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REPUBLICA DEMOCRATICA DE TIMOR-LESTE
SECRETARIA DE ESTADO DOS RECURSOS NATURAIS

Tasi Mane Project - Suai Supply Base Environmental Impact Assessment

Final Report

May 2012

Volume 3 - Attachments

301012-01504-EN-REP-0003

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The Tasi Mane Project – Suai Supply Base Environmental Impact Assessment Final Report is made up of separate three volumes.

VOLUME 1 of 3: Suai Supply Base Environmental Impact Assessment Main Report Part A (Chapters 1 to 14)

VOLUME 2 of 3: Suai Supply Base Environmental Impact Assessment Main Report Part B (Chapters 15 to 20)

VOLUME 3 of 3: Suai Supply Base Environmental Impact Assessment Attachments:

Flora and Fauna Final Technical Report
Marine Ecology and Fisheries Final Technical Report
Tasi Mane Project Strategic Environmental Management Plan

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ENVIRONMENTAL IMPACT STATEMENT
Tasi Mane Project - Suai Supply Base
VOLUME 1 of 3: Main Report Part A

ENVIRONMENTAL IMPACT STATEMENT
Tasi Mane Project - Suai Supply Base
VOLUME 2 of 3: Main Report Part B

ENVIRONMENTAL IMPACT STATEMENT
Tasi Mane Project - Suai Supply Base
VOLUME 3 of 3: ATTACHMENTS

Attachment 1:
Terrestrial Flora and Fauna Final Technical Report

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Tasi Mane Project - Suai Supply Base
VOLUME 3 of 3: ATTACHMENTS

Attachment 2:
Marine Ecology and Fisheries Final Report

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Attachment 3:
Tasi Mane Project Strategic Environmental Management Plan

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ATTACHMENT 1

Tasi Mane Project - Suai Supply Base EIA

Terrestrial Flora and Fauna

Final Technical Report

301012-01504-EN-REP-0001

May 2012

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PROJECT 301012-01504 - TASI MANE PROJECT – SUAI SUPPLY BASE EIA: TERRESTRIAL FLORA AND FAUNA TECHNICAL REPORT

REV	DESCRIPTION	ORIG	REVIEW	WORLEY-PARSONS APPROVAL	DATE	CLIENT APPROVAL	DATE
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EXECUTIVE SUMMARY

In December 2011, WorleyParsons was commissioned by the Secretaria de Estado dos Recursos Naturais, on behalf of the Government of Timor-Leste, to undertake a flora and vertebrate fauna assessment for the Tasi Mane Project, specifically the Suai supply base. This was part of a wider commission to prepare an environmental impact assessment to describe the likely environmental and social impacts associated with the proposed development.

The Suai supply base will be located on the south coast on the island nation of Timor-Leste. Timor-Leste is part of the Lesser Sunda Archipelago, an assemblage of islands comprised of a northern, volcanogenic arc (the Inner Banda Arc, with main islands Bali, Lombok, Sumbawa, Flores, and Wetar) and a southern, orogenic arc (the Outer Banda Arc, with main islands Sumba, Roti, and Timor). The site is approximately 90 km south west of the capital city of Dili.

The flora assessment and the vertebrate fauna assessment for the project occurred from 9 to 13 December 2011 and from 6 to 8 February 2012.

The objectives of the flora assessment were to:

- Validate the accuracy of desktop reviews;
- Describe broad vegetation units and agricultural areas;
- Identify remnant areas of primary and secondary forest, coastal forest and mangroves;
- Identify species of potential conservation significance (International Union for Conservation of Nature (IUCN) Red List);
- Identify species of economic importance (teak, rosewood, sandalwood, food crops); and
- Determine any significant impacts to species or vegetation communities of conservation significance.

The objectives of the vertebrate fauna assessment were to:

- Validate the accuracy of desktop reviews;
- Ground-truth the extent and condition of fauna habitat types present;
- Identify species of potential conservation significance (IUCN Red List);
- Further delineate and characterise the species and fauna habitat types present and potentially present at each site;
- Provide additional information for any subsequent clearing requirements; and
- Determine any significant impacts to species of conservation significance.

The geographical area covered by the Tasi Mane Project - Suai Supply Base project is termed the Suai development area, and it comprises five components: the Suai supply base, industrial estate, Nova Suai, Suai Airport upgrade, and two crocodile reserves (We Dare and We Matan Bua Oan).

Dominant and common species were the main focus of the flora and vegetation survey due to time constraints. In the desktop survey, 36 flora species were listed as being of 'Least Concern' on the IUCN Red List for Timor-Leste, and none of these were recorded during the field survey. No further flora species were listed by the IUCN Red List specifically for Timor-Leste; however, sandalwood (*Santalum album*) and rosewood (*Pterocarpus indicus*), both 'Vulnerable' species listed for south-east Asia, were recorded in the Suai development area.

Most flora species recorded in the Suai development area have a widespread distribution in the tropics. Three of these species are listed on the IUCN's Global Invasive Species Database (GISD) of the 100 worst invasive species, Siam weed *(Chromolaena odorata*), cogon grass (*Imperata cylindrica*) and coffee bush (*Leucaena leucocephala*).

Several species of economic or local importance, primarily timber or food crops, were recorded in the Suai development area. Two of these species, rosewood (*Pterocarpus indicus)* and sandalwood (*Santalum album)* are also of conservation concern. Small plantations or estates of coconuts, bananas, and occasionally mango were present in the Suai development area. The tenure of trees within estates may be external to local villages. Occasional fruit and spice trees were encountered and appear to be individually owned and marked accordingly.

Natural vegetation within the Suai development area exists primarily as narrow bands of open coastal forest with small areas of mangrove and riparian vegetation. The coastal plain has largely been cleared in association with swidden (or 'slash and burn') agriculture, sandalwood harvesting, plantation estates and timber plantations. Remnant vegetation exists as highly fragmented and secondary communities.

Mangroves, which are considered to be of conservation significance, were recorded in the proposed areas for the crocodile reserves and supply base. Mangroves are an important coastal habitat for marine organisms and also function to stabilise soils, thereby reducing the amount of soil erosion that would otherwise occur.

Within the Suai development area, 68 species of vertebrate fauna were recorded, consisting of two species of amphibians, seven species of reptiles, 48 species of birds and 11 species of mammals. Due to a lack of baseline knowledge and regional context, it is difficult to gauge the adequacy of survey effort and therefore the extent of expected faunal assemblages for the area.

Species listed as Critically Endangered, Endangered, Vulnerable and Near Threatened under the IUCN Red List constitute species as having conservation significance. Lack of baseline data of Timor-Leste's fauna means that conservation significant species which have not been recorded may still be present. Five species of conservation significance were recorded in the study area: the yellow-crested cockatoo (*Cacatua sulphurea*), canut's horseshoe bat (*Rhinolophus canuti timoriensis*), beach thick-knee (*Esacus magnirostris*), slaty cuckoo dove (*Turacoena modesta*) and Timor bush-chat (*Saxicola gutturalis*). The yellow-crested cockatoo (listed as Critically Endangered on the IUCN Red List) was

recorded on five occasions within the Suai development area, making the habitat within the Suai development area potentially sensitive to environmental impacts proposed by the project.

Limitations existed for both the flora and vegetation, and fauna surveys, given the limited assessment period. Further survey effort to achieve optimum results should be undertaken throughout the year and for longer periods of time, enabling the identification of a broader range and seasonality of species to be identified.

Environmental impacts associated with flora and vegetation include but are not limited to; the loss of IUCN listed flora species, loss of commercial timber species, loss of mangrove habitats, spread of weeds and the destabilization of soils.

Fauna environmental impacts include the potential depletion/degradation of the habitat associated with supporting five conservation significant species found in the Suai development area, one of which is Critically Endangered.

1. INTRODUCTION

In December 2011, WorleyParsons was commissioned by the Secretaria de Estado dos Recursos Naturais (SERN), on behalf of the Government of Timor-Leste (GoTL) to undertake a flora and vegetation, and vertebrate fauna assessment of the Tasi Mane Project – Suai Supply Base (the project). This study involves only one of the three components of the Tasi Mane project - the development of the Suai supply base component. This was part of a wider commission to prepare an environmental impact assessment (EIA) to describe the likely environmental and social impacts associated with the proposed development.

The project comprises the following components:

- Supply Base.
- Industrial estate.
- A new town, Nova Suai.
- Upgrade to the existing Suai Airport.
- Two crocodile reserves.

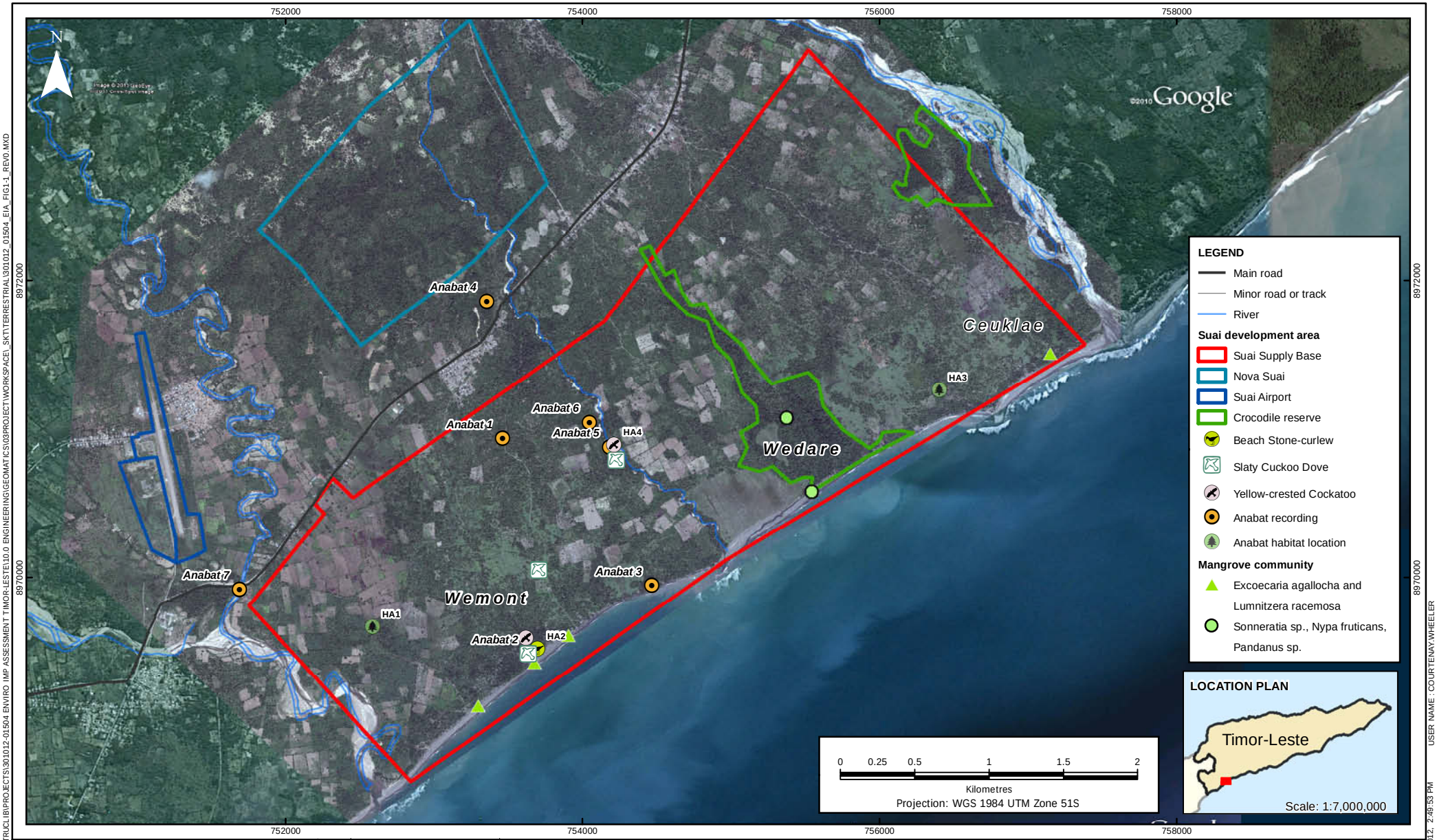
1.1 Location

The Suai development area will be located on the south coast of the island nation of Timor-Leste. Timor-Leste is part of the Lesser Sunda Archipelago, an assemblage of islands comprised of a northern, volcanogenic arc (the Inner Banda Arc, with main islands Bali, Lombok, Sumbawa, Flores, and Wetar) and a southern, orogenic arc (the Outer Banda Arc, with main islands Sumba, Roti, and Timor). The Suai development area is approximately 138 km south west of Dili (the capital city of Timor-Leste).

1.2 Project Brief/Scope

The proposed project development is likely to result in the clearance of some terrestrial flora and vegetation, and have further adverse impacts on the species that currently relies on the vegetation. WorleyParsons' ecological team surveyed and described terrestrial flora and vertebrate fauna species at each site in accordance with the terms of reference, in order to provide sufficient information to address both biodiversity conservation and ecological function values, and meet the GoTL objectives for the protection of the environment.

The Tasi Mane Project - Suai Supply Base investigation is discussed further in this report. The geographical area covered by this project is termed the Suai development area, and comprises five components: the Suai supply base, industrial estate, a new town (Nova Suai), upgrade to the existing Suai Airport, and the establishment of two crocodile reserves.



NOTES:
This map consists of:
1. Imagery Suai: SRTM (2011)
2. Imagery: Google Earth (2010)
3. Rivers: GIGTimorLeste (2010)
4. Roads: DivaGIS (2010)

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PROJECT No: 301012-001504

TASI MANE PROJECT - SUAI SUPPLY BASE
TERRESTRIAL ENVIRONMENT TECHNICAL REPORT

WorleyParsons resources & energy

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REPUBLICA DEMOCRATICA DE TIMOR-LESTE
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Figure 1-1
Suai study area biodiversity key sites

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A broad focus approach was taken to flora and vegetation surveys in order to obtain information on species and areas of conservation and economic importance. Given time constraints and limited knowledge of the flora and vegetation in the Suai development area, the survey focused on potential matters of environmental and economic importance to the people of Timor-Leste and GoTL.

A stronger emphasis was placed on the flora survey rather than the vegetation survey due to time constraints. This allowed for the collection of preliminary baseline information in the absence of a baseline survey. Adequate baseline flora data is a prerequisite to completing meaningful vegetation survey work. This also provided more time to focus on the assessment of threatened species and economically important species.

Broad objectives for the assessment included:

- Review existing knowledge on the flora, vegetation and fauna of Timor-Leste through a desktop study;
- Conduct a database search to identify species of potential conservation significance on the IUCN Red List;
- Describe, analyse and report on the project's terrestrial flora and vertebrate fauna species present;
- Describe the conservation significant species present in and within the vicinity of the project; and
- Provide baseline ecological knowledge for the project.

1.3 Regulatory Context

The Democratic Republic of Timor-Leste (RDTL) became party to the United Nations Convention on Biological Diversity (UNCBD) in 2007. A thematic assessment report of Timor-Leste was prepared for the UNCBD by Alves (2007). Under this Convention, countries are obliged to develop a National Biodiversity Strategy and Action Plan (NBSAP) which involves identifying actions and measures for conservation of biodiversity. Timor-Leste is yet to develop regulations and policy documents specifically addressing biodiversity conservation.

There are several laws and regulations from previous administrations (United Nations Transitional Administration in East Timor (UNTAET) and Indonesian) that address environmental protection and biodiversity conservation in Timor-Leste:

- Law No. 5, 1990 on Conservation of Biological Resources and their Ecosystems;
- Law No. 5, 1994 Concerning Biodiversity;
- Government Regulation No. 28, 1985 on Forest Protection;
- Government Regulation No. 51, 1993 on Environmental Impact Analysis;
- UNTAET Regulation No. 2000/17; and

- UNTAET Regulation No. 2000/19.

UNTAET Regulation No. 2000/19 on protected places (30 June 2000) was in place for the purpose of protecting designated areas, endangered species, wetlands, mangrove areas, historic, cultural and artistic sites, conservation of biodiversity and protection of the biological resources of Timor-Leste. Fifteen natural areas were protected under this regulation and have been designated as Protected Natural Areas (PNAs). The majority comprise primary forest areas, coral reefs, mangroves, wetland habitat and mountain summits above 2,000 m.

Of particular relevance to this survey is:

- Section 5 - Wetlands and Mangroves, which states that wetlands and mangrove areas shall be protected. Cutting, damaging or removing of a mangrove shall be prohibited; and
- Section 3 - Endangered Species – which states that endangered species and their habitats shall be protected throughout the terrestrial territory of Timor-Leste.

Section 3 states that the following species of animal shall constitute endangered species within Timor-Leste:

- Sea turtles (addressed in the marine ecology technical report);
- Marine mammals, including bottlenose dolphins, whales and dugongs (addressed in the marine ecology technical report);
- Wallabies;
- Crocodiles;
- All animal and plant species listed in Appendix I or Appendix II of the Convention on the International Trade in Endangered Species; and
- Any other plant or animal species designated as endangered by the Transitional Administrator.

The State Secretariat for the Environment (SEMA), under the Ministry of Economy and Development, and the Ministry of Agriculture, Forestry and Fisheries (MAFF) are the two government agencies with primary responsibilities for the environment. SEMA deals with the environmental issues in the sectors, and MAF deals with resource management, including; forests, fisheries, and biodiversity conservation. The laws and regulations from previous administrations listed above are not necessarily recognised.

