

Figure 7. Aquatic Habitat within the Project Site

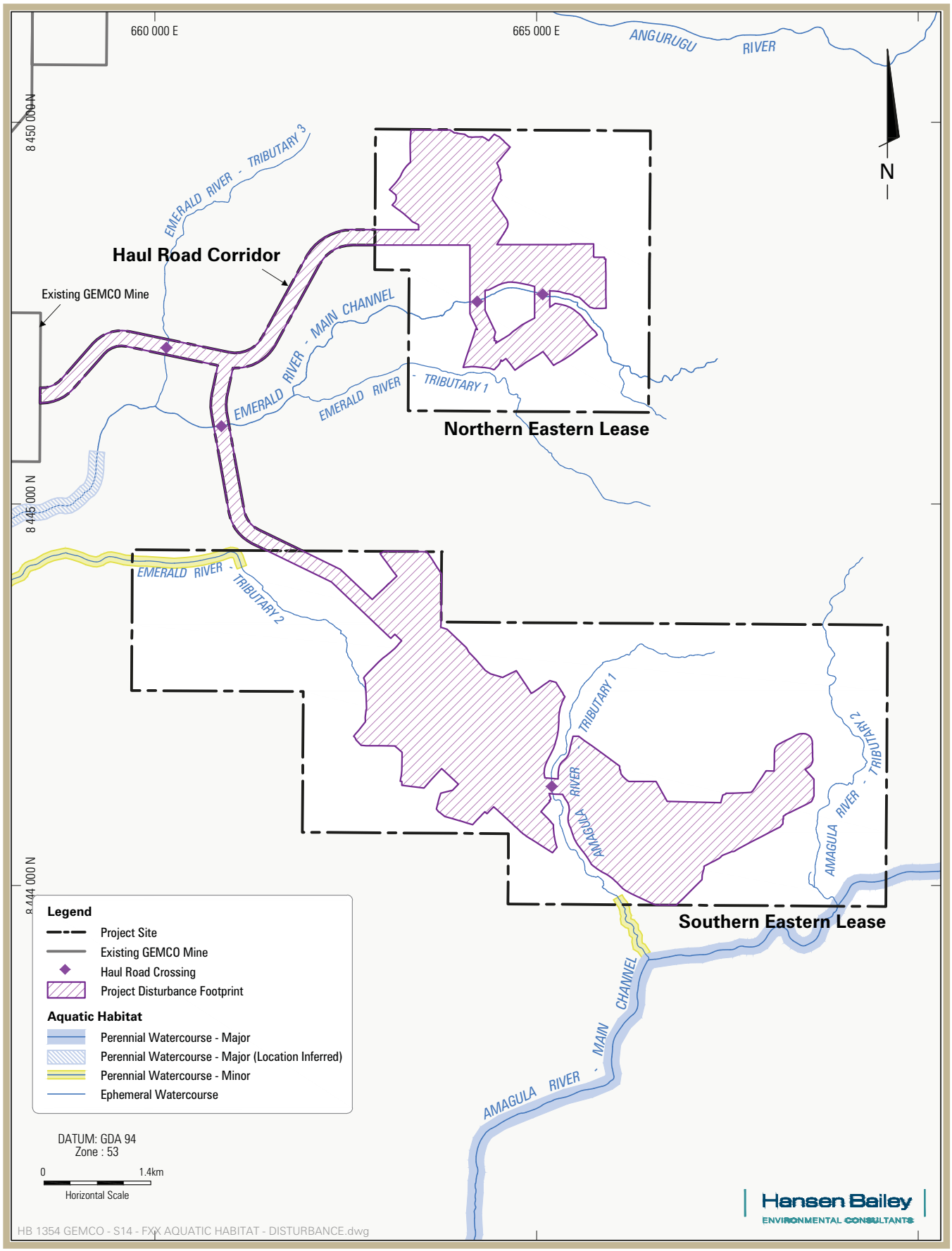

Figure 8. Aquatic Habitat within the Disturbance Footprint

CUMBERLAND ECOLOGY

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Appendix A

Protected Matters Search Tool Results

Australian Government
Department of the Environment

EPBC Act Protected Matters Report

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 is available about Environment Assessments and the EPBC Act including significance guidelines, forms and application process details.

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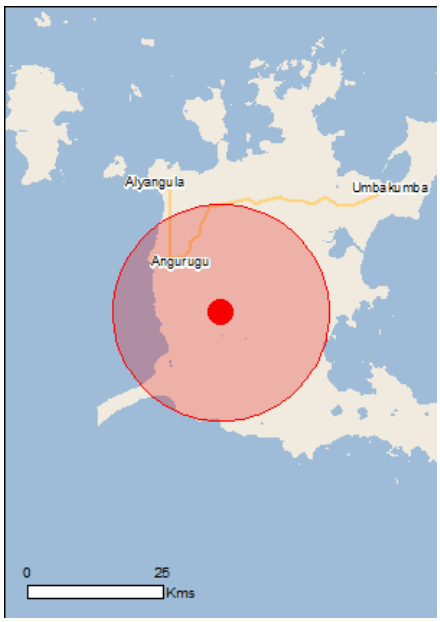

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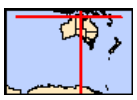

Summary

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.

World Heritage Properties:	None
National Heritage Places:	1
Wetlands of International Importance:	None
Great Barrier Reef Marine Park:	None
Commonwealth Marine Areas:	None
Listed Threatened Ecological Communities:	None
Listed Threatened Species:	18
Listed Migratory Species:	28

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.

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.

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.

Commonwealth Land:	None
Commonwealth Heritage Places:	None
Listed Marine Species:	60
Whales and Other Cetaceans:	11
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	None
Commonwealth Reserves Marine	None

Extra Information

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

Place on the RNE:	4
State and Territory Reserves:	1
Regional Forest Agreements:	None
Invasive Species:	3
Nationally Important Wetlands:	None
Key Ecological Features (Marine)	None

Details

Matters of National Environmental Significance

National Heritage Properties		[Resource Information]
Name	State	Status
Indigenous		
Saltwater Country of the Groote Eylandt Archipelago	NT	Nominated place

Listed Threatened Species		[Resource Information]
Name	Status	Type of Presence
Birds		
Erythrotriorchis radiatus		
Red Goshawk [942]	Vulnerable	Species or species habitat likely to occur within area
Mammals		
Balaenoptera musculus		
Blue Whale [36]	Endangered	Species or species habitat may occur within area
Conilurus penicillatus		
Brush-tailed Rabbit-rat, Brush-tailed Tree-rat, Pakooma [132]	Vulnerable	Species or species habitat may occur within area
Dasyurus hallucatus		
Northern Quoll [331]	Endangered	Species or species habitat known to occur within area
Megaptera novaeangliae		
Humpback Whale [38]	Vulnerable	Species or species habitat may occur within area
Notomys aquilo		
Northern Hopping-mouse, Woorrentinta [123]	Vulnerable	Species or species habitat may occur within area
Xeromys myoides		
Water Mouse, False Water Rat, Yirrkoo [66]	Vulnerable	Species or species habitat may occur within area
Reptiles		
Acanthophis hawkei		
Plains Death Adder [83821]	Vulnerable	Species or species habitat may occur within area

Name	Status	Type of Presence
Caretta caretta		
Loggerhead Turtle [1763]	Endangered	Breeding likely to occur within area
Chelonia mydas		
Green Turtle [1765]	Vulnerable	Breeding known to occur within area
Dermochelys coriacea		
Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Breeding likely to occur within area
Eretmochelys imbricata		
Hawksbill Turtle [1766]	Vulnerable	Breeding known to occur within area
Lepidochelys olivacea		
Olive Ridley Turtle, Pacific Ridley Turtle [1767]	Endangered	Foraging, feeding or related behaviour known to occur within area
Natator depressus		
Flatback Turtle [59257]	Vulnerable	Breeding known to occur within area
Sharks		
Carcharodon carcharias		
Great White Shark [64470]	Vulnerable	Species or species habitat may occur within area
Pristis clavata		
Dwarf Sawfish, Queensland Sawfish [68447]	Vulnerable	Species or species habitat likely to occur within area
Pristis zijsron		
Green Sawfish, Dindagubba, Narrowsnout Sawfish [68442]	Vulnerable	Species or species habitat may occur within area
Rhincodon typus		
Whale Shark [66680]	Vulnerable	Species or species habitat may occur within area

Listed Migratory Species [Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Migratory Marine Birds		
Apus pacificus		
Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Calonectris leucomelas		
Streaked Shearwater [1077]		Species or species habitat may occur within area
Puffinus leucomelas		
Streaked Shearwater [66541]		Species or species habitat may occur within area
Migratory Marine Species		
Balaenoptera edeni		
Bryde's Whale [35]		Species or species habitat may occur within area
Balaenoptera musculus		
Blue Whale [36]	Endangered	Species or species habitat may occur within area
Carcharodon carcharias		
Great White Shark [64470]	Vulnerable	Species or species habitat may occur within area
Caretta caretta		
Loggerhead Turtle [1763]	Endangered	Breeding likely to occur within area
Chelonia mydas		
Green Turtle [1765]	Vulnerable	Breeding known to occur within area