The Convention on International Trade in Endangered Species (CITES) is an international agreement that aims to ensure that international trade in fauna and flora does not threaten their survival. The Convention controls international trade in fauna but does not necessarily reflect conservation status in a particular country. Appendix I lists species that are considered the most endangered among CITES-listed animals and plants, while Appendix II lists species that are not necessarily currently threatened with extinction but that may become so unless trade is closely controlled. Consequently, CITES can be used to provide some indication of the relative global conservation status of species listed under CITES but not assessed on the IUCN Red List (e.g., pythons, monitor lizards, birds of prey).

2. EXISTING ENVIRONMENT

2.1 Climate

Little climate information is available for the south-coast of Timor-Leste. Trainor *et al*. (2008) identified Timor-Leste as having a highly seasonal, dry tropical climate which is geographically variable depending on the elevation and aspect of the location. The south coast is known to receive the highest rainfall, falling in the wet season which occurs mainly between November and April and extending sometimes to June **(**Trainor 2008). The annual precipitation for Timor-Leste is approximately 1,500 to 4,000mm of rain per year (Trainor *et al*. 2008). Coastal towns are typically hot during the day (31°C to 33°C) and warm at night (20°C to 25°C); however, the dry season is cooler (18°C to 20°C at night compared to 25°C to 28°C by day) and less humid (Trainor 2008).

2.2 Biogeography

The island of Timor-Leste is part of the Malay Archipelago, representing the largest and easternmost of the Lesser Sunda Islands (World Bank 2009). The island is non-volcanic, part of the Outer Banda Arc, derived from the basement of rocks of the Australian continental margin and is characteristically limestone with karst formations.

Timor-Leste is located in the Central Melesia (Wallacea) region and its flora is considered to be transitional between the main rainforest blocks of the Sunda (Peninsula Malaysia, Sumatra, Borneo, West Java) and Sahul (New Guinea) shelves (van Welszen *et al.* 2005).

Few publications document the flora and vegetation of Timor-Leste; however, some information can be gained from studies undertaken in the bordering country of Nusa Tenggara (West Timor) and surrounding islands. A review of literature by Monk *et al.* (1997) concludes that Nusa Tenggara has a mixture of Indo-Malay and Australian elements.

A total of 407 endemic species and five genera of plants are known from Nusa Tenggara and Maluku, of which only eight species are shared between each location (Monk *et al.* 1997). Nusa Tenggara and the Maluku groups of islands have differing geological origins, ranging from young, active volcanic islands, to limestone with karst formations. The plant genera endemic to Timor are *Sautiera* and *Sinthraoblastes*. Timor was identified as having the highest number of endemic species recorded in Indonesia, at approximately 10.3% (Monk *et al.* 1997).

Both Indo-west Malaysian (rainforest plants) and eastern genera species (mix of rainforest and seasonal) are moderately represented in Nusa Tenggara. Wallace's Line has no significance for plants between Bali and Lombok Islands and both western and eastern floral elements are present. Wallace's Line was not the most significant biogeographic boundary for plant species in the study (Rhee *et al.* 2004).

The following broad vegetation types have been described within Nusa Tenggara:

- Lowland Evergreen Rainforests are common, generally on the drier slopes;

- Semi-Evergreen Rainforest is structurally complex vegetation which is transitional between Lowland Evergreen Rainforest and Monsoon Forest;
- Montane Forest – little seasonal Montane Forest survives in Nusa Tenggara;
- Seasonal Montane Forest occurs above Monsoon Forest, and would have originally covered mountainous areas in Nusa Tenggara;
- Heath Forests are rare with small patches in Timor-Leste;
- Forests on ultra-basic rocks occur on Timor island;
- Forests on limestone rocks in Nusa Tenggara occur in both ever wet and seasonal areas; and
- Mangroves – small areas.

Existing forest cover in Timor-Leste occurs in scattered areas along the south coast with smaller remnants elsewhere. The former closed forest areas of Timor-Leste currently consist of a mosaic of secondary forest and grassland, possibly with primary forest fragments. In 1991, approximately one quarter of the forested area was primary forest and three quarters was secondary forest (Oxfam 2003).

The rate of deforestation in Timor-Leste from 1972 to 1999 has been estimated at 1.1% per year, which is four times as high as the global average of 0.3%. The direct results have been severe soil erosion, reduced forest productivity and loss of biodiversity (Alves 2007).

Alves (2007) identified that there are six major ecosystem types recognised within Timor-Leste and the status of biological diversity was assessed for each:

- Marine and Coastal Zone,
- Arid Lowland Areas,
- Moist Lowland Areas,
- Mountainous Areas,
- Highland Plains, and
- Wetlands.

Two of the ecosystem types were relevant to the project and are described in (Table 2-1).

Table 2-1 Ecosystem Types

Ecosystem Type	Description	Efforts to Manage Biological Diversity
Marine and Coastal Zone	Includes specialised coastal vegetation like mangroves, shallow seas adjacent to land, coral reefs and sea grass beds	Mangroves and coral reefs are protected by (UNTAET) Regulation No. 2000/19
Moist Lowland Areas	Include those areas roughly between the altitudes of 0 and 600 m, where the temperatures are above 24°C, there is a heavier rainfall and the dry season lasts three months. The original vegetation was mainly moist deciduous forest, semi-evergreen forests or rain forests. Present vegetation includes cultivated lands, plantations, secondary vegetation and some badlands. Includes the coastal plain and steep hillsides.	BirdLife International has identified nine Important Bird Areas in closed forest canopy vegetation Identification of two endangered tree species, conservation and restoration activities including provision of seedlings (government initiated reforestation)

2.3 Flora and Vegetation

2.3.1 Previous Surveys

Recent published flora and vegetation knowledge has been confined to the far east of Timor-Leste. Since Timor-Leste independence, several flora and vegetation surveys have been undertaken in the proposed Jaco-Tutuala-Lore National Park (Cowie 2006, 2007). The proposed park contains the largest remaining area of natural closed forest vegetation on the island of Timor-Leste. Several flora and vegetation surveys have also been completed for proposed infrastructure projects such as the Iralalaro Hydropower Project (Cowie 2007). The flora of Timor-Leste was estimated at 2,500 species and 22 new plant species were recorded during preliminary findings by Cowie (2006).

Cowie (2006) provides an account of the previous botanical exploration of Timor-Leste and states that there are limited recent flora checklists for Timor-Leste. Flora collections have been intermittent and were often conducted for specific purposes such as ethnobotanical study or taxonomic studies relating to specific groups. A recent checklist of Timor-Leste orchids comprised 66 species, including 32 new species records for the island, and four newly described species (Silveira *et al.* 2008). At least 10 orchid species are considered endemic to Timor-Leste. This list is likely to increase as further plant material is identified and further botanical research is undertaken.

Primary forests are closed communities including ever-wet, semi-evergreen and moist deciduous forests. These feature an abundance and dominance of tree species with relatively large fleshy fruits

(bird attractive fruits). These trees may be dependent on larger fruit pigeons and flying foxes for dispersal of seed.

The large fruited trees are absent from the secondary dry deciduous forest and thorn forest typical in most parts of Timor-Leste.

2.4 Fauna

2.4.1 Previous Surveys

Current documented vertebrate fauna knowledge of Timor-Leste is limited, especially for the south coast. The few biological surveys that have been undertaken within the past ten years include Rapid Biodiversity Surveys in Jaco Island and Lake Iralalaru areas, which were conducted by conservation organisations such as BirdLife International in conjunction with NDCF.

Historically, the vertebrate fauna of Timor-Leste has been poorly documented; however, some studies have been conducted on herpetofauna, birds and mammals. Kaiser *et al.* (2011) conducted field surveys throughout Timor-Leste resulting in the identification of seven species of amphibians and 30 species of reptiles. Among the amphibians the most frequently encountered were toads, rice paddy frogs and rhacophorid treefrogs (Kaiser *et al*. 2011). Common skinks included the four fingered skinks (*Carlia* spp.), wedge skinks (*Sphenomorphus* spp.) and night skinks (*Eremiascincus* spp.). Of the snakes recorded, pit vipers such as *Cryptelytrops insularis* amounted to 25% of all the snakes found.

Trainor *et al*. (2008) noted that 262 bird species are known for Timor-Leste, and of these, 169 are considered resident, 76 regular migrants and 17 vagrants. Up until 1980, 24 ornithological surveys or reports are listed for Timor Island (White and Bruce 1986). Recent studies by Richard Noske (Noske 1994, 1996, 1997, Noske and Saleh 1996) have added many new birds to the expected species list. Extensive tropical forests in Lautem district have been the prime target of recent fieldwork Trainor *et al*. (2008).

The mammal fauna of Timor-Leste is dominated by Asian families with at least 52 mammalian species potentially occurring, of which about one-third are introduced (Trainor *et al*. 2008). Remarkably, only four native terrestrial mammals have been recorded including the Timor Shrew (*Crocidura tenuis*), Sunda shrew (*Crocidura maxi*), Timor rat (*Rattus timoriensis*) and Ricefield Rat (*Rattus argentiventer*) Trainor *et al*. (2008). Timor once had a native rat fauna including giant rats, but these may have become extinct after the introduction of mammals associated with human settlement during the last 1,000 to 7,000 years (Glover 1986).

There have been relatively few bat surveys on the island of Timor, and the fauna is not yet completely described. The earliest and still the most comprehensive summary of the bats of Timor is that of Goodwin (1979), who conducted field surveys, an extensive examination of museum collections and a review of the literature to derive a list of taxa with their current taxonomy. Based on Goodwin's field surveys and taxonomic examinations, there are 22 species known from Timor, 11 of which he added (Goodwin 1979).

3. METHOD

3.1 Survey Areas

An investigation of flora and vegetation communities and fauna was completed at the proposed Suai supply base, industrial estate, Nova Suai, Suai Airport upgrade, and two crocodile reserves (We Dare and We Matan Bua Oan).

3.2 Timing of Surveys

A five day field survey was made from 9 to 13 December, 2011, and a second three day field survey from 6 to 8 February, 2012.

3.3 Flora and Vegetation

3.3.1 Desktop Review – IUCN

Before fieldwork was undertaken, data from a detailed desktop review of historical information and past surveys undertaken near the study area was compiled into a list of flora, vegetation and fauna species present.

The IUCN Red List of Threatened Species was used for this desktop review, identifying the conservation status of some species in Timor-Leste that have been assessed by IUCN.

The IUCN Red List is recognised globally as being the most comprehensive tool for evaluating the conservation status of plant and animal species, not only allocating a category (out of nine) for relative risk of extinction but also their distribution. Conservation can then be targeted towards those species at higher risk of extinction. A full description and list of IUCN categories is available in **Appendix 1**.

The flora and vegetation assessment comprised of a desktop review to collate historical data and/or knowledge, previous opportunistic flora collections and delineation and characterisation of the known range of vegetation communities present in the study area. The flora and vegetation desktop assessment included:

- Review of all available and current information; and
- IUCN Red List search.

3.3.2 Vegetation Survey

A broad assessment of plant communities and their distribution, floristic composition and structure was undertaken. Vegetation communities were sampled opportunistically within each study area at observation points. Information regarding dominant species present and the physical characteristics

at each site was recorded. It was not possible to complete a quadrat sampling design in the time available for surveys.

Vegetation descriptions used for the Suai development area were adapted from those developed by Cowie (2006, 2007) in the Lautem district on the east coast of Timor-Leste, approximately 100 to 200 km from the study area. Descriptions were based on vegetation structure and dominant species composition.

3.3.3 Flora Survey

The overall objectives of the flora and vegetation assessment within the Suai development area include:

- Identify species of potential conservation significance (IUCN Red List);
- Identify commercial timber and food crops (teak, coconuts, bananas, sandalwood);
- Collect and photograph dominant species;
- Describe broad vegetation units – remnant areas of primary and secondary forest, coastal, mangroves, agricultural, riparian; and
- Determine any significant impacts to species or vegetation communities of conservation significance.

Within the Suai development area more emphasis was given to the flora survey than the vegetation survey. This approach was adopted by Cowie (2006, 2007) for the east coast of Timor-Leste and allows for the collection of preliminary baseline information for the project in the absence of a baseline survey. Adequate baseline flora data is a prerequisite to completing meaningful vegetation survey work. This also provided more time to focus on the assessment of threatened species and economically important species.

The flora survey aimed to record the diversity of flora species in the Suai development area, with a focus on the common and dominant species and on species of conservation and economic importance. There was no emphasis placed on quantitative sampling or recording structural attributes. Where known, the threatened status or weed status was recorded, as well as local names in Tetum.

Specimens were collected from various plant life forms including trees, shrubs, herbaceous species, vines, grasses and sedges, ferns, and epiphytes (non-ferns). Photographs were taken where possible of live specimens in the field or of fresh pressed specimens.

All collected plant specimens were pressed for several days in field presses and then preserved for the short term, using a technique described by Forman and Bridson (1989) to suit the wet tropical conditions experienced at the time of survey. This technique involved pressing specimens between folds of newspaper which were then tied in bundles with string and placed in heavy duty plastic bags to which sufficient 70% ethanol was added to wet newspaper. The top of the bag was folded over and sealed with adhesive tape, and then placed in a second bag to reduce drying. On return to Australia

the plant specimens were submitted for Gamma irradiation to meet Australian Quarantine Inspection Services (AQIS) regulations. This process took approximately four weeks for the first collection of plants (December 23, 2011 to January 23, 2012) and three weeks for the second collection (February 16, 2012 to March 8, 2012). On completion of treatment plant specimens were submitted to the Northern Territory herbarium where they were returned to normal plant presses and dried at 50^{o}C.

Flora identifications were completed by Ian Cowie of the Northern Territory (NT) Herbarium who has considerable expertise with the flora of east Timor-Leste and Northern Australia. The NT Herbarium houses a reference collection of Timor-Leste flora collected by Cowie (2006, 2007)[1].

3.4 Fauna

3.4.1 Desktop Review

The terrestrial vertebrate fauna assessment also comprised a desktop review to collate historical knowledge on fauna species and fauna habitat present. A comprehensive inventory of relevant fauna was compiled, using as many sources as possible. The fauna desktop assessment included the following:

- Review of all available and current information; and
- IUCN Red List search.

Additional locally relevant information was sourced from relevant reference texts and important key stakeholders.

The purpose of the desktop review was to gather background information on the study area and the fauna that it may support. This involved a search of the following sources:

- Birdlife International database search;
- IUCN Red List expected species search tool; and
- Previous vertebrate fauna surveys (e.g. previous biological surveys / research).

Collectively, these sources were used to compile a list of species that have been previously recorded in the region and specifically within the vicinity of the study area. This list will invariably include some species that do not occur in the study area, because some fauna have a limited or patchy distribution, high level of habitat specificity, are locally extinct or were erroneously identified in previous surveys. Some records were excluded from this list, such as extinct species.

3.4.2 Field Survey

The primary objectives of the terrestrial fauna assessment were to:

- Validate the accuracy of desktop reviews;

[1] A number of the flora collected also occurs in Northern Australia.

- Ground-truth the extent and condition of fauna habitat types present;
- Identify species of potential conservation significance (IUCN Red List);
- Further delineate and characterise the species and fauna habitat types present and potentially present at each site;
- Provide additional information for any subsequent clearing requirements; and
- Determine any significant impacts to species of conservation significance.

The fauna field methodology comprised the following:

- Selection of field sites from aerial photography;
- A description of fauna habitat at each site;
- Map the extents of each fauna habitat type;
- Conduct Anabat microbat recordings;
- Opportunistic observations of vertebrate fauna species present; and
- Assessment of the site's potential to house species of conservation significance.

Broad fauna habitats were identified based on vegetation associations and known landforms. These fauna habitats were then assessed for their potential to support fauna, in particular species of conservation significance. Habitats were assessed on the basis of their complexity, the presence of microhabitats (including significant trees with hollows, loose bark, fallen hollow logs and leaf litter) and other habitat features likely to provide foraging opportunities and/or shelter for fauna, such as water bodies and rocky outcrops (Figure 1-1).

Acoustic ultrahigh frequency equipment was used to record the presence of microbats. Acoustic Anabat recording equipment was placed in the study area to achieve a broad coverage but also designed to target potential maternal and breeding roosts. The analysis of ultrasonic echolocation calls of bat species with bat recording or other acoustic equipment is a very convenient and cost-effective method to determine the presence of bat species at a particular site. Often many more species can be identified at a greater number of sites using passive acoustic recording equipment than by trapping alone such as harp traps and mist nets (Figure 1-1).

A significant effort in diurnal searching was undertaken in the study area. Active searching for ground-dwelling reptiles and mammals usually involves searching the particular microhabitats present and includes the following:

- Searching and recording scats, tracks and other traces;
- Digging up burrows;
- Turning over rock and logs;
- Splitting fallen timber;

- Raking soil and leaf litter;
- Peeling off bark; and
- Searching rocky habitats, in cracks and caves, around water bodies and holes in fence posts.

In addition, call play back was undertaken for avian species which are known to respond to species-specific calls for active identification in the study area. This technique is often used to allow positive identification of species that can be overlooked during surveys or have cryptic behaviour.

3.4.3 Nomenclature

Naming conventions for amphibians and reptiles are based on the paper by Kaiser *et al.* (2011). For bird species, BirdLife International (2012) is used, with the following exceptions: the distinctive *capistratus* race of rainbow lorikeet *Trichoglossus haematodus* is recognised as a full species, as is the marigold lorikeet (*T. capistratus*) and the distinctive Timor race of pheasant coucal is recognised as a full species, Timor coucal (*Centropus mui*). The nomenclature for mammals follows the adopted taxonomy contained in the IUCN Red List. Local Tetum names were included where known.

3.5 Limitations

3.5.1 Flora and Vegetation

A broad approach was taken to assess flora and vegetation within the Suai development area to accommodate the limited time frame available for field survey. Flora and vegetation were assessed together to maximise available time at each site. An emphasis was placed on vegetation structure and dominant species composition.

Detailed mapping of vegetation types was not undertaken during these surveys. Extensive ground-truthing, detailed inventories from plots/quadrats and high resolution aerial photography is required for vegetation mapping. It has previously been documented that the classification and field recognition of closed canopy forest formations (rainforest and monsoon) is problematic (Cowie 2006).

An exhaustive species inventory of each site could not be prepared in the limited survey period, and as such effort was focused on recording dominant species and plants of interest. Less emphasis was placed on ferns, herbs and other non-dominant flora. Lichens, bryophytes (mosses, liverworts), epiphytes and parasitic plants occurring high up in the tree canopy were not included in the survey.

Flora surveys are ideally undertaken at the best time of year for detecting the most plant species. In areas with highly seasonal rainfall distribution this is at the end of the wet season. Field work at other times of the year is also needed to detect the full range of species. The wet season is not the optimal sampling period for many plant species, and is likely to have limited the number of species recorded at the site.

3.5.2 Fauna

The significant lack of fauna baseline data for Timor-Leste makes the assessment of project impacts on population, distribution and ecological occurrences of fauna problematic. Fauna surveys are ideally undertaken throughout the year, across seasons, to be able to identify a full range of species. Conducting a study in the wet season may have impacted on the completeness of results. The length of field survey may also impact results, with eight days being insufficient to extensively survey the project area and accurately identify all species that potentially occur.

4. RESULTS

4.1 Flora and Vegetation

4.1.1 Vegetation Communities

General Overview

A Global Forest Resources Assessment was completed for Timor-Leste in 2010 by the Forestry Department of the Food and Agriculture Organization (FAO) of the United Nations (FRA 2010). This report states that no consistent and agreed land and vegetation classification system had been developed for the country, and therefore a set of classifications and definitions were created (Table 4-1).

Cowie (2006) noted that there is no structural/floristic classification derived from vegetation data collected in any region of Timor-Leste. Plant communities recognised by Cowie (2006) were regarded as preliminary and were based on field observations and limited quadrat data from few locations without classification or ordination of quadrat data. Importantly, Cowie (2006) notes that many plant communities intergrade floristically and structurally and the boundaries and distinctions between these are arbitrary and difficult to determine in the field.

Table 4-1 Vegetation classifications and definitions developed for Timor-Leste (FRA 2010)

National Class	Definition		Size of Area (ha)
Lowland Forest <1000 m asl	Forest defined as trees and shrubs > 30% tree canopy cover Occurs below 1000 m asl	Moist lowland forest - dense	261,694
		Moist lowland forest - sparse	174,992
		Dry lowland forest - mainly one species	135,720
		Dry lowland forest - mixed composition	189,080
Highland Forest 1000-2000 m asl		Moist mixed forest	65,103
		Single species forest	2,356

National Class	Definition		Size of Area (ha)
Montane Forest > 2000 m asl			2,611
Wetland Forest	Wetland forests are identified with drainage and slope. Normally flat poorly drained wetland areas or basin type features will contain wetland vegetation and/or related land uses.	Swamp forest	269
		Palm forest	NA
Coastal Forest	Includes three subclasses (i) Mangrove forest; (ii) Dune forests – mixed species; (iii) Coastal forest – single species	Mangrove forest	19,709
		Dune forests – mixed species	NA
		Coastal forest – single species	NA
Man-made Forest		Teak Other commercial plantings, woodlots	918

Suai Development Area

The south coast of Timor-Leste features a broad coastal plain with hills that extend to the coastline at intervals. Rivers are numerous and mainly without water, and there are large drainage areas between rivers. Soil erosion is high, especially within drainage basins.

The Suai Supply base study area lies between two major rivers on a broad coastal plain and is intersected by several predominantly dry rivers and numerous drainage channels. Low lying areas between the rivers and drainage channels are frequently inundated and muddy during the wet season, a period from October to February as indicated by local sources. There are also several coastal lagoon areas at inlets, two of which are within the proposed crocodile reserve areas (We Dare and We Matan Bua Oan). The We Dare area is located near the center of the proposed Suai supply

base development area, extending inland from the coastline and covers approximately 45 ha. The We Matan Bua Oan area is located inside the north-east boundary of the Suai development area (adjacent to the Rio Raiketan) and covers approximately 10 ha. Nova Suai and the upgrade works to Suai Airport will be located within 3 km from the coastline and also lie on the broad coastal plain.

Natural vegetation within the Suai development area exists primarily as narrow bands of open coastal forest with small areas of mangrove and riparian vegetation. The coastal plain has largely been cleared in association with swidden agriculture, sandalwood harvesting, plantation estates and timber plantations. Remnant vegetation exists as highly fragmented and secondary communities.

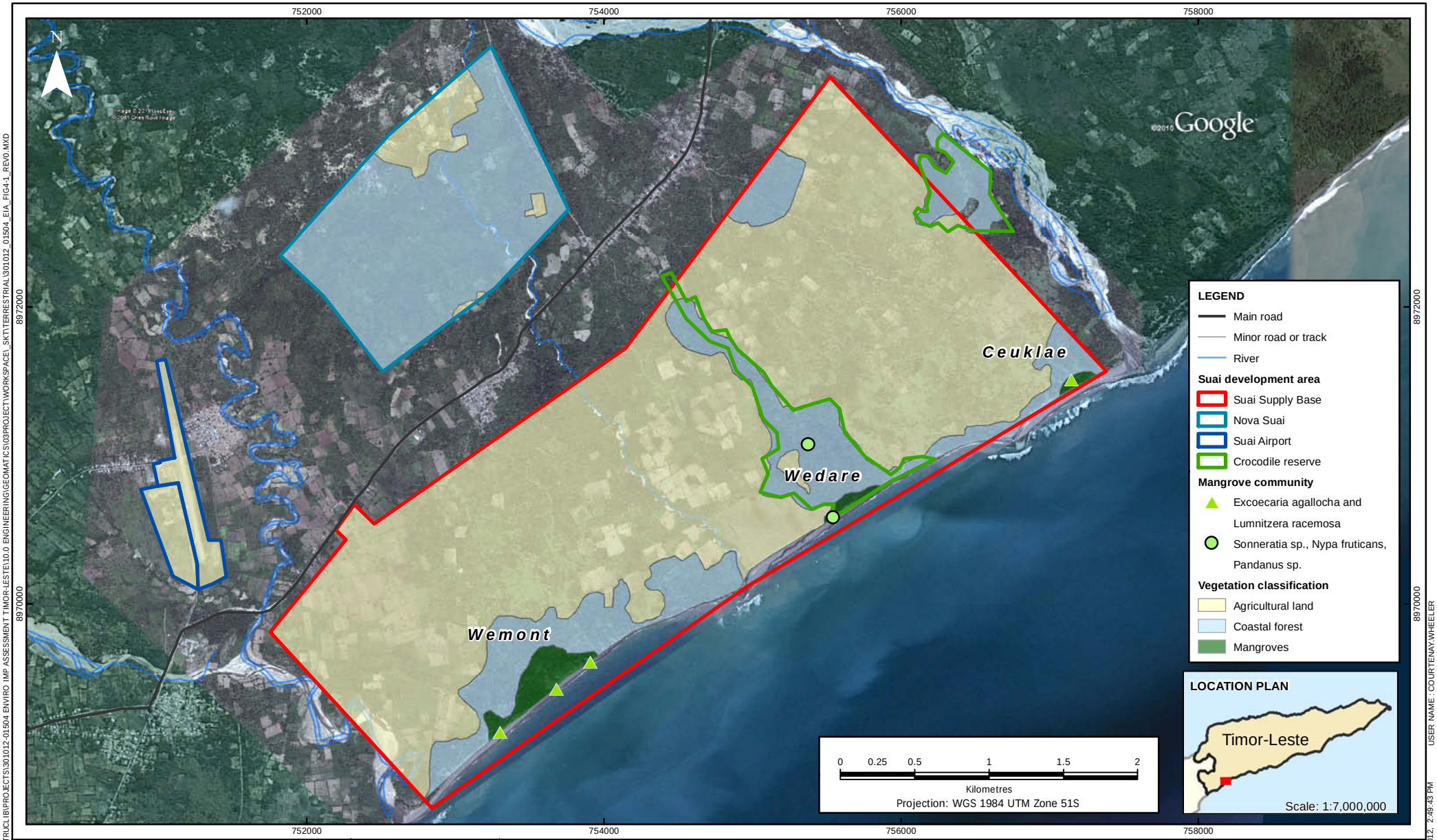
The majority of vegetation within the Suai development area has been cleared for villages and associated agriculture along with small teak and coconut plantations. Remnant vegetation exists in strips along drainage channels and isolated patches that are no larger than 20 ha. Aerial imagery indicates that less than 20% of the study area is covered by remnant secondary vegetation. Most of the understory within remnant vegetation and agricultural land is dominated by invasive weeds, particularly Siam weed *(Chromolaena odorata)* and cogon grass (*Imperata cylindrica*). Grasses are extensively grazed by domestic animals such as cattle, water buffalo, pigs and goats.

There is no remnant vegetation within the Suai Airport study area, and the land is highly disturbed and covered with invasive shrubby weeds including Siam weed, crown flower (*Calotropis gigantea*) and Bellyache bush (*Jatropha gossypifolia*) and thickets of prickly Acacia (*Vachellia nilotica*) trees (Plate 4-1). This area is used for cattle grazing.

Vegetation communities in the Suai development area can be described as mixed coastal vegetation, with small communities of riparian and mangrove vegetation. Vegetation community distribution was broadly mapped and is shown in Figure 4-1.

Plate 4-1 Airport

Plate 4-2 Coastal Vegetation



LOCATION: \\PERWORFIL1\INFSTRUCL\IB\PROJECTS\301012-01504 ENVIRO IMP ASSESSMENT TIMOR-LESTE\10.0 ENGINEERING\GEOMATICS\03PROJECT\WORKSPACE_SKT\TERRESTRIAL\301012_01504_EIA_FIG4-1_REV0.MXD

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NOTES:
This map consists of:
1. Imagery Suai: SRTM (2011)
2. Imagery: Google Earth (2010)
3. Rivers: GIGTimorLeste (2010)
4. Roads: DivaGIS (2010)

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WorleyParsons resources & energy

TIMOR GAP, E.P. Timor Gas & Petróleo

REPUBLICA DEMOCRATICA DE TIMOR-LESTE
SECRETARIA DE ESTADO DOS RECURSOS NATURAIS

OneWay to zero harm

TASI MANE PROJECT - SUAI SUPPLY BASE
TERRESTRIAL ENVIRONMENT TECHNICAL REPORT

Figure 4-1
Suai study area vegetation mapping

Coastal Vegetation

Three main types of coastal vegetation are commonly recognised in the Melasian regions; *Pes-caprae* formation, Barringtonia formation and vegetation of rocky shores (Whistler 1987). The work by Monk *et al*. (1997) regards coastal vegetation as open forest and doesn't define coastal forest. Cowie (2006) interprets coastal vegetation on the east coast of Timor-Leste as strand vegetation and the associated non-closed forest formations, excluding mangroves.

Barringtonia formation occurs on sandy soils and is a common beach forest/mangrove along south Timor coastline; however, no *Barringtonia* vegetation was observed in the Suai development area. No rocky shore vegetation occurred at any of the study areas.

Pes-caprae formation occurs along sandy foreshores where sand is actively deposited or eroded, and is typical near lagoons and in areas of low nutrients and high salt (Monk *et al*. 1997). Pes-caprae is described as an open community of low sand-binding herbs, trailing vines, grasses and sedges including *Ipomoea pes-caprae* and *Spinifex longifolius* or *S. littoreus.* Within the area of the Suai development area, the *Pes-caprae* formation is highly degraded and largely disturbed by cattle grazing and water erosion. The characteristic *Ipomoea pes-caprae* and *Spinifex littoreus* were present on the beach within the crocodile reserve area. The weed *Calotropis gigantea* was prevalent.

Coastal vegetation within the Suai supply base is structurally diverse and comprises a mosaic of *Imperata cylindrica* grassland, strand vegetation, shrubland and open forest dominated by *Borassus flabellifer* and *Corypha utan* palms and *Schleichera oleosa*. Other common tree species within the open forest were *Casuarina* sp. affin. *junghuhniana, Albizia saman, Ficus variegata, Alstonia scholaris, Nauclea orientalis, Peltophorum pterocarpum, Albizia lebbeckoides, Terminalia catappa,* and *Diospyros montana.* Common shrub species include *Tabernaemontana pandacaqui, Ziziphus timoriensis, Ziziphus mauritiana* and *Gmelina elliptica. Fimbristylis cymosa* sedges and *Christella arida* ferns occur in low lying drainage areas.

Also present within the mixed coastal forest were thickets of invasive tree species such as coffee bush (*Leucaena leucocephala*) and prickly Acacia (*Vachellia nilotica)* and introduced fruit and timber trees including candlenut (*Aleurites moluccana*), tamarind (*Tamarindus indicus*), teak (*Tectona grandis*), *Stercula foetida,* mango (*Mangifera indica*), breadfruit (*Artocarpus altilis*) and jackfruit (*Artocarpus heterophyllus*). There are also food plants including Timor Cherry (*Muntingia calabura*). The majority of tree species appear to be deciduous in the dry season, apart from palms.

Sandy beaches are bordered with narrow strips of strand vegetation and common species include *Borassus flabellifer, Corypha utan*, *Pandanus tectorius*, *Hibiscus tiliaceous* and *Thespesia populnea*. In some places, dense *Borassus flabellifer* palms fringe the coast (Plate 4-2). Scattered *Borassus flabellifer, Pandanus* spp. and *Casuarina* sp. affin. *junghuhniana* trees commonly occur on very limited areas of sandy substrates along the south coast.

The vegetation at Nova Suai is predominantly open coastal forest with very little understory and a heavy infestation of Siam Weed and Bellyache bush (Plate 4-3). Dominant species include *Barossus flabellifer*, *Alstonia scholaris* (ai-roti), *Schleichera oleosa* (ai-dak), *Senna timorensis* (ai-cachote) and Tamarind to 20 m in height over a shrub understory dominated by *Tabernaemontana pandacaqui*. The vegetation is deciduous with the majority of the canopy losing leaves at the completion of the wet season. Soils are muddy during the wet season and prone to flooding.

Riparian Vegetation

Several large dry river beds intersect the Suai supply base study area. The majority of river banks are eroded by turbulent water flow and cattle trampling creating a loss of vegetation. Riparian vegetation included Bamboo (*Bambusa blumeana*), occasional *Pterocarpus indicus*, *Albizia lebbeckoides* and infestations of Siam weed (Plate 4-4). Often gardens and paths were located adjacent to river banks. Riparian vegetation is predominantly deciduous during the dry season.

Mangroves

In the Suai supply base area several mangrove communities were present on the beach and surrounding coastal lagoons at river outlets.

Excoecaria agallocha (ai-tano) was the dominant mangrove species occurring in stands on beach sand and in muddy lagoons with freshwater input adjacent to the beach. *Excoecaria agallocha* is a multi-stemmed tree or shrub growing to 15m in height and is characterised by exposed cable roots and leaves which turn red and orange before falling in the dry season. *Lumnitzera racemosa* (ai-biku) was the second dominant mangrove species, and also occurred on both beach sand and muddy lagoons. *Lumnitzera racemosa* is a multi-stemmed evergreen tree or shrub growing to 15m in height.

A large *Excoecaria agallocha* and *Lumnitzera racemosa* mangrove forest community was recorded on a large inlet/lagoon with freshwater input in an area known locally as ‘Wemout’. This area was considered to be an important crocodile habitat by local people. Epiphytes including *Drynaria quercifolia* (basket fern), *Pyrrosia longifolia* (fern) and *Dischidia major* (rattle skulls) were present on large trees. This mangrove community merged into coastal forest further inland. Other tree species included *Cathormion umbellatum* and *Peltophorum pterocarpum.*

A small area of *Excoecaria agallocha* trees occurred on the exposed coastline adjacent to the coastal forest. This area is subject to land and river runoff, and is unprotected from high tides and storm surges. These trees appeared to be declining and those close to the high tide mark have died, possibly due to salt water toxicity. A number of trees had been felled for timber.

Rhizophora stylosa propagules (hypocotyl) were found on the beach, and this species may occur within the area.