Name	Threatened	Type of Presence
Crocodylus porosus Salt-water Crocodile, Estuarine Crocodile [1774]		Species or species habitat likely to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Breeding likely to occur within area
Dugong dugon Dugong [28]		Species or species habitat known to occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Breeding known to occur within area
Lepidochelys olivacea Olive Ridley Turtle, Pacific Ridley Turtle [1767]	Endangered	Foraging, feeding or related behaviour known to occur within area
Manta birostris Giant Manta Ray, Chevron Manta Ray, Pacific Manta Ray, Pelagic Manta Ray, Oceanic Manta Ray [84995]		Species or species habitat likely to occur within area
Megaptera novaeangliae Humpback Whale [38]	Vulnerable	Species or species habitat may occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Breeding known to occur within area
Orcaella brevirostris Irrawaddy Dolphin [45]		Species or species habitat likely to occur within area
Orcinus orca Killer Whale, Orca [46]		Species or species habitat may occur within area
Rhincodon typus Whale Shark [66680]	Vulnerable	Species or species habitat may occur within area
Sousa chinensis Indo-Pacific Humpback Dolphin [50]		Species or species habitat likely to occur within area
Migratory Terrestrial Species		
Haliaeetus leucogaster White-bellied Sea-Eagle [943]		Species or species habitat known to occur within area
Hirundo rustica Barn Swallow [662]		Species or species habitat may occur within area
Merops ornatus Rainbow Bee-eater [670]		Species or species habitat may occur within area
Rhipidura rufifrons Rufous Fantail [592]		Species or species habitat known to occur within area
Migratory Wetlands Species		
Ardea alba Great Egret, White Egret [59541]		Species or species habitat known to occur within area
Ardea ibis Cattle Egret [59542]		Species or species habitat may occur within area
Charadrius veredus Oriental Plover, Oriental Dotterel [882]		Species or species

Name	Threatened	Type of Presence
		habitat may occur within area
Glareola maldivarum		
Oriental Pratincole [840]		Species or species habitat may occur within area

Other Matters Protected by the EPBC Act

Listed Marine Species		[Resource Information]
* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.		
Name	Threatened	Type of Presence
Birds		
Apus pacificus		
Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Ardea alba		
Great Egret, White Egret [59541]		Species or species habitat known to occur within area
Ardea ibis		
Cattle Egret [59542]		Species or species habitat may occur within area
Calonectris leucomelas		
Streaked Shearwater [1077]		Species or species habitat may occur within area
Charadrius veredus		
Oriental Plover, Oriental Dotterel [882]		Species or species habitat may occur within area
Glareola maldivarum		
Oriental Pratincole [840]		Species or species habitat may occur within area
Haliaeetus leucogaster		
White-bellied Sea-Eagle [943]		Species or species habitat known to occur within area
Hirundo rustica		
Barn Swallow [662]		Species or species habitat may occur within area
Merops ornatus		
Rainbow Bee-eater [670]		Species or species habitat may occur within area
Pandion haliaetus		
Osprey [952]		Species or species habitat known to occur within area

Name	Threatened	Type of Presence
Rhipidura rufifrons Rufous Fantail [592]		Species or species habitat known to occur within area
Sterna bergii Crested Tern [816]		Breeding likely to occur within area
Fish		
Campichthys tricarinatus Three-keel Pipefish [66192]		Species or species habitat may occur within area
Choeroichthys brachysoma Pacific Short-bodied Pipefish, Short-bodied Pipefish [66194]		Species or species habitat may occur within area
Choeroichthys suillus Pig-snouted Pipefish [66198]		Species or species habitat may occur within area
Corythoichthys amplexus Fijian Banded Pipefish, Brown-banded Pipefish [66199]		Species or species habitat may occur within area
Corythoichthys flavofasciatus Reticulate Pipefish, Yellow-banded Pipefish, Network Pipefish [66200]		Species or species habitat may occur within area
Doryrhamphus excisus Bluestripe Pipefish, Indian Blue-stripe Pipefish, Pacific Blue-stripe Pipefish [66211]		Species or species habitat may occur within area
Doryrhamphus janssi Cleaner Pipefish, Janss' Pipefish [66212]		Species or species habitat may occur within area
Festucalex cinctus Girdled Pipefish [66214]		Species or species habitat may occur within area
Halicampus brocki Brock's Pipefish [66219]		Species or species habitat may occur within area
Halicampus grayi Mud Pipefish, Gray's Pipefish [66221]		Species or species habitat may occur within area
Halicampus spinirostris Spiny-snout Pipefish [66225]		Species or species habitat may occur within area
Haliichthys taeniophorus Ribboned Pipehorse, Ribboned Seadragon [66226]		Species or species habitat may occur within area
Hippichthys cyanospilos Blue-speckled Pipefish, Blue-spotted Pipefish [66228]		Species or species habitat may occur within area
Hippichthys penicillus Beady Pipefish, Steep-nosed Pipefish [66231]		Species or species habitat may occur within area
Hippocampus histrix Spiny Seahorse, Thorny Seahorse [66236]		Species or species habitat may occur within area
Hippocampus kuda Spotted Seahorse, Yellow Seahorse [66237]		Species or species habitat may occur within area

Name	Threatened	Type of Presence
Hippocampus planifrons		
Flat-face Seahorse [66238]		Species or species habitat may occur within area
Hippocampus spinosissimus		
Hedgehog Seahorse [66239]		Species or species habitat may occur within area
Micrognathus micronotopterus		
Tidepool Pipefish [66255]		Species or species habitat may occur within area
Solegnathus hardwickii		
Pallid Pipehorse, Hardwick's Pipehorse [66272]		Species or species habitat may occur within area
Trachyrhamphus bicoarctatus		
Bentstick Pipefish, Bend Stick Pipefish, Short-tailed Pipefish [66280]		Species or species habitat may occur within area
Trachyrhamphus longirostris		
Straightstick Pipefish, Long-nosed Pipefish, Straight Stick Pipefish [66281]		Species or species habitat may occur within area
Mammals		
Dugong dugon		
Dugong [28]		Species or species habitat known to occur within area
Reptiles		
Acalyptophis peronii		
Horned Seasnake [1114]		Species or species habitat may occur within area
Aipysurus duboisii		
Dubois' Seasnake [1116]		Species or species habitat may occur within area
Aipysurus eydouxii		
Spine-tailed Seasnake [1117]		Species or species habitat may occur within area
Aipysurus laevis		
Olive Seasnake [1120]		Species or species habitat may occur within area
Astrotia stokesii		
Stokes' Seasnake [1122]		Species or species habitat may occur within area
Caretta caretta		
Loggerhead Turtle [1763]	Endangered	Breeding likely to occur within area
Chelonia mydas		
Green Turtle [1765]	Vulnerable	Breeding known to occur within area
Crocodylus porosus		
Salt-water Crocodile, Estuarine Crocodile [1774]		Species or species habitat likely to occur within area
Dermochelys coriacea		
Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Breeding likely to occur within area
Disteira kingii		
Spectacled Seasnake [1123]		Species or species habitat may occur within area
Disteira major		
Olive-headed Seasnake [1124]		Species or species habitat may occur within area
Enhydrina schistosa		
Beaked Seasnake [1126]		Species or species

Name	Threatened	Type of Presence
		habitat may occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Breeding known to occur within area
Hydrelaps darwiniensis Black-ringed Seasnake [1100]		Species or species habitat may occur within area
Hydrophis atriceps Black-headed Seasnake [1101]		Species or species habitat may occur within area
Hydrophis elegans Elegant Seasnake [1104]		Species or species habitat may occur within area
Hydrophis inornatus Plain Seasnake [1107]		Species or species habitat may occur within area
Hydrophis mcdowelli null [25926]		Species or species habitat may occur within area
Hydrophis ornatus Spotted Seasnake, Ornate Reef Seasnake [1111]		Species or species habitat may occur within area
Hydrophis pacificus Large-headed Seasnake, Pacific Seasnake [1112]		Species or species habitat may occur within area
Lapemis hardwickii Spine-bellied Seasnake [1113]		Species or species habitat may occur within area
Lepidochelys olivacea Olive Ridley Turtle, Pacific Ridley Turtle [1767]	Endangered	Foraging, feeding or related behaviour known to occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Breeding known to occur within area
Parahydrophis mertoni Northern Mangrove Seasnake [1090]		Species or species habitat may occur within area
Pelamis platurus Yellow-bellied Seasnake [1091]		Species or species habitat may occur within area

Whales and other Cetaceans [Resource Information]

Name	Status	Type of Presence
Mammals		
Balaenoptera edeni Bryde's Whale [35]		Species or species habitat may occur within area
Balaenoptera musculus Blue Whale [36]	Endangered	Species or species habitat may occur within area
Delphinus delphis Common Dophin, Short-beaked Common Dolphin [60]		Species or species habitat may occur within area
Grampus griseus Risso's Dolphin, Grampus [64]		Species or species habitat may occur within area

Name	Status	Type of Presence
Megaptera novaeangliae		
Humpback Whale [38]	Vulnerable	Species or species habitat may occur within area
Orcaella brevirostris		
Irrawaddy Dolphin [45]		Species or species habitat likely to occur within area
Orcinus orca		
Killer Whale, Orca [46]		Species or species habitat may occur within area
Sousa chinensis		
Indo-Pacific Humpback Dolphin [50]		Species or species habitat likely to occur within area
Stenella attenuata		
Spotted Dolphin, Pantropical Spotted Dolphin [51]		Species or species habitat may occur within area
Tursiops aduncus		
Indian Ocean Bottlenose Dolphin, Spotted Bottlenose Dolphin [68418]		Species or species habitat likely to occur within area
Tursiops truncatus s. str.		
Bottlenose Dolphin [68417]		Species or species habitat may occur within area

Extra Information

Places on the RNE [Resource Information]

Note that not all Indigenous sites may be listed.