The crocodile reserve site is located within the boundary of the Suai supply base site in an area known locally as ‘We Dare’. The vegetation within this area is relatively undisturbed deciduous coastal forest and mangrove community. The We Dare area includes a spring fed creek which drains into an area of mangroves on a lagoon adjacent to the beach. Mangrove vegetation includes

Excoecaria agallocha, Sonneratia alba, Pandanus sp., *Nypa fruticosa* (Mangrove Palm) and *Hibiscus tiliaceus* (Plate 4-5).

Sonneratia alba (White-flowered Apple Mangrove) is a large evergreen tree growing to 20 m in height with cone-shaped pneumatophores up to 1.5 m tall. *Nypa fruticans* (Mangrove Palm) is a trunkless palm that grows to 10 m in height and occurs in river dominated estuaries. The vegetation communities recorded in the Suai development area are presented below in Table 4-2.

Plate 4-3 Nova Suai

Plate 4-4 Riparian Vegetation

Table 4-2 Vegetation types recorded in the Suai development areas

Vegetation Formation (Monk *et al*. 1997)	Vegetation Formation (Cowie 2006)	Presence in project areas	Biological Features	Inferred Distribution	Current Threats to Vegetation
Coastal Forest	Coastal and strand vegetation	Suai supply base, Nova Suai		Coastal plain	Intensive grazing by cattle, conversion for agriculture, weed invasion
Tidal Forest	Mangroves	Suai supply base, crocodile reserves	Refers to the habitat rather than a single entity. includes trees, shrubs, palm or ground fern	Small scattered areas, coastal lagoons	Fire wood harvesting
N/A		Suai supply base, Nova Suai, crocodile reserves	Riparian	Large rivers	Potentially conversion for rice, cattle grazing, weeds

Descriptions adapted from Monk *et al*. 1997 and Cowie 2006

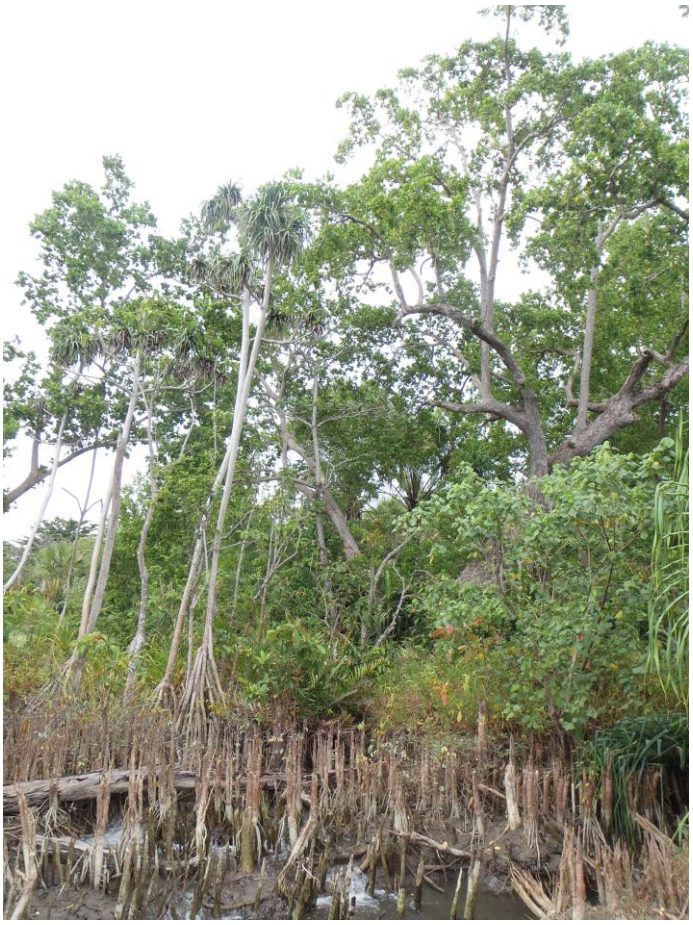

Plate 4-5 Mangroves

Plate 4-6 Corn Garden

Agriculture

The traditional slash and burn (swidden) system of agriculture is used in Timor-Leste. Forest is cleared for cultivation, cropped for several years and then followed by fallow periods to allow for natural regeneration. Boundary markers are used around plots of land to indicate land ownership.

Cultivated soils appear to be nutrient-poor with little remaining topsoil. Run-off of topsoil into rivers and the ocean is high. The soil is generally shallow and susceptible to landslides and flooding (Oxfam 2003). The vulnerability to erosion is enhanced by highly uneven and erratic rainfall. Large river systems flow onto the coastal plain.

The majority of the area within the Suai development area comprised agricultural land used for subsistence farming. Few marketable cash crops were encountered. Gardens appeared to be in fallow over the wet season. The primary crops grown are corn/ maize, cassava, peanuts, long beans, papaya, watermelon and bananas (Plate 4-6). Gardens in the study areas supported weeds and secondary species. A large area established for rice cultivation within the Suai supply base site is no longer used. Small plantations or estates of coconuts, bananas, and occasionally mango were present in the Suai development area. Grazing by water buffalo, cattle, goats and pigs is widespread in the Suai development area.

Teak Plantations/Woodlots

A large area of teak plantation and several large agricultural gardens occur in the Nova Suai study area (Plate 4-7). Other timber trees recorded within the study area include *Senna timorensis* (ai-cachote), *Pterocarpus indicus* (ai-na), *Gemelina arborea* (Malaysian teak), *Senna siamea* [ai-johar] and ai-lantoro. Large gardens were predominantly planted with corn crops with minor crops of papaya, basil, cassava and coconut.

4.1.2 Vegetation of Conservation Interest

In the Suai supply base area several mangrove communities were present on the beach and surrounding coastal lagoons at river outlets (locations shown in Figure 4-1).

Mangroves are of particular conservation interest in the Suai development area for their economic and conservation benefits; however they are also cut for timber. Mangroves stabilize soils, primarily in coastal and estuarine communities and reduce coastal and soil erosion, and also provide important marine and fauna habitat. Loss of mangrove habitat affects the conservation status of Timor-Leste and also the economic gain by reducing land available for agriculture and forestry.

The mangroves are listed under the UNTAET Regulation No. 2000/19, section 5 ‘Wetlands and Mangroves’, prohibiting any destruction of this vegetation type. Exploitation still occurs, however.

Plate 4-7 Teak estate

4.1.3 Flora

These results focus on the dominant flora species, conservation significant flora, economically important flora species and weed species.Local Tetum names were recorded where possible, and this list of names is considered indicative only as there were several inconsistences. In some cases the usage of the same name varied between local guides and regions, and several species or plant forms were grouped together under one name.

A total of 201 species were identified from collected material and photographs and a species list for the Suai development area is presented in Appendix 3.

Two species listed on the IUCN Red List as Vulnerable were recorded; rosewood (*Pterocarpus indicus)* and sandalwood (*Santalum album*). A large number of species recorded in the Suai development area have a widespread distribution in the tropics. Several of these are invasive weed species and discussed in detail below, and several are considered to be naturalized species.

Some large fruited species that are bird and bat attracting were recorded; including *Cerbera manghas*, *Ficus variegata* and other *Ficus* spp.

4.1.4 Species of Conservation Interest

The IUCN Red List of Threatened Species does not list any Critically Endangered, Endangered or Vulnerable plant species specifically for the region of Timor-Leste (IUCN 2011). However, there are previous records of three Vulnerable species from the east coast of Timor-Leste; *Intsia bijuga*, *Pterocarpus indicus* and *Santalum album* (Cowie 2006, 2007). Two of these were recorded in the Suai development area during the field surveys, *Pterocarpus indicus* and *Santalum album.* There are 36 plant species on the IUCN Red List that are listed as being of Least Concern for Timor-Leste, and these are considered to have a low risk of extinction (Appendix 2). None of these were recorded in the Suai development area during the field surveys.

Within the broad region of Indonesia the following numbers of plant species are listed on the IUCN Red List: 207 Vulnerable, 86 Near Threatened, 78 Endangered and 115 Critically Endangered. It is likely that as more surveys are undertaken within Timor-Leste that more plant species will be listed specifically for the country.

Santalum album (sandalwood, Tetum ai-cameli*)* was present in very low numbers in Nova Suai as young trees only and not at the harvestable stage. Sandalwood is a highly sought after timber which has been overexploited for several centuries. By the beginning of the 1900s Sandalwood was brought close to extinction by Chinese and European traders (Sandlund *et al*. 2001). Further overexploitation occurred during Indonesian occupation during 1975 to 1999.

Pterocarpus indicus (rosewood, Tetum ai-na) was present within the Nova Suai site on the banks of a dry river bed. It is a tall timber species, reaching 25 to 35 m, is a briefly deciduous tree and can be useful for soil stabilization and adding nitrogen to soil. It is a highly sought after timber and listed as an IUCN Red List vulnerable species. Described as a widespread tree found in lowland primary and

some secondary forest, native subpopulations have declined because of overexploitation of the timber and increasing general habitat loss. Cultivated subpopulations are widely distributed throughout the tropics.

Intsia bijuga (Moluccan ironwood) is a reasonably common tree of primary semi-evergreen rainforest, moist deciduous forest, and coastal forest.

Cowie (2006) also lists a further four species recorded on the east coast that may be considered threatened in Timor-Leste; *Antiaris toxicaria, Neoalsomitra podagrica, Carallia brachiate* and *Cycas rumphii.* The forest communities in which these species occur are under threat; deciduous forest, thorn forest and coastal forest. None of these species were recorded in the Suai development area.

Sheoak trees (*Casuarina* sp. aff. *junghuhniana)* occurring within the Suai development area in low numbers are thought to be an important habitat for the yellow-crested cockatoo. Previously these trees have been recorded occurring abundantly along the sandy beaches of south Timor (Monk *et al*. 1997) and able to grow on poor sandy soils.

A large patch of *Albizia saman* trees (ai-matan dukur) were recorded within Suai supply base area in place known locally as ‘To’os ai-lok laran’.

4.1.5 Species of Economic Importance

Within the Suai development area the species listed in Table 4-3 are considered to have economic or local importance either as timber or food crops. Two of these species, rosewood (*Pterocarpus indicus)* and *s*andalwood (*Santalum album),* have been discussed in the previous section.

Small plantations or estates of coconuts, bananas, and occasionally mangos were present in the Suai development area. The tenureship of trees within estates may be external to local villages. Occasional breadfruit, jackfruit, cashew or cinnamon trees were encountered, and appear to be individually owned and marked accordingly.

The Suai supply base is located near some State Forest Plantations in the Covalima district and some seedlings may have been made available and planted within the Suai development area in previous government forestry initiatives. The following species were planted in nearby areas; *Tectona grandis* (teak), *Gmelina arborea*, *Senna siamea* (johar), *Albizzia chinensis* (sengon), *Pterocarpus* sp. (kayu merah), *Swietenia* sp. (mahogany), *Santalum album* (sandalwood), *Aleurites moluccana* (kemiri) and *Anacardium occidentale* (Cashew).

Table 4-3 Species of economic interest and/or local importance recorded in the Suai development area

Common Name	Scientific Name	Tetum Name	Use/Importance
Coconut	*Cocus nucifera*	nú	Food
Cashew	*Anacardium occidentale*	caijus	Food
Banana	*Musa spp.*	hudi	Food
Breadfruit	*Artocarpus altilis*	kulu modo	Food
Mango	*Mangifera spp.*	has	Food
Candlenut	*Aleurites moluccana*	kemiri or cami	Food
Cinnamon	*Cinnamomum sp.*	ai-canela	Spice
Teak	*Tectonia grandis*	ai-teka	Timber
Gmelina	*Gmelina arborea*	gmelina, ai-teka Malaysia	Timber
Cassod tree	*Senna siamea*	ai-johar	Timber
Sandalwood	*Santalum album*	ai-cameli	Timber
Rosewood, Narra	*Pterocarpus indicus*	ai-na	Timber
Mangrove trumpet tree	*Dolichandrone spathacea*	ai-sirian	Timber

4.1.6 Weeds / Invasive Species

Weeds are a major component of secondary vegetation in the Suai development area, and many are likely to have spread through intensive grazing. The major weed species recorded are listed in Table 4-4. Siam weed *(Chromolaena odorata*), cogon grass (*Imperata cylindrica*) and coffee bush (*Leucaena leucocephala*) are listed on the IUCN's Global Invasive Species Database (GISD) of the 100 worst invasive species.

Siam weed is a perennial shrub in the Asteraceae family which forms dense tangled thickets up to 2m tall. It has an extremely fast growth rate and prolific seed production (CRC Weed Management 2003). Siam weed was the most widespread weed throughout the Suai development area. Originally native to Central and South America, it is highly invasive and is considered to be one of the world's worst tropical weeds. It is estimated that Siam weed covers more land than any other plant species in Timor-Leste (Cowie 2007), and affects about one-fifth of all cropland (World Bank 2009). Siam weed invades secondary vegetation and agricultural land and its spread may be facilitated by fire.

Table 4-4 Major weed species identified in the Suai development area

Weed Species	Common Name	Tetum Name	Location
Chromolaena odorata	Siam weed	ai-funanmutik	all
Imperata cylindrica	Cogon grass	pae	all
Leucaena leucocephala	Coffee bush	ai-café	all
Lantana camara	Lantana	ai-funan meak	Suai supply base
Vachellia nilotica	prickly *Acacia*	bakuro malae, ai-tarak	Suai supply base, Suai Airstrip
Chrysopogon aciculatus	Golden false beardgrass	du'ut	all
Jatropha gossypifolia	Bellyache bush	miro	all
Calotropis gigantea	Crown flower	fuka	all
Zizyphus mauritiana	Jujube, Chinese Apple	Ai-lok	all

Cogon grass is considered to be one of the ten worst weeds in the world. This species is of concern as it displaces native plant and animal species. It has an extensive rhizome system and adapts to poor soils.

Coffee bush is a fast growing tree that was widely introduced as a fodder plant and has become an aggressive invader of agricultural and disturbed areas, often coastal and riverine habitats, in many tropical locations (GISD). It can form dense thickets and may threaten endemic species of conservation concern in some areas (Smith 1995). It was originally native to Central America.

Bellyache bush was widespread throughout all development areas and a second weed species of the same genus, *Jatropha curcas,* was recorded infrequently in the Suai development area. *Jatropha* spp. form erect perennial shrubs with thick stems and have small red flowers clustered on stalks, oblong fruit capsules and toxic seeds. Shrubs form dense thickets which out-compete other species (Smith 1995).

Calotropis gigantea is a shrub growing to 4m in the *Asclepiadaceae* family, which has clusters of waxy white or mauve coloured flowers. It is a common weed of roadsides, disturbed areas, sandy beaches, water courses and river flats and thrives on poor soils. It is particularly widespread in coastal vegetation.

Prickly Acacia (*Vachellia nilotica)* is a fast growing species that forms thickets and may displace native species (Smith 1995).

Chrysopogon aciculatus is a rhizomatous perennial grass growing to 0.4m in height. This grass was widespread.

Lantana camara is a sprawling thicket-forming shrub growing to 5m in height. This plant is considered a major invasive weed in many habitats, although within the Suai development area Lantana is not widespread.

Zizyphus mauritiana is a spiny evergreen shrub growing to 15m in height, and is commonly found in tropical regions.

Several introduced flora species are now considered naturalized as they are widespread and not considered invasive weeds. *Passiflora foetida,* part of the *Passifloraceae* family, is a woody climber with cream-white-blue flowers and occurs in coastal areas and rivers. Tamarind (*Tamarindus indicus*) is a common tree species in secondary forest.

4.2 Fauna

4.2.1 Fauna Habitat

Currently the knowledge on the habitat requirements of Timor-Leste vertebrate fauna is lacking and most studies conducted have largely been focused on bird species. The level of knowledge on ground-dwelling species such as reptiles and mammals is minimal and therefore conducting an assessment for such species requirements is difficult. There is no baseline data to compare against and develop an understanding of regional representation. This therefore makes deducing possible impacts from development to population occurrences, distribution and ecological diversity problematic. Therefore, for this project a broad assessment approach was adopted, utilising the best possible information available.

An important information source was the Global Forest Resources Assessment for Timor-Leste in 2010 by the Forestry Department of the Food and Agriculture Organisation (FAO) of the United Nations (FRA 2010). Six vegetation classifications were recognised and can be used as analogues for vertebrate fauna habitats. As previously stated that no consistent and agreed land and vegetation classification system had previously been developed for the country, and therefore a set of classifications and definitions were created (Table 4-5).

Other significant vertebrate fauna work included Trainor *et al*. (2007). Although largely confined to avian species diversity and distribution, this study provided a detailed account of habitat types. Their classification included tall evergreen forest (tree height up to 40 m), semi-deciduous and tropical dry forest types (tree height up to 20 m), a patchy tropical Montane forest (elevations > 1,000 m), beach forest and coastal scrub, savanna woodland, open eucalyptus forest, shaded coffee plantations (> 600 m), swamps and swamp forests, rice paddies, and village land.

A compilation of previously identified vertebrate fauna habitats, plus those described for the project during the field survey, was developed for the current assessment. This process also took into consideration the study areas' location on the south coast of Timor-Leste and was correspondingly

revised. Table 4-5 describes the four categories of vertebrate fauna habitats that were present within the project's study areas and immediate vicinity.

Seven vertebrate fauna habitat assessments were conducted across the project study areas (Appendix 4).

Table 4-5 Vertebrate fauna habitat types developed for the Tasi Mane Timor-Leste project, relevant for Suai development area.