Name	State	Status
Indigenous		
Angurugu Mission Group	NT	Registered
Historic		
Emerald River Cemetery	NT	Indicative Place
Emerald River Mission	NT	Indicative Place
Emerald River Sawmill Site	NT	Indicative Place

State and Territory Reserves [Resource Information]

Name	State
Anindilyakwa	NT

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
Mammals		
Felis catus		
Cat, House Cat, Domestic Cat [19]		Species or species habitat likely to occur within area
Rattus rattus		
Black Rat, Ship Rat [84]		Species or species habitat likely to occur within area
Reptiles		

Name	Status	Type of Presence
Hemidactylus frenatus Asian House Gecko [1708]		Species or species habitat likely to occur within area

Coordinates

-14.06183 136.52912

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.

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
-Geoscience Australia
-CSIRO
-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

Northern Territory InfoNet Database Search Results

Territory Natural Resource Management

Northern Territory Government

CHARLES DARWIN UNIVERSITY

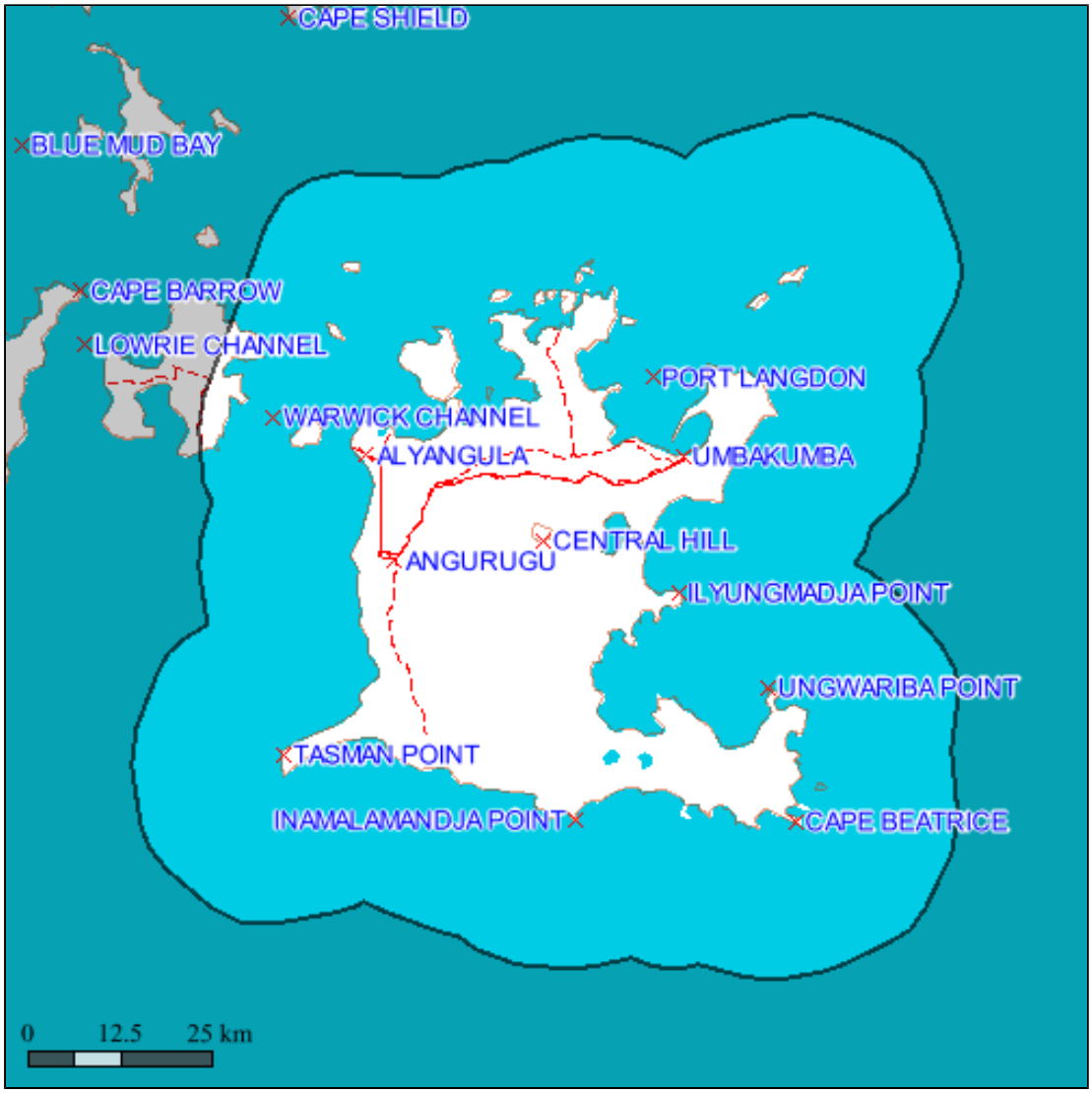
Custom area

NT NRM Report

Custom area

Custom area encompasses an area of 10230.23 sq km extending from 13 deg 26.0 min to 14 deg 29.0 min S and 136 deg 8.0 min to 137 deg 8.0 min E.
Custom area is located in the Arnhem Coast, bioregion(s)

Location of Custom area

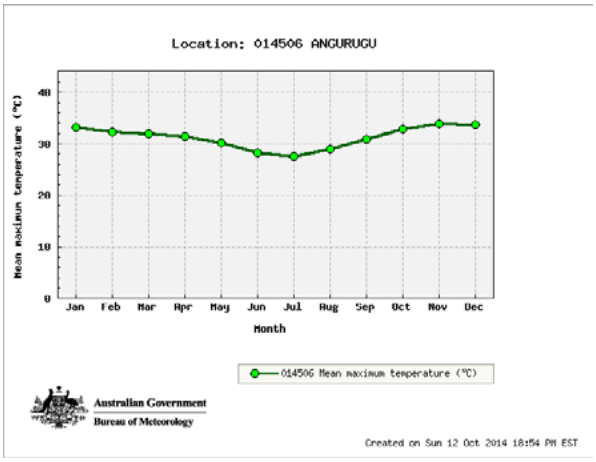


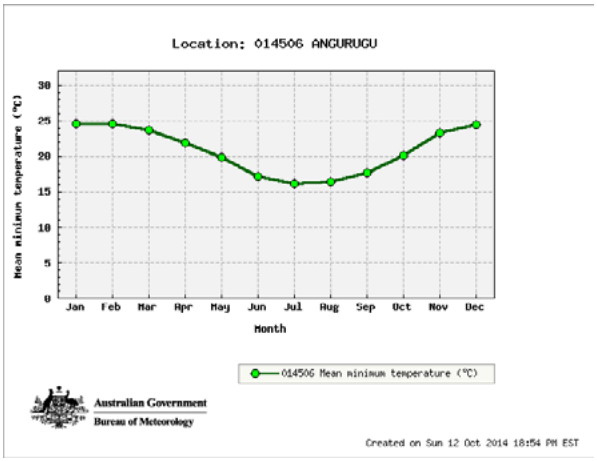
Custom area Climate

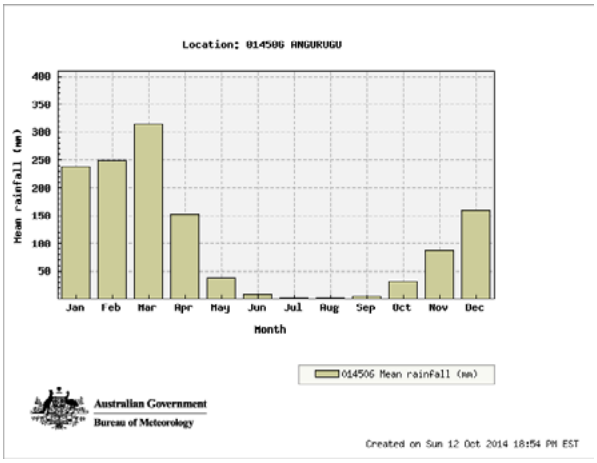
The closest long-term weather station is ANGURUGU (13 deg 59.0 min S, 136.4333E) 23 km W of the center of selected area

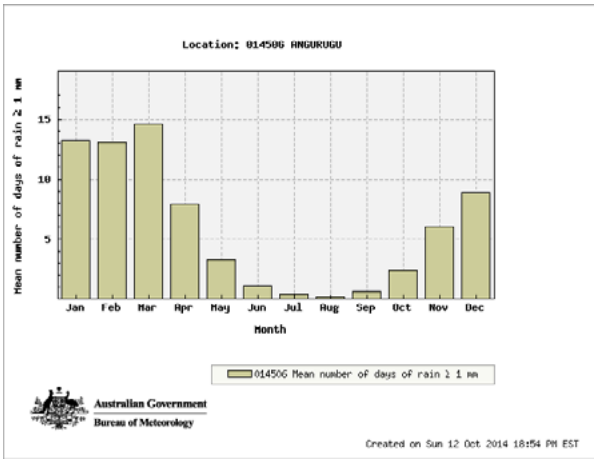
Statistics	Annual Values	Years of record
Mean max temp (deg C)	31.3	37
Mean min temp (deg C)	20.8	36
Average rainfall (mm)	1287.8	68
Average days of rain	71.7	67

Climate summaries from Bureau of Meteorology (www.bom.gov.au)



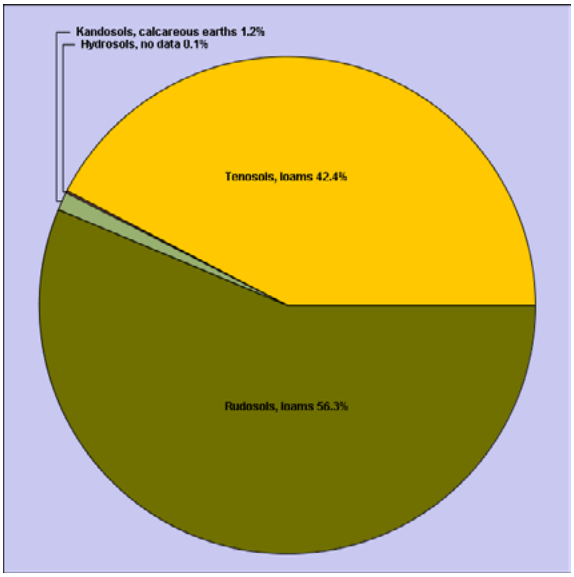






Custom area Soils

Soil Types



Area of soil types (Northcote Factual Key)

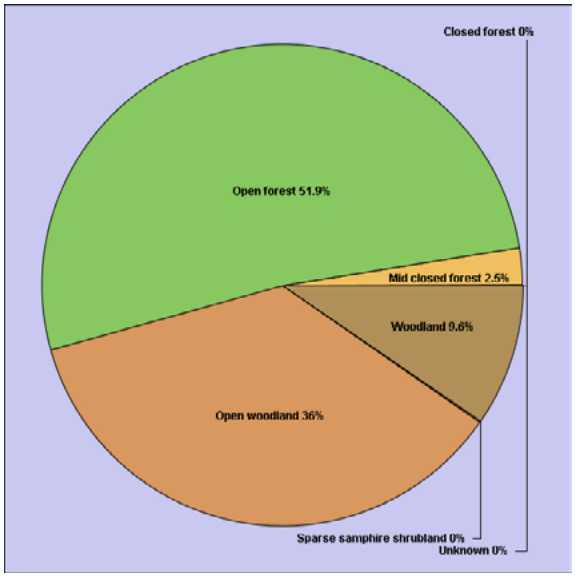
Category	Area sq km	Area%
Rudosols, loams	1351.25	13.21
Tenosols, loams	1018.24	9.95
Kandosols, calcareous earths	29.54	.29
Hydrosols, no data	2.46	.02

Soil Types

Soils 1:2M Layer is a copy of the NT portion (1:2,000,000 scale dataset) of the CSIRO Atlas of Australian Soils - K.H. Northcote et al. Data scale: 1:2,000,000 ANZLIC Identifier: 2DBCB771205D06B6E040CD9B0F274EFE
More details: Go to www.lrm.nt.gov.au/nrmapsnt/ and enter the ANZLIC identifier in the Spatial Data Search

Custom area Vegetation

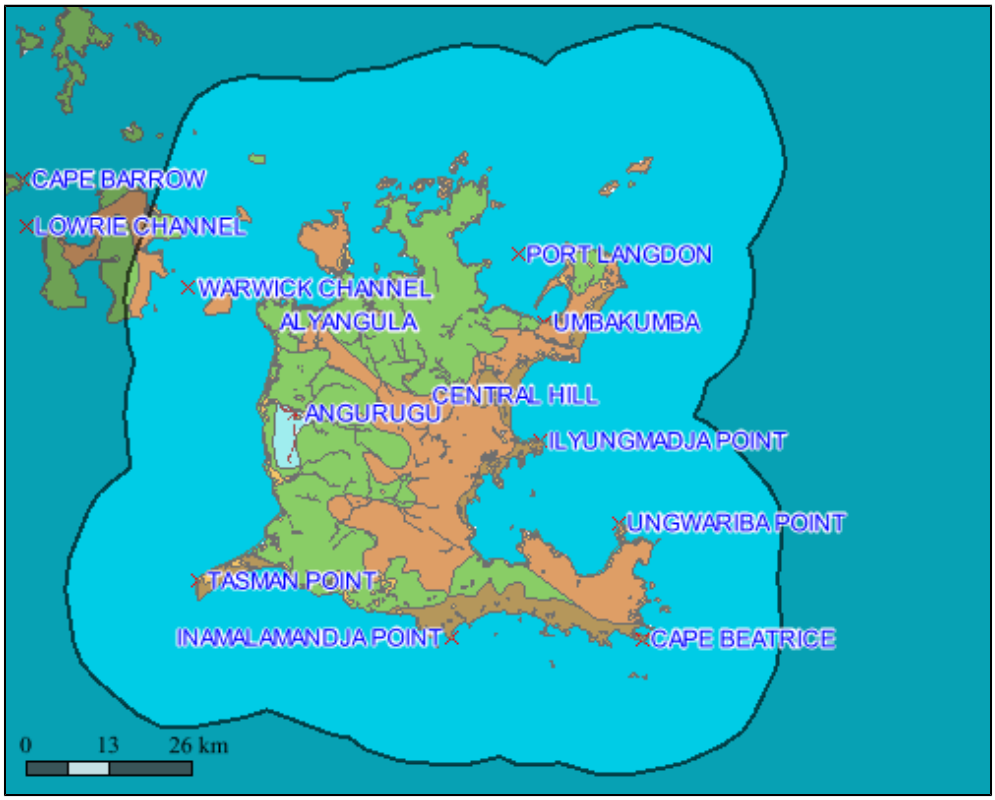
Vegetation Communities



Area of vegetation communities

Category	Area sq km	Area%
Open forest	1155.16	11.29
Open woodland	802.41	7.84
Woodland	213.60	2.09
Mid closed forest	55.43	.54
Sparse samphire shrubland	.84	.01
Closed forest	.19	.00
Unknown	.08	.00

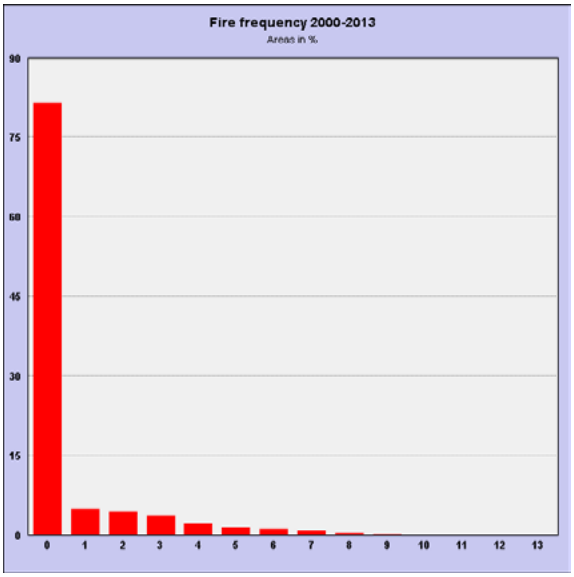
Vegetation Communities



The NVIS 2005 Layer is compiled from a number of vegetation and land unit survey maps that were recoded and re-attributed for the National Vegetation Information System (NVIS)
Data scale variable depending on location. ANZLIC Identifier:2DBCB771207006B6E040CD9B0F274EFE
More details:Go to www.lrm.nt.gov.au/nrmapsnt/ and enter the ANZLIC identifier in the Spatial Data Search