Fauna Habitat Type	Vegetation	Study Area
Deciduous Woodland / Forest	Woodland defined as trees and shrubs < 30% tree canopy cover	Suai
Coastal	Includes three subclasses (i) Mangrove forest; (ii) Dune forests – mixed species; (iii) Coastal dunes and reef platforms	Suai
Riparian	Includes drainage lines (major and minor), drainage basins, creek lines and water catchments; includes associated vegetated banks.	Suai
Swidden Agriculture	Includes 'man made' plantations and associated fringing vegetation and habitat	Suai

4.2.2 Fauna Assemblages

General

Fauna assemblages were collated from the desktop review. Many of the species identified from the desktop assessment are unlikely to occur in the study areas on a regular basis since the desktop addressed a large area encompassing a wide range of habitats (Appendix 5).

Within the Suai development area 68 species of vertebrate fauna were recorded, and this includes two species of amphibians, seven species of reptiles, 48 species of birds and 11 species of mammals

Amphibians

The two amphibians identified within the Suai development area were the Common Indian Toad (*Duttaphrynus melanostictus*) and the Indian Bullfrog (*Fejervarya* sp.).

Table 4-6 Number of Species recorded for the Suai development area

Assemblage	Suai Development Area
Amphibians	2
Reptiles	7
Birds	48
Mammals	11
Total	**68**

Previous study results can be found in Appendix 5.

Reptiles

Reptiles identified in the Suai development area comprised seven species from five families including: tokay (*Gekko gecko*), Asian house gecko (*Hemidactylus frenatus*), East Indian brown mabuya (*Eutropis* cf. *multifasciata*), common wolf snake (*Lycodon capucinus*), and the saltwater crocodile (*Crocodylus porosus*).

Birds

A large number of birds were identified within the Suai development area, consisting of 20 families and 48 species. The most common species included the spotted dove (*Streptopelia chinensis*), the barred dove (*Geopelia maugei*) and the streak-breasted honeyeater (*Meliphaga reticulata*). The two most common families were the *Columbidae* (pigeons and doves) and the *Meliphagidae* (honeyeaters).

Mammals

Mammal species recorded in the Suai development area consisted of seven families and 11 different species, and included the domestic dog / dingo (*Canis familiaris*), domestic pig (*Sus scrofa*), bali cattle (*Bos javanicus*), domestic cattle (*Bos taurus*) and the domestic goat (*Capra hircus*).

Bats

Within the Suai development area four species of known bats were recorded, including the Canut's horseshoe bat (*Rhinolophus canuti)* which is listed as Vulnerable on the IUCN Red List, and the little long-fingered bat (*Miniopterus australis),* which is listed as being of Least Concern. A full report on survey results for bats is included in Appendix 6**.**

4.2.3 Conservation Significant Fauna

Species listed as Critically Endangered, Endangered, Vulnerable and Near Threatened on the IUCN Red List comprise species of conservation significance (Table 4-7). The lack of baseline data regarding the fauna of Timor-Leste suggests that conservation significant species which have not

been recorded could potentially be present. The full extent of results including all categorised species is described in Appendix 7**.**

In addition, Section three of the UNTAET Regulation No. 2000/19, states that 'All animals and plant species listed in Appendix I or Appendix II of the Convention on the International Trade in Endangered Species' (CITES)''shall mean a species of animal or plant at risk of extinction within East Timor'.

The desktop review identified 34 species of conservation significance potentially occur or have been previously recorded for Timor-Leste.

Five species of conservation significance were recorded in the study area: the yellow-crested cockatoo (*Cacatua sulphurea*), Canut's horseshoe bat (*Rhinolophus canuti timoriensis*), Beach thick-knee (*Esacus magnirostris*), Slaty Cuckoo Dove (*Turacoena modesta*) and Timor Bush-chat (*Saxicola gutturalis*).

Table 4-7 shows that two of the fauna species identified from desktop and field studies, one 'Possible', the Christmas Island Frigatebird, and one 'Recorded', yellow-crested cockatoo are also listed on CITES Appendices I or II and thus considered Endangered under Regulation 2000/19.

Table 4-7 Conservation significant species and their likelihood of occurring in the Suai development area

Species	Conservation Significance				Likelihood of Occurrence
	IUCN	Endemic	CITES	Introduced	
Mauremys reevesii Reeves' turtle (freshwater and land based species)	EN			x	Unlikely
Fregata andrewsi Christmas Island frigatebird	CR		App I		Possible
Esacus magnirostris Beach thick-knee	NT				Recorded
Charadrius peronii Malaysian plover	NT				Possible
Charadrius javanicus Javan plover	NT				Possible
Numenius madagascariensis Far eastern curlew	VU				Likely
Numenius arquata Eurasian curlew	VU				Likely
Limosa limosa Black-tailed godwit	NT				Likely
Calidris tenuirostris	VU				Likely

Species	Conservation Significance				Likelihood of Occurrence
	IUCN	Endemic	CITES	Introduced	
Great knot					
Limnodromus semipalmatus Asian dowitcher	NT				Likely
Turacoena modesta Slaty cuckoo-dove	NT				Recorded
Gallicolumba hoedtii Wetar ground-dove	EN				Possible
Treron psittaceus Timor green-pigeon	EN				Likely
Ducula rosacea Pink-headed imperial-pigeon	NT				Likely
Ducula cineracea Timor imperial-pigeon	EN				Unlikely
Cacatua sulphurea Yellow-crested cockatoo	CR		App I		Recorded
Psitteuteles iris Iris lorikeet	NT				Likely
Aprosmictus jonquillaceus Olive-shouldered parrot	NT				Likely
Todiramphus australasia	NT				Likely

Species	Conservation Significance				Likelihood of Occurrence
	IUCN	Endemic	CITES	Introduced	
Cinnamon-banded kingfisher					
Bradypterus timoriensis Timor bush-warbler	NT				Unlikely
Heleia muelleri Timor white-eye	NT	x			Possible
Ficedula timorensis Black-banded flycatcher	NT	x			Possible
Saxicola gutturalis Timor bushchat	NT				Recorded
Zoothera dohertyi Chestnut-backed thrush	NT				Unlikely
Zoothera peronii Orange-banded thrush	NT				Likely
Lonchura fuscata Timor sparrow	NT				Possible
Acerodon mackloti Sunda fruit bat	VU				Possible
Nyctimene keasti Keast's tube nosed fruit bat	VU				Unlikely
Pteropus temminckii	VU		App II		Unlikely

Species	Conservation Significance				Likelihood of Occurrence
	IUCN	Endemic	CITES	Introduced	
Temminick's flying-fox					
Pteropus vampyrus Large flying-fox	NT		App II		Possible
Rhinolophus canuti timoriensis Canut's horseshoe bat	VU				Recorded

The conservation significant IUCN Red Listed species recorded during this survey, including their locations, are detailed in Table 4-8.

Table 4-8 The conservation significant fauna recorded during survey work in the Suai development area

Common Name	Conservation Status	Location
Beach thick-knee	NT	Suai
Slaty cuckoo-dove	NT	Suai
yellow-crested cockatoo	CR	Suai
Timor bushchat	NT	Suai
Canut's horseshoe bat	VU	Suai

The yellow-crested cockatoo, listed as Critically Endangered on the IUCN Red List, was sighted in the Suai development area. Up to 11 individuals were recorded on five occasions within the Suai development area only. Generally this species was recorded foraging and roosting in Sheoak (*Casuarina* sp. affin. *junghuhniana*) as well as individuals seen flying overhead. It is categorized as Critically Endangered mainly due to unsustainable trapping for the caged bird trade in the late 20th century (BirdLife International 2012). Its home is usually between sea level – 1,000 m in tropical dry forest or woodland plantations and it was found widely in Wallacea until intensive trading commenced in the late 1970s (Trainor *et al*. 2008). Fewer than 5,000 birds are thought to still remain in the wild, with approximately 500 in Timor-Leste (Trainor *et al*. 2008). It has been found to sometimes depend on closed canopy primary forest; however, it has also been identified in areas of cleared land which highlights it's apparent capability of being flexible with habitat choice. The yellow-crested cockatoo's nesting habits rely on tree cavities with specific requirements, and they tend to use cracks or fissures in a trunk or branch, or a pre-existing nest-hole made by other species, usually in dead, snagged or rotting trees (BirdLife International 2012). The distribution and abundance of suitable nesting cavities may be an additional limiting factor on the distribution of the yellow-crested cockatoo.

Bats identified as species of conservation interest include two cave roosting horseshoe bats; the Timorese horseshoe bat (*Rhinolophus montanus*) and the Canut's horseshoe bat (*R. canuti timoriensis*). The Timorese horseshoe bat is listed as Data Deficient and the Canut's Horseshoe-bat is listed as Vulnerable on the IUCN Red List. In addition to these species, the possibility of some of the undescribed taxa discovered on recent surveys by Pavey and Milne (2004) and Armstrong (2007), namely *Pipistrellus* spp., may occur in the Suai development area.

The recording of the Timorese horseshoe bat is significant as it has only been recorded on two previous occasions; the site of the first collection near Lequi Mia, south of Ermera (7 to 8 individuals), and calls from the Ira Chaupiti watercourse on the southern side of the Paitchau Range. The Canut's horseshoe bat (*R. canuti*) was commonly encountered in the acoustic and trapping surveys of Pavey

and Milne (2004) and Armstrong (2007), but there is no information on how widespread this species is outside of the most forested areas in the east of Timor-Leste.

Conservation significant fauna, listed in Appendix 7 includes species distribution and ecology, their regional context and their likelihood of occurring in the Timor-Leste study areas.

4.2.4 Endemic Fauna

Timor-Leste lies in a biogeographic region known as Wallacea, which is predominately colonised with plants and animals from Asia and Australia. Due to the island's long isolation, endemism has reached exceptional levels (Trainor *et al*. 2008), with Timor having the highest rates of endemism recorded in Indonesia, at 10.3 % (Rhee *et al.* 2004). Endemism occurs especially for frogs (about 50% Timor-endemic), skinks (25%) and geckos (25%). Remarkably, only four native terrestrial mammals have been recorded including the Timor shrew (*Crocidura tenuis*), Sunda shrew (*Crocidura maxi*), Timor rat (*Rattus timoriensis*) and ricefield rat (*Rattus argentiventer*) Trainor *et al*. (2008).

5. DISCUSSION

5.1 Summary

A flora and vertebrate fauna assessment for the Tasi Mane Project - Suai Supply Base was undertaken in December 2011 and February 2012. A total of 201 species of flora were recorded. Sixty-eight species of vertebrate fauna were recorded, consisting of two species of amphibians, seven species of reptiles, 48 species of birds and 11 species of mammals.

Species listed as Critically Endangered, Endangered, Vulnerable and Near Threatened under the IUCN Red List constitute species as having conservation significance. A lack of baseline data of Timor-Leste's flora and fauna indicates that not all occurrences of conservation significant species have been assessed by the IUCN. There is a possibility that further species within the Suai development area may be considered to have conservation significance.

Two Vulnerable listed flora species have been recorded in the Suai development area to date, *Pterocarpus indicus* and *Santalum album,* which are both valuable timber species. Five fauna species of conservation significance were recorded in the study area: the yellow-crested cockatoo (*Cacatua sulphurea*), Canut's horseshoe bat (*Rhinolophus canuti timoriensis*), Beach thick-knee (*Esacus magnirostris*), Slaty cuckoo dove (*Turacoena modesta*) and Timor bush-chat (*Saxicola gutturalis*). The yellow-crested cockatoo is Critically Endangered on the IUCN Red List and was recorded on five occasions within the Suai development area, making Suai potentially sensitive to environmental impacts proposed by the project.

Mangrove communities in the Suai development area represent some of the only remnant vegetation in good condition and are considered to have conservation significance. The largest communities recorded were the *Excoecaria agallocha* and *Lumnitzera racemosa* mangrove community on the lagoon at 'Wemout', and the *Excoecaria agallocha*, *Sonneratia alba*, *Pandanus* sp., *Nypa fruticosa* (Mangrove Palm) community on the lagoon at 'We Dare'.

5.1.1 Environmental Impacts/Issues

Flora and Fauna

In the absence of detailed design information on the project, the following section is written based on the conservative assumoption that there is to be 100% clearance of all vegetation and agricultural land within the Suai development area, with the exclusion of two areas of existing crocodile habitat that are proposed for reserves. The We Dare area is located near the center of the proposed Suai supply base development area, extending inland from the coastline and covers approximately 45 ha. The We Matan Bua Oan area is located inside the north-east boundary of the Suai development area (adjacent to the Rio Raiketan) and covers approximately 10 ha.

The construction and operation of the Suai development area will have adverse effects on the terrestrial environment. The potential environmental and economic impacts upon the area and its people, include, but are not limited to;

- Loss of individuals of IUCN listed species; *Santalum album* (sandalwood) *Pterocarpus indicus* (rosewood), both valuable timber trees;
- Loss of floristic biodiversity that has not been documented;
- Secondary weed invasion after clearing, particularly Siam weed and Cogon grass;
- Loss of forest and tree cover;
- Loss of important mangrove habitat;
- Loss of agricultural land and subsistence gardens;
- Loss of food crops and estates e.g. coconuts, bananas;
- Loss of timber for fuel source;
- Loss of cash crops e.g. teak, rosewood and sandalwood; and
- Loss of fauna habitat, specifically important habitat for species of conservation significance.

The removal of vegetation cover is likely to result in the destabilization of soils and an increased rate of erosion and sedimentation.

5.1.2 Avoidance, Management and Mitigation Measures

Flora and Fauna

Management issues exist for the protection of remnant flora and vegetation within crocodile reserves. These include:

- The conversion of coastal forest for swidden agriculture;
- Harvesting of timber for firewood and building materials;
- Grazing of coastal vegetation; and
- Weed invasion of disturbed understory.

The loss of vegetation within the Suai development is a likely and unavoidable consequence of the construction process. The potential impact of these alterations has been reduced by avoiding sensitive and high conservation value habitats when selecting the development location.

Construction and operational activities will unavoidably result in the clearance of all remnant vegetation excluding the proposed crocodile reserves. Limiting the size of clearance areas will reduce the intensity and extent of impact on remnant vegetation.

Policies and procedures will be developed for construction works to reduce unnecessary vegetation clearance. These procedures will be incorporated into an environmental management system for the Suai supply base. A reporting and response system will be developed to ensure that vegetation clearing activities are controlled and monitored.

The impact of remnant vegetation clearance may be reduced by avoiding impacts to the high conservation value remnant vegetation within the two crocodile reserve boundaries.

Removal of the vegetation within the Suai development area will result in the loss of soil structure and associated soil erosion. This effect is likely to be greatest around rivers with the loss of riparian vegetation. It is recommended that riparian vegetation be preserved and rehabilitated to reduce erosion and maintain current flow patterns of rivers.

To reduce soil erosion, those areas not in use within the Suai supply base area can be rehabilitated and revegetated.

Mangroves

Construction will unavoidably remove some areas of mangrove habitat and the faunal communities they contain. Further impacts on mangroves will be limited through the control of vegetation clearance.

The location of any wastewater or desalination outlet is critical for the minimisation of impacts from the discharge on mangrove habitat. This should be located away from remnant mangrove vegetation within the two crocodile reserve areas.

Invasive Plant Species

The removal of the canopy layer in coastal forest is likely to result in the spread of invasive weeds, in particular Siam weed, Cogon grass and Coffee bush. Weed hygiene practices should be adopted to reduce spread of weed seeds, and weed control measures to reduce the colonization of weed species within the development area.

Protocols will be developed into an invasive weed management plan and incorporated as part of the environmental management system for the Suai supply base.

5.1.3 Monitoring and Reporting

Flora and Fauna

The monitoring and reporting measures for flora and fauna during construction and operations include:

- A multiple season baseline flora, vegetation and fauna assessment of the remnant vegetation within the proposed crocodile reserves is recommended;
- Surveys undertaken at different seasons during the year to record different fauna species assemblages and to capture fruiting and flowering patterns;

- A monitoring program for the proposed crocodile reserves may be designed and implemented at the completion of a baseline assessment, including independent expert advice on the potential sites ability to house displaced individuals; and
- A mangrove health monitoring program should be established within the remnant mangrove communities to document the health of mangrove species during the construction and operation phase of the project.

5.1.4 Recommendations

Flora

It is recommended that additional baseline flora and vegetation assessment be undertaken at the proposed Suai development area, including:

- Quadrats to define floristic composition and structural form of each vegetation community, particularly in mangrove and moist forest vegetation;
- A checklist of flora species including annual herbs, ferns, epiphytes, mosses, bryophytes, parasitic plants, to record floristic diversity; and
- Vegetation mapping at a scale of 1:10,000.
- Undertaking field work at other times of the year to detect a full range of species.

Fauna

The high level approach used for this survey due to the lack of baseline data means that more intensive work needs to be completed. Multiple surveys in each season would be required, plus extending the duration of the trips to ensure a more thorough survey. This is to ensure that potentially critically endangered species which could be present in the area but not yet sighted can be recorded. Further work will provide more established results, providing a more exhaustive environmental assessment and improved knowledge on potential environmental and economic impacts.

Sightings of the Critically Endangered yellow-crested cockatoo highlight the need for further work to identify specific habitat requirements, the abundance and distribution of nesting sites and their tolerance to varying disturbance levels.