Custom area Fire History

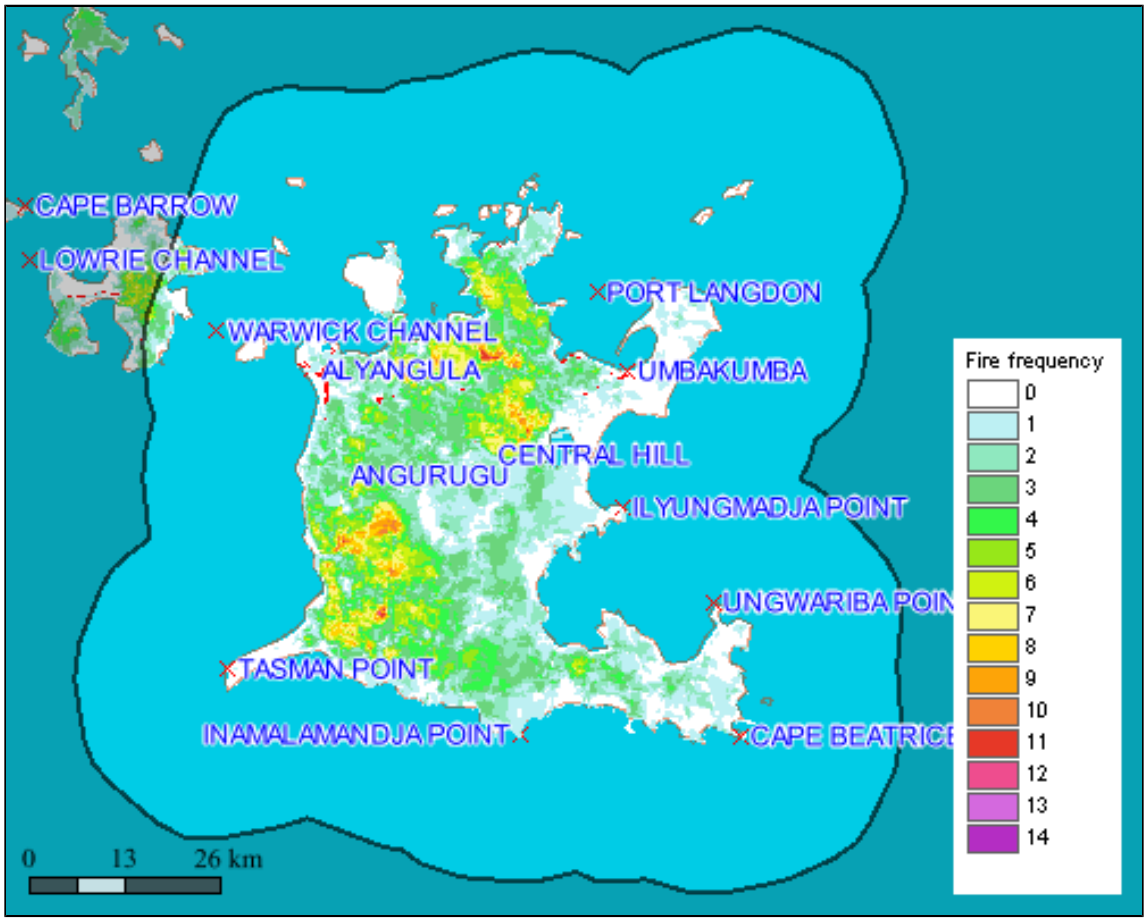
Years burnt 2000-2013



and area burnt in each category

Category	Area sq km	Area%
0	8334.58	81.47
1	492.34	4.81
2	434.81	4.25
3	373.30	3.65
4	222.64	2.18
5	149.55	1.46
6	102.83	1.01
7	67.26	.66
8	28.71	.28
9	14.28	.14
10	7.44	.07
11	2.03	.02
12	.38	.00
13	.08	.00

Years burnt 2000-2013



The fire frequency(250m) Layer is derived from satellite imagery sourced from the Moderate Resolution Imaging Spectroradiometer (MODIS) on the NASA Terra satellite
Spatial Resolution: 250m x 250m pixels (at Nadir).

Custom area Threatened Species

Threatened species recorded in Custom area (Records Updated: Sept 2013)

Group	Common Name	Scientific Name	NT Status	National Status	ID	#Observations (Latest)	#Specimens (Latest)	#Surveys (Latest)
Flowering Plants	Lantern Tree	*Hernandia nymphaeifolia*	VU	.	253736	0 (Unknown)	2 (1988)	0 (Unknown)
Reptiles	Green Turtle	*Chelonia mydas*	.	VU	176291	213 (2006)	3 (Unknown)	0 (Unknown)
Reptiles	Hawksbill Turtle	*Eretmochelys imbricata*	VU	VU	176298	133 (2006)	15 (1979)	0 (Unknown)
Reptiles	Olive Ridley	*Lepidochelys olivacea*	VU	EN	176305	5 (1994)	10 (1979)	0 (Unknown)
Reptiles	Flatback Turtle	*Natator depressus*	.	VU	176284	185 (2006)	4 (2006)	0 (Unknown)
Reptiles	Mertens` Water Monitor	*Varanus mertensi*	VU	.	347295	6 (2008)	4 (1982)	3 (2009)
Reptiles	Yellow-spotted Monitor	*Varanus panoptes*	VU	.	347307	1 (2006)	3 (1976)	2 (2006)
Birds	Partridge Pigeon	*Geophaps smithii*	VU	VU	176384	0 (Unknown)	3 (Unknown)	0 (Unknown)
Birds	Lesser Sand Plover	*Charadrius mongolus*	VU	.	.	6 (1997)	0 (Unknown)	0 (Unknown)
Birds	Greater Sand Plover	*Charadrius leschenaultii*	VU	.	.	4 (1979)	0 (Unknown)	0 (Unknown)
Birds	Bar-tailed Godwit	*Limosa lapponica*	VU	.	.	6 (1996)	1 (1922)	0 (Unknown)
Birds	Eastern Curlew	*Numenius madagascariensis*	VU	.	.	19 (2006)	0 (Unknown)	0 (Unknown)
Birds	Great Knot	*Calidris tenuirostris*	VU	.	.	3 (1998)	0 (Unknown)	0 (Unknown)
Birds	Red Knot	*Calidris canutus*	VU	.	.	2 (1979)	0 (Unknown)	0 (Unknown)
Birds	Curlew Sandpiper	*Calidris ferruginea*	VU	.	.	6 (1996)	0 (Unknown)	0 (Unknown)
Birds	Gouldian Finch	*Erythrura gouldiae*	VU	EN	176370	1 (1925)	0 (Unknown)	0 (Unknown)
Mammals	Northern Quoll	*Dasyurus hallucatus*	CR	EN	176443	32 (2007)	19 (1992)	36 (2009)
Mammals	Brush-tailed Rabbit-rat	*Conilurus penicillatus*	EN	VU	176414	6 (2007)	18 (1969)	1 (2005)
Mammals	Northern Hopping-mouse	*Notomys aquilo*	VU	VU	176436	55 (2007)	41 (2006)	3 (2009)
Mammals	Pale Field-rat	*Rattus tunneyi*	VU	.	.	0 (Unknown)	1 (1972)	0 (Unknown)

EX = Extinct
EW = Extinct in the Wild
ER = Extinct in the NT
EN = Endangered
EN/VU = One Endangered subspecies/One Vulnerable subspecies
VU=Vulnerable
VU/- = One or more subspecies vulnerable EN/- = One or more subspecies endangered

Survey = this category refers to data collected using systematic survey methodology
Specimen = this category refers to museum or other records where a specimen has been collected and lodged
Observation = this category refers to all other incidental recordings where systematic methodology may not have been used consistently.

More species info: Go to www.landmanager.org.au/view/index.aspx?id=####
where #### is the ID number from the tables above for the species of interest.

Custom area Threatened Species Grid

Threatened species recorded in the grid cell(s) in which Custom area occurs (Records Updated: Sept 2013)

Group	Family Name	Scientific Name	Common Name	NT Status	National Status	#Observations	Latest Observation Date	#Specimens	Latest Specimen Date	#Surveys	Latest Survey Record
Flowering Plants	Hernandiaceae	*Hernandia nymphaeifolia*	Lantern Tree	VU		0	Unknown	2	1988	0	Unknown
Reptiles	Cheloniidae	*Chelonia mydas*	Green Turtle		VU	283	2006	3	Unknown	0	Unknown
Reptiles	Cheloniidae	*Eretmochelys imbricata*	Hawksbill Turtle	VU	VU	134	2006	15	1979	0	Unknown
Reptiles	Cheloniidae	*Lepidochelys olivacea*	Olive Ridley	VU	EN	8	1994	10	1979	0	Unknown
Reptiles	Cheloniidae	*Natator depressus*	Flatback Turtle		VU	236	2006	8	2006	0	Unknown
Reptiles	Varanidae	*Varanus mertensi*	Mertens` Water Monitor	VU		6	2008	4	1982	3	2009
Reptiles	Varanidae	*Varanus panoptes*	Yellow-spotted Monitor	VU		1	2006	3	1976	6	2008
Birds	Columbidae	*Geophaps smithii*	Partridge Pigeon	VU	VU	0	Unknown	3	Unknown	0	Unknown
Birds	Charadriidae	*Charadrius mongolus*	Lesser Sand Plover	VU		7	1998	0	Unknown	0	Unknown
Birds	Charadriidae	*Charadrius leschenaultii*	Greater Sand Plover	VU		4	1979	0	Unknown	0	Unknown
Birds	Scolopacidae	*Limosa lapponica*	Bar-tailed Godwit	VU		18	1996	1	1922	0	Unknown
Birds	Scolopacidae	*Numenius madagascariensis*	Eastern Curlew	VU		24	2006	0	Unknown	0	Unknown
Birds	Scolopacidae	*Calidris tenuirostris*	Great Knot	VU		3	1998	0	Unknown	0	Unknown
Birds	Scolopacidae	*Calidris canutus*	Red Knot	VU		2	1979	0	Unknown	0	Unknown
Birds	Scolopacidae	*Calidris ferruginea*	Curlew Sandpiper	VU		7	1998	0	Unknown	0	Unknown
Birds	Estrildidae	*Erythrura gouldiae*	Gouldian Finch	VU	EN	2	1971	0	Unknown	0	Unknown
Mammals	Dasyuridae	*Dasyurus hallucatus*	Northern Quoll	CR	EN	32	2007	21	1992	36	2009
Mammals	Muridae	*Conilurus penicillatus*	Brush-tailed Rabbit-rat	EN	VU	6	2007	23	1969	1	2005
Mammals	Muridae	*Mesembriomys gouldii*	Black-footed Tree-rat	VU		1	1943	0	Unknown	0	Unknown
Mammals	Muridae	*Notomys aquilo*	Northern Hopping-mouse	VU	VU	55	2007	41	2006	3	2009
Mammals	Muridae	*Rattus tunneyi*	Pale Field-rat	VU		0	Unknown	1	1972	0	Unknown

EX = Extinct
EW = Extinct in the Wild
ER = Extinct in the NT
EN = Endangered
EN/VU = One Endangered subspecies/One Vulnerable subspecies
VU=Vulnerable
VU/- = One or more subspecies vulnerable EN/- = One or more subspecies endangered

Survey = this category refers to data collected using systematic survey methodology
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More species info: Go to www.landmanager.org.au/view/index.aspx?id=####
where #### is the ID number from the tables above for the species of interest.

Species listed in the table above were recorded from all the grid cells shown below (red/blue line) that overlap Custom area

Custom area Weeds and Potential Weeds

Introduced plants recorded in the grid cell(s) in which Custom area occurs and that have been identified as problem weeds in one or more locations in northern Australia. Occurrence based on Northern Territory Government databases.

Family Name	Scientific Name	Common Name	NT Status	National Status	Other Status	#Surveys	Latest Record
Asparagaceae	*Agave sisalana*	Century Plant			*G&M*	0	Unknown
Apocynaceae	*Allamanda cathartica*	Yellow Allamanda			*C&E*	0	Unknown
Amaranthaceae	*Alternanthera pungens*	Khaki Weed	*B C*		*DEU NSW SA*	0	Unknown
Anacardiaceae	*Anacardium occidentale*	Cashew Nut			*C&E*	0	Unknown
Polygonaceae	*Antigonon leptopus*	Coral Vine			*C&E*	0	Unknown
Acanthaceae	*Asystasia gangetica subsp. Gangetica*	Chinese Violet		*ALERT*	*NAQS Gr WeedsAus*	0	Unknown
Meliaceae	*Azadirachta indica*	Neem			*MP K1 C&E G&M CYP WeedsAus*	0	Unknown
Poaceae	*Bothriochloa pertusa*	Indian Bluegrass			*DEU*	0	Unknown
Arecaceae	*Caryota mitis*	Clustering Fishtail Palm			*C&E WeedsAus*	0	Unknown
Apocynaceae	*Cascabela thevetia*	Yellow Oleander			*Q3 C&E G&M CYP*	0	Unknown
Fabaceae	*Cassia fistula*	Golden Shower			*WeedsAus*	0	Unknown
Apocynaceae	*Catharanthus roseus*	Pink Periwinkle			*C&E*	0	Unknown
Poaceae	*Cenchrus brownii*	Fine-bristled Burr Grass			*NSW*	0	Unknown
Poaceae	*Cenchrus echinatus*	Mossman River Grass	*B C*		*NSW*	0	Unknown
Poaceae	*Cenchrus pedicellatus*	Mission Grass (annual)			*WeedsAus*	0	Unknown
Poaceae	*Cenchrus polystachios*	Mission Grass (perennial)	*B C*		*MP K2 C&E G&M*	0	Unknown
Fabaceae	*Centrosema molle*	Centro			*MP*	0	Unknown
Poaceae	*Chloris barbata*	Purpletop Chloris			*DEU*	0	Unknown
Cyperaceae	*Cyperus rotundus*	Nutgrass			*DEU SA*	0	Unknown
Fabaceae	*Delonix regia*	Poinciana			*C&E*	0	Unknown
Poaceae	*Echinochloa colona*	Awnless Barnyard Grass			*DEU*	0	Unknown
Amaranthaceae	*Gomphrena celosioides*	Gomphrena Weed			*DEU*	0	Unknown
Lamiaceae	*Hyptis suaveolens*	Hyptis	*B C*		*G&M*	3	1995
Convolvulaceae	*Ipomoea quamoclit*	Cupid`s Flower			*C&E*	0	Unknown
Euphorbiaceae	*Jatropha gossypiifolia*	Bellyache Bush	*B C*		*K2 WA1 WA4 Q2 C&E G&M CYP DEU*	0	Unknown
Meliaceae	*Khaya senegalensis*	African Mahogany			*C&E*	0	Unknown
Fabaceae	*Leucaena leucocephala*	Coffee Bush			*MP C&E G&M CYP*	0	Unknown
Fabaceae	*Leucaena leucocephala subsp. glabrata*	Lead Tree			*MP*	0	Unknown
Fabaceae	*Macroptilium atropurpureum*	Siratro			*C&E*	0	Unknown
Poaceae	*Megathyrsus maximus*	Guinea Grass			*MP DEU*	2	1995
Poaceae	*Melinis repens*	Red Natal Grass			*DEU*	4	1995
Fabaceae	*Mucuna pruriens var. utilis*	Cow Itch		*ALERT*	*NAQS C&E*	0	Unknown
Verbenaceae	*Phyla nodiflora var. nodiflora*	Lippia			*G&M NSW*	0	Unknown

Family Name	Scientific Name	Common Name	NT Status	National Status	Other Status	#Surveys	Latest Record
Combretaceae	*Quisqualis indica*	Rangoon Creeper			*C&E*	0	Unknown
Acanthaceae	*Ruellia tuberosa*	Spearpod			*C&E*	0	Unknown
Asparagaceae	*Sansevieria trifasciata*	Mother-In-Law`s Tongue			*C&E CYP*	0	Unknown
Plantaginaceae	*Scoparia dulcis*	Bitter Broom			*DEU*	0	Unknown
Fabaceae	*Senna alata*	Candle Bush	*B C*		*WA1 WA2*	0	Unknown
Fabaceae	*Senna occidentalis*	Coffee Senna	*B C*		*G&M DEU*	0	Unknown
Malvaceae	*Sida acuta*	Spiny-head Sida	*B C*		*WA1 G&M*	0	Unknown
Malvaceae	*Sida cordifolia*	Flannel Weed	*B C*		*WA1 G&M DEU*	0	Unknown
Malvaceae	*Sida rhombifolia*	Paddy`s Lucerne	*B C*		*MP G&M DEU*	1	1995
Poaceae	*Sorghum almum*	Columbus Grass			*NSW*	0	Unknown
Bignoniaceae	*Spathodea campanulata subsp. campanulata*	African Tulip Tree			*Q3 WeedsAus*	0	Unknown
Asteraceae	*Sphagneticola trilobata*	Singapore Daisy			*Q3 C&E CYP*	0	Unknown
Verbenaceae	*Stachytarpheta cayennensis*	Cayenne Snakeweed	*B C*		*NSW*	0	Unknown
Verbenaceae	*Stachytarpheta jamaicensis*	Jamaican Snakeweed	*B C*			0	Unknown
Verbenaceae	*Stachytarpheta mutabilis*	Pink Snakeweed	*B C*			0	Unknown
Fabaceae	*Stylosanthes hamata*	Caribbean Stylo			*DEU*	2	1995
Fabaceae	*Stylosanthes humilis*	Townsville Lucerne			*DEU*	0	Unknown
Fabaceae	*Stylosanthes scabra*	Shrubby Stylo			*G&M DEU*	0	Unknown
Asteraceae	*Synedrella nodiflora*	Cinderella Weed			*C&E*	0	Unknown
Zygophyllaceae	*Tribulus cistoides*	Beach Caltrop	*B C*			4	2006
Zygophyllaceae	*Tribulus terrestris*	Caltrop	*B C*		*CYP SA*	0	Unknown
Poaceae	*Urochloa mosambicensis*	Sabi Grass			*DEU*	0	Unknown
Poaceae	*Urochloa mutica*	Para Grass			*MP G&M*	0	Unknown

Status Codes:
1. NATIONAL STATUS CODES
Alert, Alert List for Environmental Weeds (Please call Exotic Plant Pest Hotline 1800 084 881 if you think you have seen this weed)
Sleeper, National Sleeper Weed
Target,Targeted for eradication. (www.landmanager.com.au/view/index.aspx?id=449837)
WONS, Weeds of National Significance

2. NT STATUS CODES
A, NT Class A Weed (to be eradicated)
B, NT Class B Weed (growth & spread to be controlled)
C, NT Class C Weed (not to be introduced) (www.landmanager.com.au/view/index.aspx?id=449869)