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Appendix 1 – IUCN Red List

The IUCN Red List of Threatened Species™ is widely recognized as the most comprehensive, objective global approach for evaluating the conservation status of plant and animal species (IUCN 2012). It provides taxonomic, conservation status and distribution information on plants and animals that have been globally evaluated using the IUCN Red List Categories and Criteria (IUCN 2012). The IUCN red List describes nine categories that which a species of flora and fauna can be assessed as. Table 1 details the nine categories in which species can be determined as. This system is designed to determine the relative risk of extinction, and the main purpose of the IUCN Red List is to catalogue and highlight those plants and animals that are facing a higher risk of global extinction (i.e. those listed as Critically Endangered, Endangered and Vulnerable). The IUCN Red List also includes information on plants and animals that are categorized as Extinct or Extinct in the Wild; on taxa that cannot be evaluated because of insufficient information (i.e., are Data Deficient); and on plants and animals that are either close to meeting the threatened thresholds or that would be threatened were it not for an ongoing taxon-specific conservation programme (i.e., are Near Threatened) (IUCN 2012).

Table 1 The detailed criteria and categories of the IUCN Red List

Criteria		Description
EX	Extinct	A taxon is Extinct when there is no reasonable doubt that the last individual has died. A taxon is presumed Extinct when exhaustive surveys in known and/or expected habitat, at appropriate times (diurnal, seasonal, annual), throughout its historic range have failed to record an individual. Surveys should be over a time frame appropriate to the taxon's life cycle and life form.
EW	Extinct in the Wild	A taxon is Extinct in the Wild when it is known only to survive in cultivation, in captivity or as a naturalized population (or populations) well outside the past range. A taxon is presumed Extinct in the Wild when exhaustive surveys in known and/or expected habitat, at appropriate times (diurnal, seasonal, annual), throughout its historic range have failed to record an individual. Surveys should be over a time frame appropriate to the taxon's life cycle and life form.
CR	Critically Endangered	A taxon is Critically Endangered when the best available evidence indicates that it meets any of the criteria A to E for Critically Endangered (see Section V), and it is therefore considered to be facing an extremely high risk of extinction in the wild.
EN	Endangered	A taxon is Endangered when the best available evidence indicates that it meets any of the criteria A to E for Endangered (see Section V), and it is therefore considered to be facing a very high risk of extinction in the wild.
VU	Vulnerable	A taxon is Vulnerable when the best available evidence indicates that it meets any of the criteria A to E for Vulnerable, and it is therefore considered to be facing a high

Criteria		Description
		risk of extinction in the wild.
NT	Near Threatened	A taxon is Near Threatened when it has been evaluated against the criteria but does not qualify for Critically Endangered, Endangered or Vulnerable now, but is close to qualifying for or is likely to qualify for a threatened category in the near future.
LC	Least Concern	A taxon is Least Concern when it has been evaluated against the criteria and does not qualify for Critically Endangered, Endangered, Vulnerable or Near Threatened. Widespread and abundant taxa are included in this category.
DD	Data Deficient	A taxon is Data Deficient when there is inadequate information to make a direct, or indirect, assessment of its risk of extinction based on its distribution and/or population status. A taxon in this category may be well studied, and its biology well known, but appropriate data on abundance and/or distribution are lacking. Data Deficient is therefore not a category of threat. Listing of taxa in this category indicates that more information is required and acknowledges the possibility that future research will show that threatened classification is appropriate. It is important to make positive use of whatever data are available. In many cases great care should be exercised in choosing between DD and a threatened status. If the range of a taxon is suspected to be relatively circumscribed, and a considerable period of time has elapsed since the last record of the taxon, threatened status may well be justified.
NE	Not Evaluated	A taxon is Not Evaluated when it is has not yet been evaluated against the criteria.

Source: http://www.iucnredlist.org/technical-documents/categories-and-criteria/2001-categories-criteria

Appendix 2 – IUCN Listed Flora

Table 1 Flora Species on IUCN Red List in Timor-Leste

Family	Species	Status
Acanthaceae	*Acanthus ilicifolius* (Holy Mangrove)	Least Concern
Burmanniaceae	*Burmannia disticha*	Least Concern
Ceratophyllaceae	*Ceratophyllum muricatum*	Least Concern
Cyperaceae	*Carex baccans* (Crimson Seeded Sedge)	Least Concern
Cyperaceae	*Cyperus compactus*	Least Concern
Cyperaceae	*Diplacrum caricinum*	Least Concern
Cyperaceae	*Echinochloa picta*	Least Concern
Cyperaceae	*Eleocharis geniculata* (Canada Spikesedge)	Least Concern
Cyperaceae	*Eleocharis retroflexa*	Least Concern
Cyperaceae	*Fimbristylis argentea*	Least Concern
Cyperaceae	*Fimbristylis bisumbellata* (Fimbristylis à Deux Ombelles)	Least Concern
Cyperaceae	*Fimbristylis consanguinea*	Least Concern
Cyperaceae	*Fimbristylis dipsacea* (Harper's Fimbristylis)	Least Concern

Family	Species	Status
Cyperaceae	*Fimbristylis nutans*	Least Concern
Cyperaceae	*Fimbristylis ovata*	Least Concern
Cyperaceae	*Fuirena pubescens* (Fuirène Pubescent)	Least Concern
Cyperaceae	*Lipocarpha gracilis*	Least Concern
Cyperaceae	*Pycreus macrostachyos*	Least Concern
Cyperaceae	*Pycreus sanguinolentus*	Least Concern
Cyperaceae	*Schoenoplectiella lateriflora*	Least Concern
Cyperaceae	*Scleria mikawana*	Least Concern
Cyperaceae	*Scleria terrestris*	Least Concern
Fabaceae	*Parochetus communis* (Blue Oxalis)	Least Concern
Halagoraceae	*Myriophyllum tuberculatum*	Least Concern
Leguminosae	*Sesbania javanica*	Least Concern
Lemnaceae	*Lemna minor* (Common Duckweed)	Least Concern
Lygodiaceae	*Lygodium microphyllum*	Least Concern

Family	Species	Status
Poaceae	*Brachiaria eruciformis*	Least Concern
Poaceae	*Eriochloa procera* (Spring Grass)	Least Concern
Poaceae	*Leptochloa fusca*	Least Concern
Poaceae	*Leptochloa obtusiflora*	Least Concern
Poaceae	*Leptochloa panicea* (Mucronate Sprangletop)	Least Concern
Podocarpaceae	*Podocarpus rubens*	Lower Risk/least concern
Podocarpaceae	*Sundacarpus amarus*	Lower Risk/least concern
Podostemaceae	*Cladopus nymanii*	Least Concern
Scrophulariaceae	*Lindernia antipoda*	Least Concern

Appendix 3 – Flora Species List

Table 1 Vascular flora species recorded in the Tasi Mane project area

Life Form Key: Tree (T), Shrub (S), Vine (V), Herb (H)

Family	Genus Species Infra	Local Name	Common name	Life Form	Weed	Distribution if known
ACANTHACEAE	*Acanthus ilicifolius*		Holly leaf mangrove	S		
ACANTHACEAE	*Avicennia marina*	ate-dara		T		
ACANTHACEAE	*Lepidagathis eucephala*			H		
ACANTHACEAE	*Ruellia tuberosa*		Petunia	H		
AMARANTHACEAE	*Aerva sanguinolenta*			H		
AMARYLLIDACEAE	*Crinum* affin *stuhlmannii*			H		
ANACARDIACEAE	*Anacardium occidentale*	caijus	cashew	T		
ANACARDIACEAE	*Mangifera indica*	has	mango	T		
ANACARDIACEAE	*Mangifera timorensis*	has fuik	wild mango	T		
ANNONACEAE	*Annona squamosa*	ayata		T		
ANNONACEAE	*Uvaria rufa*	hudi-clar		V		
APOCYNACEAE	*Alstonia scholaris*	ai-roti		T		
APOCYNACEAE	*Alstonia spectabilis*	ate-rutik	native frangipani	T		
APOCYNACEAE	*Amphineurion marginatum*			V		
APOCYNACEAE	*Asclepias curassavica*			H		
APOCYNACEAE	*Cascabela thevetia*	ai-askabit		S		
APOCYNACEAE	*Cerbera manghas*	ai-odi	native frangipani	T		
APOCYNACEAE	*Dischidia major*	tatalik		V		
APOCYNACEAE	*Tabernaemontana pandacaqui*	ai-kahoruk		S		
APOCYNACEAE	*Wrightia* sp.	ai-lele fuik		V		
ARACEAE	*Amorphophallus paeonifolius*	maek		H		
ARECACEAE	*Borassus flabellifer*	tali	palm	T		
ARECACEAE	*Cocus nucifera*	nú	coconut	T		

Family	Genus Species Infra	Local Name	Common name	Life Form	Weed	Distribution if known
ARECACEAE	*Corypha utan*	tuatali metan	Kennedy palm	T		
ARECACEAE	*Nypa fruiticans*	ai-tasi	mangrove palm	T		
ARECACEAE	*Salacca edulis*	ai-rota		T		
ASCLEPIDIACEAE	*Calotropis gigantea*	fuka	Crown flower	S	*	
ASPARAGACEAE	*Asparagus racemosus*	hatikibi		V		
ASPARAGACEAE	*Pleomele flexuosa*			S		
ASTERACEAE	*Chromolaena odorata*	ai-funanmutik	Siam weed	S	*	
ASTERACEAE	*Pluchea indica*			S		
ASTERACEAE	*Tridax procumbens*			H		
BIGNONIACEAE	*Dolichandrone spathacea*	ai-sirian		T		
BORAGINACEAE	*Cordia dichotoma*	ai-nunak		T		
BORAGINACEAE	*Cordia subcordata*	ate-biamete		S		
BORAGINACEAE	*Tournefortia sarmentosa*	vine		S		
CACTACEAE	*Opuntia ficus-indica*		cactus	S		
CARICACEAE	*Carica papaya*	aidila	papaya	S		
CASUARINACEAE	*Casuarina* sp. affin. *junghuhniana*	ai-kakeu	she-oak	T		
CELASTRACEAE	*Maytenus marginata*	ai-luruka		T		
CLEOMACEAE	*Cleome viscosa*			H		
CLUSIACEAE	*Calophyllum inophyllum*	ai-toh		T		
COMBRETACEAE	*Lumnitzera racemosa*	ai-biku	mangrove	T		Timor, Alor
COMBRETACEAE	*Terminalia catappa*	ai-lesse		T		
CONVOLVULACEAE	*Ipomoea aquatica*	kanko (Kangkung)		H		
CONVOLVULACEAE	*Ipomoea batatas*	fehuk midar	sweet potato	H		
CONVOLVULACEAE	*Ipomoea pes-caprae*			V		
CONVOLVULACEAE	*Ipomoea sp.*			V		
CONVOLVULACEAE	*Ipomoea triloba*	tatalik		V		

Family	Genus Species Infra	Local Name	Common name	Life Form	Weed	Distribution if known
CONVOLVULACEAE	*Merremia emarginata*	tatalik		V		
CUCURBITACEAE	*Citrullus lanatus*	pateka	watermelon	V		
CUCURBITACEAE	*Cucumis sativus*	pipinu	cucumber	V		
CUCURBITACEAE	*Cucumis sp.*	melansia	melon	V		
CUCURBITACEAE	*Cucurbita sp.*	lakeru	pumpkin	V		
CYPERACEAE	*Cyperus javanicus*	du'ut	sedge	H		
CYPERACEAE	*Fimbristylis cymosa*	du'ut	sedge	H		
CYPERACEAE	*Fimbristylis ferruginea*	du'ut		H		
CYPERACEAE	*Schoenus falcatus*			H		
EBENACEAE	*Diospyros littorea*	ai-metan		T		
EBENACEAE	*Diospyros montana*	ai-metan		T		Philippines, Celebes, E Java, LSI (Lombok, Sumba, Flores, Timor)
EUPHORBIACEAE	*Aleurites moluccana*	cami	candlenut	T		India to Pacific Is; t/o Malesia; (pres Timor), cult
EUPHORBIACEAE	*Euphorbia tithymaloides*	ai-tatalik tasi		H		
EUPHORBIACEAE	*Excoecaria agallocha*	ai-tano	mangrove	T		
EUPHORBIACEAE	*Jatropha curcas*	banut-mutin		S	*	
EUPHORBIACEAE	*Jatropha gossypiifolia*	miro		S	*	introduced Timor
EUPHORBIACEAE	*Mallotus philippensis*	ai-sablama		T		
EUPHORBIACEAE	*Manihot esculenta*	aiferina	cassava	H		
FABACEAE	*Abrus prectatorius*	olonanawa		V		
FABACEAE	*Albizia lebbeckoides*	ai-samtuku, ai-martuku		T		China to NG; LSI (Bali, Kisar, Sumba, Sumbawa, Komodo, Flores, Timor)
FABACEAE	*Albizia saman*	ai-matan dukur	sleeping tree	T		Native to S Am; intro in LSI; scarcely naturalised Timor
FABACEAE	*Arachis hypogaea*	forai	peanut	H		
FABACEAE	*Bauhinia cunninghamii*			S		

Family	Genus Species Infra	Local Name	Common name	Life Form	Weed	Distribution if known
FABACEAE	*Cathormion umbellatum*	ai-lulun		T		
FABACEAE	*Centrosema molle*	tatalik		V		
FABACEAE	*Delonix regia*		poinciana	T		
FABACEAE	*Desmanthus virgatus*			S		
FABACEAE	*Dichrostachys cinerea*	ai-adelae		T		
FABACEAE	*Leucaena leucocephala*	ai-café	coffee tree	T	*	Pantropical; t/o Malesia (intro) Timor
FABACEAE	*Peltophorum pterocarpum*	ai-máme, bak-mur		T		Sri Lanka to N Aust; t/o Malesia, pres Timor
FABACEAE	*Pterocarpus indicus*	ai-na		T		
FABACEAE	*Senna timorensis*	ai-cachote		S		
FABACEAE	*Tamarindus indica*	sukaer	tamarind	T	*	
FABACEAE	*Teramnus labialis*			V		
FABACEAE	*Uraria lagopodioides*	Ervilha	pea	H		all LSI
FABACEAE	*Vachellia nilotica*	ai-bakuro malae, ai-tarak		T	*	
FABACEAE	*Vigna unguiculata* subsp. *sesquipedalis*	fore	beans	H		
FLAGELLARIACEAE	*Flagellaria indica*	tatalik tirilolo		V		
GOODENIACEAE	*Scaevola taccada*	ai- tasi	scaevola	S		
LAMIACEAE	*Callicarpa candicans*	sapateri	vine	S		
LAMIACEAE	*Gmelina arborea*	ai-teka	teak	T		
LAMIACEAE	*Gmelina elliptica*	ai-lok fuk		V		
LAMIACEAE	*Ocimum tenuiflorum*			H		
LAMIACEAE	*Premna serratifolia*	tatalik, ai-tasi	vine	S		
LAMIACEAE	*Vitex pinnata*	ai-tahan tolu		T		
LAMIACEAE	*Vitex trifolia*	ai-tasi		S		
LAURACEAE	*Cinnamomum* sp.	ai-canela	cinnamon tree	T		
LAURACEAE	*Litsea glutinosa*			T		

Family	Genus Species Infra	Local Name	Common name	Life Form	Weed	Distribution if known
LECYTHIDACEAE	*Barringtonia racemosa*	ai-baknas	mangrove	T		
LILIACEAE	*Gloriosa superba*	tatalik	vine	V		
LOGANIACEAE	*Strychnos lucida*	bakmur lotuk		T		IndoAustralia, E Java, LSI (Bali, Flores, Sumbawa, Timor, Wetar, Babar)
LOMARIOPSIDACEAE	*Nephrolepis sp.*		fern	F		
LYGODIACEAE	*Lygodium circinnatum*	ai-tatalik lutu	fern	F		
LYTHRACEAE	*Sonneratia alba*	ate-kesu	red mangrove	T		
LYTHRACEAE	*Sonneratia caseolaris*	ai-tano	mangrove	T		
MALPIGHIACEAE	*Hiptage benghalensis*	tatalik		V		India to Taiwan to LSI (Bali, Alor, Timor) vine, mericarp1, 3-winged
MALPIGHIACEAE	*Ryssopterys timoriensis*	tatalik		V		
MALVACEAE	*Ceiba petandra*	cabas katal - Timor	wild cotton	T		
MALVACEAE	*Gossypium arboreum*		wild cotton	S		
MALVACEAE	*Grewia sp.*			T		
MALVACEAE	*Helicteres isora*			S		
MALVACEAE	*Heritiera littoralis*	ai-kebo	mangrove	T		
MALVACEAE	*Hibiscus tiliaceus*	ai-fau, ai-araleu, ai-katar		T		
MALVACEAE	*Sida.* sp.			H		
MALVACEAE	*Stercula foetida*	ai-bano		S		
MELIACEAE	*Aphanamixis polystachya*			T		
MELIACEAE	*Melia azedarach*	ai-betukate		T		
MELIACEAE	*Xylocarpus moluccensis*	ate-sabrika	mangrove	T		India to N Aust.; t/o Malesia, pres Timor
MORACEAE	*Artocarpus altilis*	kulu modo	breadfruit	T		
MORACEAE	*Artocarpus heterophyllus*	kulu jaka	jackfruit	T		
MORACEAE	*Broussonetia papyrifera*	ai-bau		T		India to NG; LSI(Fl,Ti,Al,We)
MORACEAE	*Fatoua pilosa*			H		Philippines, Celebes, Java, all