3. OTHER STATUS CODES
C&E, Csurhes, S. & Edwards, R. (1998) Potential Environmental Weeds in Australia. Candidate Species for Preventative Control. Environment Australia, Canberra (www.landmanager.com.au/view/index.aspx?id=394504)
CYP, Draft Cape York Peninsula Pest Management Plan 2006-2011 (www.landmanager.com.au/view/index.aspx?id=371200)
DEU, Plants listed as environmental weeds by the Desert Uplands Strategic Land Resource
Assessment (www.landmanager.com.au/view/index.aspx?id=332123)
G&M, Grice AC, Martin TG. 2005. The Management of Weeds and Their Impact on Biodiversity in the Rangelands. Cooperative Research Centre (CRC) for Australian Weed Management and CSIRO Sustainable Ecosystems. Commonwealth Australia (www.landmanager.com.au/view/index.aspx?id=163572)
Gr, Groves et al. 2003. Weed categories for natural and agricultural ecosystem management. Bureau of
Rural Sciences (www.landmanager.com.au/view/index.aspx?id=388018)
K0, High Priority Weeds not yet established in the Katherine region
K1, High Priority Weeds posing environmental threats in the Katherine region
K2, High Priority Weeds posing existing threats in the Katherine region, as described in the Katherine Regional Weed Management Strategy 2005-2010 (www.landmanager.com.au/view/index.aspx?id=130286)
MP, Northern Territory Parks & Conservation Masterplan (www.landmanager.com.au/view/index.aspx?id=144141)
NAQS, North Australian Quarantine Strategy Target List (www.landmanager.com.au/view/index.aspx?id=449416)
NSW, Declared Noxious Weed in NSW (www.landmanager.com.au/view/index.aspx?id=449983)
Q1, QLD Class 1 Weed (not to be introduced, kept or supplied-
Q2, Class 2 Weed (eradicate where possible, not to be introduced, kept or supplied)
Q3, Qld Class 3 Weed (to be controlled near environmentally sensitive areas- not to be supplied/sold without a permit) (www.landmanager.com.au/view/index.aspx?id=190714)
SA, Declared Plant in South Australia (www.landmanager.com.au/view/index.aspx?id=449996)

WeedsAus, Listed as a significant weed by Weeds Australia (www.landmanager.com.au/view/index.aspx?id=14576)
WA1, WA Weed Class P1 (movement prohibited)
WA2, WA Weed Class P2 (aim to eradicate)
WA3, WA Weed Class P3 (control infestations)
WA4, WA Weed Class P4 (prevent spread)
WA5, WA Weed Class P3 (control infestations on public land) (www.landmanager.com.au/view/index.aspx?id=449884).

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More species info: Go to www.landmanager.org.au/view/index.aspx?id=####
where #### is the ID number from the tables above for the species of interest.

Plants listed in the table above were recorded from all the grid cells shown below (red/blue line) that overlap Custom area

Custom area Pest and Potential Pest Animals

Animals with pest potential recorded in the grid cell(s) in which Custom area occurs. Occurrence based on Northern Territory Government databases.

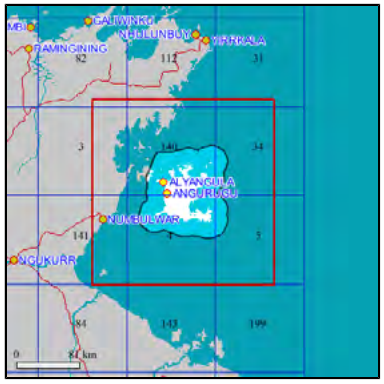
Common Name	Scientific Name	NT Status	National Status	ID	#Observations (Latest)	#Specimens (Latest)	#Surveys (Latest)
Cane Toad	*Rhinella marina*	P	.	183252	0 (Unknown)	1 (1983)	4 (2010)
Asian House Gecko	*Hemidactylus frenatus*	P	.	188964	1 (2006)	3 (2010)	1 (2006)
Red-tailed Black-cockatoo	*Calyptorhynchus banksii macrorhynchus*	N	.	223765	17 (2006)	3 (1922)	0 (Unknown)
Sulphur-Crested Cockatoo	*Cacatua galerita*	N	.	223772	33 (2009)	2 (1921)	6 (2010)
Eurasian Tree Sparrow	*Passer montanus*	P	.	450580	3 (2001)	2 (2001)	0 (Unknown)
Agile Wallaby	*Macropus agilis*	N	.	223786	11 (2008)	20 (1942)	16 (2009)
House Mouse	*Mus musculus*	P	.	187720	0 (Unknown)	3 (1989)	0 (Unknown)
Black Rat	*Rattus rattus*	P	.	183236	0 (Unknown)	4 (Unknown)	0 (Unknown)
Dingo / Wild dog	*Canis lupus*	N	.	183280	17 (2010)	0 (Unknown)	3 (2009)
Cat	*Felis catus*	P	.	183259	2 (2005)	0 (Unknown)	0 (Unknown)
Pig	*Sus scrofa*	P	.	183329	7 (1998)	0 (Unknown)	0 (Unknown)
Swamp Buffalo	*Bubalus bubalis*	P	.	183245	3 (1998)	0 (Unknown)	0 (Unknown)
Cattle	*Bos taurus*	P	.	183266	4 (1996)	0 (Unknown)	0 (Unknown)
Goat	*Capra hircus*	P	.	183301	1 (1979)	0 (Unknown)	0 (Unknown)
Rusa Deer	*Cervus timorensis*	P	.	223793	2 (2006)	0 (Unknown)	6 (2006)

NT STATUS CODES:
Int, Introduced species (all non-prohibited vertebrates, and all other exotic species (www.landmanager.com.au/view/index.aspx?id=280771)
N, Native species with pest potential.
P, Prohibited species (all exotic vertebrates except those listed as non-prohibited (www.landmanager.com.au/view/index.aspx?id=450509)

Survey = this category refers to data collected using systematic survey methodology
Specimen = this category refers to museum or other records where a specimen has been collected and lodged
Observation = this category refers to all other incidental recordings where systematic methodology may not have been used consistently.

More species info: Go to www.landmanager.org.au/view/index.aspx?id=####
where #### is the ID number from the tables above for the species of interest.

Potential pest animals listed in the table above were recorded from all the grid cells shown below (red/blue line) that overlap Custom area



Generated from NT Infonet (http://www.infonet.org.au) Fri Oct 17 09:49:41 CST 2014

Soils and vegetation graphs and tables refer to area of soils and vegetation only. Fire graphs and tables refer to entire selected area including sea if present. Calculations are derived from map images or vector data, and should be taken as a guide only. Accuracy cannot be guaranteed. For small areas, figures should be rounded to the nearest whole number.

Appendix C

Habitat Requirements of Species Recorded from Database Searches

Table C.1 Habitat Requirements of Species Recorded from Database Searches

Species Name	Common Name	Source Identifying the Species as Potentially Occurring			Conservation Category		Habitat Requirements
		TOR	PMST	InfoNet	EPBC Act Listing	NT Listing	
Varanus mertensi	Merten's Water Monitor	X		X		V	**Freshwater** The semi-aquatic Merten's Water Monitor is found in the proximity of watercourses, inhabiting both coastal and inland waters and riparian areas. It is often sighted climbing on rocks or trees nearby water, and uses burrows in the ground as nests for its eggs. This species was recorded from the project site – refer to the EIS Terrestrial Ecology Report for further detail.
Crocodylus porosus	Salt-water Crocodile		X		Mig/Mar		**Marine, Estuarine and Freshwater** The Salt-water Crocodile inhabits tidal rivers, coastal floodplains and channels, billabongs and swamps. It may be found up to 150 km inland from the coast, in habitats where salinity levels are sufficient. This species was recorded from the project site – refer to the EIS Terrestrial Ecology Report for further detail.
Pristis pristis	Largetooth Sawfish	X			V		**Marine, Estuarine and Freshwater** The Largetooth Sawfish is known to spend different phases of its life cycle in different habitats. It spends its first 3-4 years in freshwater. The species subsequently inhabits marine and estuarine areas as mature adults, in waters up to 25 m depth.

Table C.1 Habitat Requirements of Species Recorded from Database Searches

Species Name	Common Name	Source Identifying the Species as Potentially Occurring			Conservation Category		Habitat Requirements
		TOR	PMST	InfoNet	EPBC Act Listing	NT Listing	
Pristis clavata	Dwarf Sawfish	X	X		V	V	**Marine and Estuarine** The Dwarf Sawfish is found in brackish and salt water, and prefers shallow (2-3 m) coastal waters and estuarine habitats on silt/sand flats. The species have previously been recorded at sites with low macrophyte and algal cover, and with high turbidity, low dissolved oxygen, and water temperatures between 25-32 °C. Estuarine habitats are known to be used as nursery areas by the Dwarf Sawfish, and where the species spends its first three years, while adults have been found to seasonally migrate back into inshore waters. This species does not occur in freshwater habitats.
Pristis zijsron	Green Sawfish	X	X		V	V	**Marine and Estuarine** The Green Sawfish prefers muddy bottom habitats and estuaries, and occurs in inshore marine waters, river mouths and along sandy and muddy beaches, in depths ranging from <1m-70m. The Green Sawfish uses shallow inshore waters as nursery areas. This species does not occur in freshwater habitats.