Family	Genus Species Infra	Local Name	Common name	Life Form	Weed	Distribution if known
						LSI, Moluccas, Melanesia
MORACEAE	*Ficus ?benjamina* or *microcarpa*		fig	T		
MORACEAE	*Ficus hispida*	ai-kapkou		T		
MORACEAE	*Ficus sp.*	ai-hale	fig	T		
MORACEAE	*Ficus variegata*	ai-kun	fig	T		
MORACEAE	*Ficus virens, drupacea* or *superba*	hale	fig	T		
MORACEAE	*Streblus taxoides*			S		India to LSI (Fl,Ti)
MUNTINGIACEAE	*Muntingia calabura*	cerejes	Timor cherry	T		
MUSCACEAE	*Musa* sp.	hudi	banana	T		
MYRTACEAE	*Psidium guajava*	goyava	guava	T		
NYCTAGINACEAE	*Boerhavia errecta*	marlale		H		
ORCHIDACEAE	*Tropidia curculigoides*	trilolo		H		
OXALIDACEAE	*Averrhoa bilimbi*	belimbe		S		
PANDANACEAE	*Pandanus* sp.	ai-hedan	pandanus	T		
PANDANACEAE	*Pandanus tectorius*		pandanus	T		
PASSIFLORACEAE	*Passiflora foetida*	marquisas	wild passionfruit	V		
PHYLLANTHACEAE	*Bridelia ovata*	ate-siki		T		LSI (Ba, Sw, Su, Fl, Ti, Al)
PHYLLANTHACEAE	*Bridelia tomentosa*	ate-kai lakudiri		T		
PHYLLANTHACEAE	*Flueggea virosa*			S		Af to N Aust; LSI (Fl, Sw, Ti)
PHYLLANTHACEAE	*Glochidion xerocarpum*	metikai-kobi		T		
POACEAE	*Bambusa blumeana*	au	bamboo	H		D.Franklin (pers.comm.); Apparently native, possibly naturalised from historical introductions
POACEAE	*Chloris truncata*		grass	H		
POACEAE	*Chrysopogon aciculatus*	du'ut	grass	H	*	
POACEAE	*Cyrtococcum trigonum*		grass	H		

Family	Genus Species Infra	Local Name	Common name	Life Form	Weed	Distribution if known
POACEAE	*Imperata cylindrica*	pae	grass	H	*	
POACEAE	*Saccharum spontaneum*	du'ut	grass	H	*	
POACEAE	*Spinifex littoreus*		beach spinifex	H		
POACEAE	*Zea mays*	batar	corn	S		
POLYPODIACEAE	*Drynaria quercifolia*	kluku	basket fern	F		
POLYPODIACEAE	*Platycerium* sp.	pakis (indonesian)	staghorn	F		
POLYPODIACEAE	*Pyrrosia longifolia*		fern	F		
PRIMULACEAE	*Maesa* sp. affin. *integrifolia*	ai-lenuk, ai-tasi		S		
PTERIDACEAE	*Adiantum caudatum*		fern	F		
PTERIDACEAE	*Doryopteris concolor*		fern	F		
PTERIDACEAE	*Pteris ensiformis*		fern	F		
RHAMNACEAE	*Ziziphus mauritiana*	ai-lok		T	*	
RHAMNACEAE	*Ziziphus timoriensis*	ai-metan bo'ot, lerhula ki'ik		T		
RHIZOPHORACEAE	*Rhizophora stylosa*		mangrove	T		
RUBIACEAE	*Hedyotis biflora*			H		
RUBIACEAE	*Morinda citrifolia*	mengkudu or ai-lenuk		T		
RUBIACEAE	*Nauclea orientalis*	ai-kafira, sawa		T		
RUTACEAE	*Aegle marmelos*	aidila fatuk	wild papaya	T		
RUTACEAE	*Fimbristylis ferruginea*			H		
RUTACEAE	*Harrisonia brownii*	ate-gaba		S		
RUTACEAE	*Luvunga monophylla*			V		
SANTALACEAE	*Exocarpos latifolius*	ai-cacasa, tatalik metan		T		
SANTALACEAE	*Santalum album*	ai-cameli	sandalwood	T		Australia (N Territory), S NG, S Celebes, LSI (Timor, Flores);
SAPINDACEAE	*Allophylus cobbe*			S		Pantropical; all Malesia (pres Timor)

Family	Genus Species Infra	Local Name	Common name	Life Form	Weed	Distribution if known
SAPINDACEAE	*Elattostachys verrucosa*	ai-baknas		T		Java to Philip & Moluccas, LSI (Bali, Lombok, Sumba, Sumbawa, Flores, Timor, Wetar)
SAPINDACEAE	*Elattostachys verrucosa*	ate-asaulalai		T		Java to Philip & Moluccas, LSI (Bali, Lombok, Sumba, Sumbawa, Flores, Timor, Wetar)
SAPINDACEAE	*Lepisanthes rubiginosa*			S		N India to NW Aust (WA); common Malesia (Timor)
SAPINDACEAE	*Schleichera oleosa*	ai-dak		T		Sri Lanka to China & Moluccas; LSI (Bali Sumba, Sumbawa, Flores, Timor, Alor)
SCROPHULARIACEAE	*Myoporum montanum*	ai-kahoruk ki'ik		S		
SMILACACEAE	*Smilax zeylanica*	tatalik siapa	vine	V		
SOLANACEAE	*Capsicum annuum*	ai-manas		H		
STERCULIACEAE	*Helicteres isora*	oel		T		
THELYPTERIDACEAE	*Christella arida*	pakis (Indonesian)	fern	F		
VERBENACEAE	*Lantana camara*	ai-funan meak	lantana	V	*	
VERBENACEAE	*Stachytarpheta cayennensis*			H	*	
VERBENACEAE	*Tectona grandis*	ai-teka	teak	T		
VIOLACEAE	*Hybanthus enneaspermus*	fore tali		H		Philippines, E Java, all LSI, Moluccas, NG. Once in N Borneo
VITACEAE	*Ampelocissus arachnoideus*			V		
VITACEAE	*Cayratia trifolia*	tatalik		V		
VITACEAE	*Leea aequata*	ai-manek		H		Nepal to Moluccas; LSI (Sumba, Timor, Wetar)

Appendix 4 – Fauna Habitat Assessments

WorleyParsons
resources & energy

EcoNomics

Fauna Habitat Assessment			
Project	Timor Leste 301012-01504	10 December 2011	ML
Site Number – HA1 [Suai]			
Habitat	Deciduous Woodland / Forest		
UTM Coordinates	Zone 51L Easting 752588 Northing 8969667		

Stratum	Species	Cover (%)	Height (m)
Over-story	*Albizia saman* [ai-matandukur], *Casuarina* sp. affin. *junghuhniana* [ai-kakeu], Gebang Palm *Chorypha utan* [tuatali metan]	10-40%	15-20 m
Mid-story	Pandanus spp. [ai-hedan], Palmyra Palm *Borassus* spp. [tali], *Acacia* spp. [ai-tarak]	>20%	~4 m
Under-story	Siam Weed *Chromolaena odorata* [ai-funanmutik], deciduous herbs and grasses	>20%	< 0.5 m

Litter cover	Logs (%) <1%		Twigs (%) <5%		Leaves (%) 10-20%	
Cliffs	nil				Exfoliating Slabs	nil
Boulders	nil				Surface Rocks	nil
Cracks / crevices	nil					
Soils	Brown sand /mud complex					
Tree Hollows	Large	nil	Medium	Present	Small	Present
Water Bodies	nil					
Caves	Large	nil	Medium	nil	Small	nil
Cave Dimensions	Height (m)	nil	Width (m)	nil	Depth (m)	nil
Burrows	Height (m)	nil	Width (m)	nil	Depth (m)	nil
Notes	Lack of complex understory species / stratum reduced micro-niche potential; area subject to repeatable fire events and swidden agriculture and logging.					

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Fauna Habitat Assessment			
Project	Timor Leste 301012-01504	10 December 2011	ML
Site Number – HA2 [Suai]			
Habitat	Coastal		
UTM Coordinates	Zone 51L Easting 753697 Northing 8969520		

Stratum	Species	Cover (%)	Height (m)
Over-story	*Excoecaria agallocha*	10-15%	8-15 m
Mid-story	nil	nil	nil
Under-story	nil	nil	nil

Litter cover	Logs (%) <1%		Twigs (%) <5%		Leaves (%) 10-20%	
Cliffs	nil				Exfoliating Slabs	nil
Boulders	nil				Surface Rocks	nil
Cracks / crevices	nil					
Soils	Grey – black sand /mud complex					
Tree Hollows	Large	nil	Medium	Present	Small	Present
Water Bodies	High tide inundation					
Caves	Large	nil	Medium	nil	Small	nil
Cave Dimensions	Height (m)	nil	Width (m)	nil	Depth (m)	nil
Burrows	Height (m)	nil	Width (m)	nil	Depth (m)	nil
Notes	Lack of complex understory species / stratum typical of mangrove sites which are frequently inundated in high tide events. Very little leaf litter and under-story.					

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Fauna Habitat Assessment			
Project	Timor Leste 301012-01504	11 December 2011	ML
Site Number – HA3 [Suai]			
Habitat	Riparian		
UTM Coordinates	Zone 51L Easting 756401 Northing 8971261		

Stratum	Species	Cover (%)	Height (m)
Over-story	*Albizia saman* [ai-matandukur], *Schleichera oleosa* [ai-dak]	10-20%	8-10 m
Mid-story	[ai-fau], Bamboo, *Peltophorum pterocarpus* [ai-mame], [ai-na]	>20%	1-6 m
Under-story	Siam Weed *Chromolaena odorata* [ai-funanmutik], deciduous herbs and grasses	>20%	< 0.5 m

Litter cover	Logs (%) <1%		Twigs (%) <5%		Leaves (%) 10-20%	
Cliffs	nil				Exfoliating Slabs	nil
Boulders	nil				Surface Rocks	nil
Cracks / crevices	nil					
Soils	Brown sand /mud complex					
Tree Hollows	Large	nil	Medium	Present	Small	Present
Water Bodies	Small creek line with running water and stagnate pools					
Caves	Large	nil	Medium	nil	Small	nil
Cave Dimensions	Height (m)	nil	Width (m)	nil	Depth (m)	nil
Burrows	Height (m)	nil	Width (m)	nil	Depth (m)	nil
Notes	Lack of complex understory species / stratum reduced micro-niche potential; area subject to repeatable fire events and swidden agriculture.					

Fauna Habitat Assessment			
Project	Timor Leste 301012-01504	12 December 2011	ML
Site Number – HA4 [Suai]			
Habitat	Riparian		
UTM Coordinates	Zone 51L Easting 754211 Northing 8970894		

Stratum	Species	Cover (%)	Height (m)
Over-story	*Albizia saman* [ai-matandukur], *Schleichera oleosa* [ai-dak], *Casuarina* sp. affin. *junghuhniana* [ai-kakeu], Gebang Palm *Chorypha utan* [tuatali metan]	10-20%	8-10 m
Mid-story	[ai-fau], Bamboo, *Peltophorum pterocarpus* [ai-mame], [ai-na]	>20%	1-6 m
Under-story	Siam Weed *Chromolaena odorata* [ai-funanmutik], deciduous herbs and grasses	>20%	< 0.5 m

Litter cover	Logs (%) 5%		Twigs (%) 10%		Leaves (%) >10%	
Boulders	nil		Surface Rocks		Riverine, cobbles and pebbles	
Soils	Grey Sand					
Tree Hollows	Large	Present	Medium	Present	Small	Present
Water Bodies	Dry creek bed					
Caves	Large	nil	Medium	nil	Small	nil
Cave Dimensions	Height (m)	nil	Width (m)	nil	Depth (m)	nil
Burrows	Height (m)	0.1 m	Width (m)	0.1 m	Depth (m)	
Notes	Dry river bed approximately 10 m wide, heavily eroded banks (2-4 m tall). Burrowing potential for ground dwelling reptiles and mammals. Burrows / nests in heavily eroded banks (Rainbow Bee-eater nests). Large trees fringing the drainage line edge /creek bed with strong hollow potential.					

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Fauna Habitat Assessment			
Project	Timor Leste 301012-01504	7 February 2012	ML
Site Number – HA12 [Suai]			
Habitat	Deciduous Woodland / Forest (Swidden Agriculture)		
UTM Coordinates	Zone 51L Easting 753133 Northing 8973261		

Stratum	Species	Cover (%)	Height (m)
Over-story	Gebang Palm *Chorypha utan* [tuatali metan], Palmyra Palm *Borassus* spp. [tali], [sawa], *Ziziphus mauritiana* [ai-lok], [ai-martuku], *Ficus variegata* [ai-kun], Ficus spp. [hali], [ai-catimu], *Casuarina* sp. affin. *junghuhniana* [ai-kakeu]	<20%	10-15 m
Mid-story	Siam Weed *Chromolaena odorata* [ai-funanmutik], Bellyache Bush *Jatropha gossypifolia* [miro]	>50%	1-3 m
Under-story	nil	nil	nil

Litter cover	Logs (%) <1%		Twigs (%) <10%		Leaves (%) >10%	
Cliffs	nil				Exfoliating Slabs	nil
Boulders	nil				Surface Rocks	nil
Cracks / crevices	nil					
Soils	Grey-Brown sand/mud complex					
Tree Hollows	Large	nil	Medium	nil	Small	present
Caves	Large	nil	Medium	nil	Small	nil
Cave Dimensions	Height (m)	nil	Width (m)	nil	Depth (m)	nil
Burrows	Height (m)	nil	Width (m)	nil	Depth (m)	nil
Notes	Lack of under-story diversity and abundance dominated by weed species restricts the level of micro-niche diversity. Plantation species present include Teak [ai-teka] and Sandalwood [ai-morin]					

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Fauna Habitat Assessment			
Project	Timor Leste 301012-01504	8 February 2012	ML
Site Number – HA13 [Suai]			
Habitat	Coastal		
UTM Coordinates	Zone 51L Easting 757223 Northing 8971496		

Stratum	Species	Cover (%)	Height (m)
Over-story	Gebang Palm *Chorypha utan* [tuatali metan], Palmyra Palm *Borassus* spp. [tali], *Casuarina* sp. affin. *junghuhniana* [ai-kakeu], Mangrove species [ai-biku, ai-tanu, ai-tano], [ai-martuku], *Ficus variegata* [ai-kun], [ai-catimu]	<20%	20-30 m
Mid-story	Pandanus spp. [ai-hedan]	<10%	1-4 m
Under-story	nil	nil	nil

Litter cover	Logs (%) <5%		Twigs (%) <10%		Leaves (%) >30%	
Cliffs	nil				Exfoliating Slabs	nil
Boulders	nil				Surface Rocks	nil
Soils	Brown sand					
Tree Hollows	Large	Present	Medium	Present	Small	Present
Water Bodies	Coastal Estuary (30 m wide)					
Caves	Large	nil	Medium	nil	Small	nil
Cave Dimensions	Height (m)	nil	Width (m)	nil	Depth (m)	nil
Burrows	Height (m)	nil	Width (m)	nil	Depth (m)	nil
Notes	Complex over-story structure and diversity, little to no mid and under-story structure and species; good potential habitat for the Saltwater Crocodile. Extensive leaf litter micro-niches and good burrowing potential for estuarine species.					