Table C.1 Habitat Requirements of Species Recorded from Database Searches

Species Name	Common Name	Source Identifying the Species as Potentially Occurring			Conservation Category		Habitat Requirements
		TOR	PMST	InfoNet	EPBC Act Listing	NT Listing	
Dugong dugon	Dugong		X		Mig/Mar		**Marine and Estuarine** Dugongs are found in coastal waters, as well as estuarine creeks and streams. Main feeding habitats are shallow, protected areas with large seagrass beds, including mangrove channels and inshore islands. Previous records of the species in deeper waters corresponds to locations of deepwater seagrass areas. This species does not occur in freshwater habitats.
Carcharodon carcharias	Great White Shark		X		V/Mar/Mig		**Marine** This species is exclusively marine, and does not occur in freshwater habitats.
Rhincodon typus	Whale Shark		X		V		**Marine** This species is exclusively marine, and does not occur in freshwater habitats.
Balaenoptera musculus	Blue Whale		X		E/Mar/Mig		**Marine** This species is exclusively marine, and does not occur in freshwater habitats.
Megaptera novaeangliae	Humpback Whale		X		V/Mig/Mar		**Marine** This species is exclusively marine, and does not occur in freshwater habitats.
Balaenoptera edeni	Bryde's Whale				Mig/Mar		**Marine** This species is exclusively marine, and does not occur in freshwater habitats.

Table C.1 Habitat Requirements of Species Recorded from Database Searches

Species Name	Common Name	Source Identifying the Species as Potentially Occurring			Conservation Category		Habitat Requirements
		TOR	PMST	InfoNet	EPBC Act Listing	NT Listing	
Manta birostris	Giant Manta Ray,				Mig/Mar		**Marine** This species is exclusively marine, and does not occur in freshwater habitats.
Orcaella brevirostris	Irrawaddy Dolphin				Mig/Mar		**Marine** This species is exclusively marine, and does not occur in freshwater habitats.
Orcinus orca	Killer Whale				Mig/Mar		**Marine** This species is exclusively marine, and does not occur in freshwater habitats.
Sousa chinensis	Indo-Pacific Humpback Dolphin				Mig/Mar		**Marine** This species is exclusively marine, and does not occur in freshwater habitats.
Natator depressus	Flatback turtle	X	X	X	V/Mar/Mig		**Marine** This species is exclusively marine, and does not occur in freshwater habitats.
Chelonia mydas	Green turtle	X	X	X	V/Mar/Mig		**Marine** This species is exclusively marine, and does not occur in freshwater habitats.
Eretmochelys imbricata	Hawksbill turtle	X	X	X	V/Mar/Mig	V	**Marine** This species is exclusively marine, and does not occur in freshwater habitats.
Caretta caretta	Loggerhead Turtle		X		E/Mar/Mig	V	**Marine** This species is exclusively marine, and does not occur in freshwater habitats.

Table C.1 Habitat Requirements of Species Recorded from Database Searches

Species Name	Common Name	Source Identifying the Species as Potentially Occurring			Conservation Category		Habitat Requirements
		TOR	PMST	InfoNet	EPBC Act Listing	NT Listing	
Lepifochelys olivacea	Olive Ridley turtle		X	X	E/Mar/Mig	V	**Marine** This species is exclusively marine, and does not occur in freshwater habitats.
Dermochelys coriacea	Leatherback Turtle		X		E/Mar/Mig	CE	**Marine** This species is exclusively marine, and does not occur in freshwater habitats.

Conservation Category Key:

V Vulnerable

CE Critically Endangered

E Endangered

Mar Marine

Mig Migratory

Appendix D

Macroinvertebrate Data

Table D.1 Macroinvertebrate Data

Common Name			Mites	Beetles						Shrimp	True Flies				Mayflies			True Bugs									Damselflies	Dragonflies	Caddisflies			
Order			Acarina*	Coleoptera						Decapoda	Diptera				Ephemeroptera			Hemiptera									Odonata	Odonata	Tricoptera			
Family			-	Curculionidae	Dytiscidae	Elmidae	Haliplidae	Hydrophilidae	Scirtidae	Atyidae	Ceratopogonidae	Chaoboridae	Chironomidae	Culicidae	Baetidae	Caenidae	Leptophlebiidae	Corixidae	Gerridae	Hydrometridae	Mesoveliidae	Naucoridae	Nepidae	Notonectidae	Pleidae	Veliidae	Coenagrionidae	Corduliidae	Ecnomidae	Hydropsychidae	Leptoceridae	Total
SIGNAL Grade			*6*	*2*	*2*	*7*	*2*	*2*	*6*	*3*	*4*	*2*	*3*	*1*	*5*	*4*	*8*	*2*	*4*	*3*	*2*	*2*	*3*	*1*	*2*	*3*	*2*	*5*	*4*	*6*	*6*	
Emerald River	Main Channel	A1B			1								1									1					2	3	3			11
		A1E			3	3	2						7						5			5	1				7	2				35
		A2B			2								1		2												1					6
		A2E			1		1			2			1	1	16				2		5						2	1				32
		A17E	3		3	1				12			3	3				1					4		6		3	5				44
	Tributary 2	A8B								3			2															1				6
		A8E			1	2				7								1	6	1	3		1			7		1				30
		A9E			2	1							2	1	2		4						1				1	3				17
		A10B	4		1																	1										6
		A10E			4	1				1				1					2				1				3					13
		A15E							2	2			1		3					1	3	1					6	5	2	1	3	30
		A16E			4				1												2	1					1	3	1		1	14
	Tributary 3	A3B	1			1							1														1					4
		A3E				11		1					9		1				4		1		1				7	1				36

Table D.1 Macroinvertebrate Data

Common Name			Mites	Beetles						Shrimp	True Flies				Mayflies			True Bugs									Damselflies	Dragonflies	Caddisflies			
Order			Acarina*	Coleoptera						Decapoda	Diptera				Ephemeroptera			Hemiptera									Odonata	Odonata	Tricoptera			
Family			-	Curculionidae	Dytiscidae	Elmidae	Haliplidae	Hydrophilidae	Scirtidae	Atyidae	Ceratopogonidae	Chaoboridae	Chironomidae	Culicidae	Baetidae	Caenidae	Leptophlebiidae	Corixidae	Gerridae	Hydrometridae	Mesoveliidae	Naucoridae	Nepidae	Notonectidae	Pleidae	Veliidae	Coenagrionidae	Corduliidae	Ecnomidae	Hydropsychidae	Leptoceridae	Total
SIGNAL Grade			*6*	*2*	*2*	*7*	*2*	*2*	*6*	*3*	*4*	*2*	*3*	*1*	*5*	*4*	*8*	*2*	*4*	*3*	*2*	*2*	*3*	*1*	*2*	*3*	*2*	*5*	*4*	*6*	*6*	
Total – Emerald River			**8**	**0**	**22**	**20**	**3**	**1**	**3**	**27**	**0**	**0**	**28**	**6**	**24**	**0**	**4**	**2**	**19**	**2**	**14**	**9**	**9**	**0**	**6**	**7**	**34**	**25**	**6**	**1**	**4**	**284**
Amagula River	Main Channel	A11E			12						1		3			1	2				1	3					8	2				33
	Tributary 1	A5B									1		7	1	1		1				1						3	1				16
		A5E			1	3							4	2													1	1	1			13
		A6B					1	1				1	9		2												2	8				24
		A6E			1								14		2			2					1	1		1		3				25
		A12E			3	1				47			18						1				2				6	9				87
		A13E		1		7				32			3		3	1		1				1	4				3	4				60
		A14E			2	3				14			10		5	1		9	1								7	3			1	56
	Tributary 2	A4B				1				1			3																			5
		A4E					2						5				1										1	2				11
		A7B											5															1	2			8
		A7E								1			2	1		1												1	1			7

Table D.1 Macroinvertebrate Data

Common Name	Mites	Beetles						Shrimp	True Flies				Mayflies			True Bugs									Damselflies	Dragonflies	Caddisflies			
Order	Acarina*	Coleoptera						Decapoda	Diptera				Ephemeroptera			Hemiptera									Odonata	Odonata	Tricoptera			
Family	-	Curculionidae	Dytiscidae	Elmidae	Haliplidae	Hydrophilidae	Scirtidae	Atyidae	Ceratopogonidae	Chaoboridae	Chironomidae	Culicidae	Baetidae	Caenidae	Leptophlebiidae	Corixidae	Gerridae	Hydrometridae	Mesoveliidae	Naucoridae	Nepidae	Notonectidae	Pleidae	Veliidae	Coenagrionidae	Corduliidae	Ecnomidae	Hydropsychidae	Leptoceridae	Total
SIGNAL Grade	*6*	*2*	*2*	*7*	*2*	*2*	*6*	*3*	*4*	*2*	*3*	*1*	*5*	*4*	*8*	*2*	*4*	*3*	*2*	*2*	*3*	*1*	*2*	*3*	*2*	*5*	*4*	*6*	*6*	
Total – Amagula River	**0**	**1**	**19**	**15**	**3**	**1**	**0**	**95**	**2**	**1**	**83**	**4**	**13**	**4**	**4**	**12**	**2**	**0**	**2**	**4**	**7**	**1**	**0**	**1**	**31**	**35**	**4**	**0**	**1**	**345**
TOTAL PROJECT SITE	**8**	**1**	**41**	**35**	**6**	**2**	**3**	**122**	**2**	**1**	**111**	**10**	**37**	**4**	**8**	**14**	**21**	**2**	**16**	**13**	**16**	**1**	**6**	**8**	**65**	**60**	**10**	**1**	**5**	**629**
TOTAL per Order	**8**	**88**						**122**	**124**				**49**			**97**									**65**	**60**	**16**			**629**

B = Bed samples, E = Edge samples

**- Acarina (the mites) were left at order level as it is particularly difficult to identify this group down to family level*