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Fauna Habitat Assessment			
Project	Timor Leste 301012-01504	8 February 2012	ML
Site Number – HA14 [Suai]			
Habitat	Deciduous Woodland / Forest		
UTM Coordinates	Zone 51L Easting 755382 Northing 8971067		

Stratum	Species	Cover (%)	Height (m)
Over-story	Palmyra Palm *Borassus* spp. [tali], ai-dak], [sawa], *Ziziphus mauritiana* [ai-lok], [ai-martuku], *Ficus variegata* [ai-kun], Ficus spp. [hali], [ai-catimu]	<35%	<25 m
Mid-story	*Acacia* spp. [ai-tarak], Pandanus spp. [ai-hedan], Bellyache Bush *Jatropha gossypifolia* [miro]	<15%	1-5 ml
Under-story	Herbaceous and deciduous grasses and herbs, Siam Weed *Chromolaena odorata* [ai-funanmutik],	>50%	<1 m

Litter cover	Logs (%) <5%		Twigs (%) <8%		Leaves (%) >20%	
Cliffs	nil				Exfoliating Slabs	nil
Boulders	nil				Surface Rocks	nil
Cracks / crevices	nil					
Soils	Brown sand					
Tree Hollows	Large	nil	Medium	Present	Small	Present
Water Bodies	nil					
Caves	Large	nil	Medium	nil	Small	nil
Cave Dimensions	Height (m)	nil	Width (m)	nil	Depth (m)	nil
Burrows	Height (m)	nil	Width (m)	nil	Depth (m)	nil
Notes	Large amounts of leaf litter (Logs, Twigs & Leaves) providing an array of micro-niches. Large trees providing nesting and roosting potential for avian and airborne mammalian species. Good burrowing potential for ground dwelling reptile and mammals					

Appendix 5 – Timor-Leste Vertebrate Fauna list

Scientific Name	Common Name	Conservation Codes				A	B	C
		IUCN	CITES	Endemic	Introduced			
Phalangeridae								
Phalanger orientalis	Northern Common Cuscus	LC	App II		x	x	x	
Soricidae								
Crocidura fuliginosa	Southeast Asian Shrew	LC			x	x	x	
Crocidura maxi	Javanese Shrew	LC				x	x	
Crocidua monticola	Sunda Shrew	LC		x		x	x	
Crocidura tenuis	Thin Shrew	DD				x	x	
Suncus murinus mulleri	House / Musk shrew	LC			x	x	x	
Crocidura sp.	Shrew						x	
Pteropodidae								
Acerodon mackloti	Sunda Fruit Bat	VU						
Cynopterus titthaecheilus	Indonesian Short-nosed Fruit Bat	LC						
Dobsonia moluccensis	Moluccan Naked-backed Fruit Bat	LC						
Dobsonia peronii peronii	Western Naked-backed Fruit Bat	LC						
Eonycteris spelaea	Lesser Dawn Bat	LC						
Macroglossus minimus	Dagger-toothed Long-nosed Fruit Bat	LC						
Nyctimene keasti	Keast's Tube-nosed Fruit Bat	VU						
Pteropus griseus	Gray Flying-fox	DD	App II					
Pteropus lombocensis	Lombok Flying-fox	DD	App II					
Pteropus temminckii	Temminck's Flying-fox	VU	App II					
Pteropus vampyrus	Large Flying-fox	NT	App I			x		
Rousettus amplexicaudatus	Geoffroy's Rousette	LC						
Emballonuridae								
Saccolaimus saccolaimus	Bare-rumped Sheath-tailed Bat	LC						
Taphozous achates	Indonesian Tomb Bat	LC						
Taphozous melanopogon	Black-bearded Tomb Bat	LC						
Rhinolophidae								
Rhinolophus canuti timoriensis	Canut's Horseshoe Bat	VU		x				x
Rhinolophus celebensis parvus	Sulawesi Horseshoe Bat	LC		x				x
Rhinolophus montanus	Timorese Horseshoe Bat	DD		x				
Rhinolophus aff. *philippinensis maros*	Unidentified Large-eared Horseshoe Bat			x				
Hipposideridae								
Hipposideros bicolor hilli	Bicoloured Leaf-nosed Bat	LC		x				
Hipposideros diadema diadema	Diadem Leaf-nosed Bat	LC						x
Hipposideros sumbae aff. *rotiensis*	Sumban Leaf-nosed Bat	LC		?				
Vespertilionidae								
Harpiocephalus aff. *harpia*	Unidentified Hairy-winged Bat			?				
Kerivoula sp.	Unidentified Woolly Bat			?				
Miniopterus australis	Little Long-fingered Bat	LC						x
Miniopterus magnater	Western Long-fingered Bat	LC						
Miniopterus oceanensis	Australasian Bent-winged Bat	LC						
Miniopterus pusillus	Small Long-fingered Bat	LC		x				
Murina aff. *florium*	Unidentified Tube-nosed Bat			?				
Myotis adversus adversus	Large-footed Myotis	LC						
Nyctophilus sp.	Unidentified Long-eared Bat			?				
Pipistrellus sp.	Unidentified Pipistrelle			?				

Scotophilus collinus	Sody's Yellow House Bat	LC						
Scotorepens sanborni	Northern Broad-nosed Bat	LC						
Tylonycteris robustula	Greater Bamboo Bat	LC						
Cercopithecidae								
Macaca fascicularis	Long-tailed Macaque	LC				x	x	x
Muridae								
Mus castaneus	Asian House Mouse				x		x	
Mus domesticus homourus	European House Mouse	LC			x	x	x	
Rattus timorensis	Timor Rat	DD		x			x	
Rattus argentiventer	Ricefield Rat	LC		x		x	x	
Rattus exulans	Polynesian Rat	LC			x	x	x	
Rattus rattus	Ship Rat	LC			x	x	x	
Rattus norvegicus	Brown Rat	LC			x	x	x	
Rattus tanezumi	Oriental House Rat	LC			x	x	x	
Canidae								
Canis familiaris	Domestic Dog / Dingo				x		x	x
Viverridae								
Paradoxurus hermaphroditus	Common Palm Civet	LC			x	x	x	
Felidae								
Felis catus	Domestic Cat				x		x	
Suidae								
Sus celebensis	Sulawesi Wild Boar / Warty Pig	NT			x	x	x	
Sus scrofa	Domestic Pig	LC			x	x	x	x
Cervidae								
Cervus timorensis	Timor / Rusa Deer	VU			x	x	x	
Bovidae								
Bos javanicus	Banteng (Bali cattle)	EN			x	x	x	x
Bos taurus	Domestic Cattle / Ongole				x		x	x
Bubalis bubalis	Water Buffalo				x		x	x
Capra hircus	Domestic Goat				x		x	x
Ovis aries	Domestic Sheep				x		x	
Equidae								
Equus ferus caballus	Horse				x			
Equus africanus asinus	Donkey				x			

Key: A = Listed under IUCN Red List; B = Recorded in previous survey; C = Recorded in current assessment

(CR, EN, VU, NT, LC, DD) denotes Critically Endangered, Endangered, Vulnerable, Near Threatened, Least Concern and Data Deficient under the IUCN Red List; (x) denotes recorded during the survey or database search

Appendix 6 – Bat Calls Identification for Timor-Leste

Bat call identification

from the south coast of Timor-Leste

DRAFT 20120306

Type:	Bat Call Analysis
Prepared for:	WorleyParsons Services Pty Ltd
Date:	$$ March 2012
Job No.:	SZ240
Prepared by:	Dr Kyle Armstrong and Ms Yuki Konishi Specialised Zoological ABN 92 265 437 422 + 61 (0) 404 423 264 kyle.armstrong@graduate.uwa.edu.au kyle.n.armstrong@gmail.com

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Date	Type
16 February 2012	First incomplete draft submitted to WorleyParsons
6 March 2012	Full draft submitted to WorleyParsons
pending	Final version submitted to WorleyParsons

1.0 INTRODUCTION

Bat species were identified on the basis of echolocation call recordings made with electronic bat detectors, as part of the flora and fauna survey for the Timor-Leste South Coast Environmental Impact Assessment, prepared by WorleyParsons Services Pty Ltd for the proposed Tasi-Mane petrochemical project. Further context details of the project can be found in the main flora and fauna report. This report by Specialised Zoological includes details related to the chiropteran mammals only, with some reiteration included in the main report. Specialised Zoological contributed electronic bat detectors, undertook analysis of echolocation recordings, provided background information (some of it the subject of private unpublished research in progress) and interpretation of the results. Apart from taxonomic comments on the Pteropodidae, the majority of this report concerns echolocating species in the remaining five chiropteran families present on Timor. For a summary of findings, please refer to section *5.0 Conclusions*.

2.0 BAT BIODIVERSITY IN TIMOR

Timor is part of the non-volcanic southern archipelago of the Lesser Sunda islands (also known as Nusa Tenggara), which forms part of the Indo-Australian tectonic plate. It can be further classified into the Moluccan Division, and the western part of the Wallacea ecoregion that contains biota of mixed Asian and Australasian origin, but with the predominance of the former. This Moluccan Division is characterised by "very impoverished faunas" according to Corbet and Hill (1992:6), being characteristic of islands east of Lombok with low endemism, and was considered to be very poorly known even as recently as this publication.

There have been relatively few bat surveys on the island of Timor, and the fauna is not yet completely described. The earliest and still the most comprehensive published summary of the bats of Timor is that of Goodwin (1979), who conducted field surveys, an extensive examination of museum collections and a review of the literature to derive a list of taxa with their current taxonomy. Based on Goodwin's field surveys and taxonomic examinations, there were 22 species known from Timor, 11 of which he added from identifications of previously described taxa or descriptions of new ones.

More recently, systematic bat surveys were conducted as part of an environmental impact assessment for a hydropower scheme involving power generation infrastructure in the vicinity of the Ira Lalaro polje and the Paitchau Range. The first survey in March 2004 near the village of Malahara recorded 16 species, of which up to four taxa were new records for the island and possibly species new to science (Pavey and Milne 2004). A second survey in October 2006 north and south of the Paitchau Range recorded 15 species, at least one of which was a new record for the island and also possibly new to science (Armstrong 2007). Voucher specimens, reference echolocation calls and tissue biopsies were collected on both surveys, and follow up taxonomic work involving comparisons with other museum specimens, micro-CT scanning of skulls, analysis of reference calls and DNA sequencing of tissue biopsies has been conducted as part of a manuscript in preparation (Armstrong et al., ms in prep.). Much of the unpublished information used for identifications in the present report is derived from this resource.

These unpublished reports have provided updates to Goodwin's (1979) species list for the island of Timor, in conjunction with another brief informal survey conducted by Helgen (2004). Based on the capture of a species of long-eared bat *Nyctophilus* sp. and the examination of museum skins, most notably of one resembling *Dobsonia moluccensis*, Helgen (2004) compiled from various sources a list of 27 (with a minimum of 25) bat species thought to be on Timor.

Armstrong (2007) provided a further update based on his own survey, museum records (most notably based on the many collections made by Kitchener et al. from the Western Australian Museum), that of Pavey and Milne (2004), and based on the taxonomic treatments of Simmons (2005), which brought the total for the island of Timor to 31 species. Of those, 28 were confirmed from within the boundaries of the nation of Timor-Leste. The work conducted for the manuscript in preparation (Armstrong et al. ms in prep.) has revised the list produced by Armstrong (2007), and is reproduced here in Table 1. Excluding doubtful records or species that may now be extinct on the island (*Dobsonia moluccensis, Nyctimene keasti, Pteropus temminckii*), there are 32 species currently likely to be extant on Timor, of which 29 are known from Timor-Leste, and of which six are currently the subject of active taxonomic studies and are potentially species or subspecies new to science. Of the 32 extant species of bat on Timor, one is endemic, an additional three have recognised endemic subspecies, and there are seven taxa that might be endemic at either species or subspecies level, pending further taxonomic investigation (Table 1). The endemics are in the families Hipposideridae, Rhinolophidae and Vespertilionidae.

Many of the bat species on Timor have an IUCN conservation status listing of Least Concern (20 species). However this means that just over a third of bats are, or could be, of conservation significance. If the three doubtful species records are excluded, two species are listed as Vulnerable, and one species is listed as Near Threatened. For the remainder, there is insufficient information on their distribution to allocate them to a category: four species are listed as Data Deficient; there are a further five taxa first recorded by Helgen (2004), Pavey and Milne (2004) and Armstrong (2007) on Timor that are not currently listed because of their uncertain taxonomic status, or because they are new and have yet to be described and evaluated; and there is one species thought previously to be widespread and listed as Least Concern, but which might actually be an undescribed endemic taxon based on recent genetic work (*Pipistrellus* aff. *tenuis*; Armstrong et al. ms in prep.). Given that there are only three other extant, non-introduced and non-commensal species of mammal on Timor (*Crocidura maxi* [widespread in Indonesia], *Crocidura tenuis* [endemic to Timor] and *Rattus timoriensis* [endemic to Timor]; Kitchener et al. 1991; Ruedi 1995; Aplin and Helgen 2010), bats represent around 90% of the known, non-commensal, native and extant Timorese mammal assemblage, and this is a significant proportion that needs consideration in the context of development proposals.

3.0 METHODS

3.1 Acoustic Recordings

The ultrasonic echolocation calls of bats, which are produced for spatial orientation and prey detection in flight, are useful for taxonomic identification because each species produces a unique and distinguishable (in many cases) signal type. Analysis of the recordings made using electronic 'bat detectors' can reveal echolocating bat diversity at sampling sites with minimal effort as part of a comprehensive to surveying bats. On the present survey, acoustic recordings were made with AnaBat SD1 and SD2 bat detectors (Titley Scientific, Brisbane), which were chosen for their ease of use and deployment, and the efficiency of data storage[1]. Data was available from two field survey periods: 10 – 19 December 2011 and 7 – 13 February 2012, and equipment was deployed by staff of WorleyParsons.

Bat detectors were waterproofed in plastic boxes, and microphones (both HiMic/green and ST1) on an extension lead were placed in a funnel made from a plastic drink bottle to reduce the chance of water exposure. The use of funnels reduces slightly the zone of signal detection, but was unavoidable as sites received rain frequently. The detectors were employed as passive stationary data recorders, being set in position prior to dusk and collected after dawn, and placed off the ground (1 m or more) with the microphone capsule tied to trees. The equipment was placed in a variety of habitats to maximise the potential to encounter all species present. A GPS position was recorded at each recording site and associated with the serial number of the recording unit and deployment date.

Echolocation signals were divided by a factor of 8 by AnaBat detectors, and stored automatically on a Compact Flash card, with each sequence of calls receiving a time and date stamp. The recording effort is summarised for each sampling locality in Table 2. The total recording effort was seven full night AnaBat recording sessions in December 2011 and six sessions in February 2012. Further deployments of AnaBat detectors were made, but recordings were not recovered because of issues with equipment.

3.2 Analysis of Acoustic Recordings

AnaBat recordings were downloaded using CFC Read 4.3s software. The output consisted of two sets of data: 1. the individual sequence files produced during interpretation by CFC Read software, which are organised into folders representing a single night's recording; and 2. the continuous representation of the AnaBat recordings in ZCA and MAP files, which show all of the signals detected by the AnaBat microphone but which have not been parsed into individual sequence files according to default interpretation parameters. The signals in both parsed sequence files and the ZCA and MAP files were examined in AnalookW 3.8s software.

Bat echolocation calls recorded with 'passively' deployed bat detectors at stationary sites over a full night are referred to here as 'anonymous' because there is no *a priori* knowledge of the number and identity of contributing bats. The first step in any analysis of acoustic recordings

[1] SM2BAT detectors (Wildlife Acoustics, Massachusetts) were available for December 2011 but could not be deployed.

of bats is attributing these anonymously recorded call types to a single species. This is usually done with the help of a reference library of good quality calls recorded from confidently identified bats. Given that trapping for bats was beyond the scope of the present survey, we took two approaches to making identifications from the recordings. Firstly, we used reference call information collected from Timorese bats by Armstrong (2007; summarised in Armstrong et al. ms in prep.). Identification of the anonymously recorded calls was made by inspection of parsed ZCA format files and matching the observed pulses with information from reference calls (pulse shape and measurement variables). Three call variables were measured on good quality search phase pulses in representative call sequences: pulse duration (milliseconds), maximum frequency (kHz) and characteristic frequency (the point at the end of the flattest portion of a pulse before any terminal secondary frequency sweep; kHz). A fourth variable was measured on Constant Frequency calls: the frequency with the greatest number of cycles (the flattest part of the call, designated as Fpz in AnalookW software). Summaries of pulse variables (Table 3) and representative sequence traces (Figure 1) are presented in support of the analysis and identifications, as recommended by the Australasian Bat Society (ABS 2006).

Call types that could not be identified based on the limited reference call material available were allocated a descriptive name according to a new nomenclatural scheme (Armstrong and Aplin ms in prep.) that defines the pulse in terms of its characteristic frequency and shape (Table 4). The scheme was modified from de Oliveira (1998a,b) and Corben and O'Farrell (1999), and has been used previously for surveys in Papua New Guinea (Armstrong and Aplin 2011; other unpublished confidential reports by K.P. Aplin and K.N. Armstrong) where the echolocation calls of many bat species have yet to be recorded and described. Fourteen call types, each representing a single species, could be recognised based on both the call type classification scheme and the reference calls. Notes on each call type and a justification for the identifications are provided, and where call types could not be attributed to a single species, candidates were noted for later verification (Table 5).

3.3 Interpreting echolocation calls – limitations and considerations

Several caveats and considerations are noted with regard to the identification of bat species based on recordings of their echolocation calls, of relevance to this survey:

- Two or more bat species may produce calls that are so similar that they cannot be distinguished reliably using the available methods or reference recordings (examples from Australia in McKenzie and Muir 2000; Milne 2002).

- A single bat species may produce more than one call type (e.g. search phase calls, approach phase calls, clutter calls) that might suggest the presence of more than one species. With sufficient experience of related species, it is generally possible for a bat echolocation specialist to take this into account, and to base identifications on the typically more diagnostic search phase calls. The development of an adequate call reference library will diminish this limitation.

- While the most recent bat surveys in Timor (Helgen 2004; Pavey and Milne 2004; Armstrong 2007) have together discovered up to six species new to Timor (some

possibly new to science), the majority of the unidentified call types will likely belong to described or these previously encountered species for which there are no verified echolocation reference calls, rather than additional new forms. As further reference calls become available, it will be possible to identify retrospectively many of the unallocated calls. Moreover, it should be noted that taxonomically unallocated call types are still useful for comparing trends in bat richness, relative abundance and community composition across sites and habitats. By using the call type as the unit of presentation and analysis, retrospective identifications can be applied through all analyses, site and habitat summaries; and knowledge of bat community structure and ecological function based on the echolocation call structure will allow predictions of changes within the bat assemblage in response to habitat modification.

- In the process of making identifications, the practice of identifying call types on the basis of general correlations between physical characteristics (e.g. forearm length, body weight) and echolocation call frequency (e.g. based on Jones 1996; Robinson 1996; Bogdanowicz *et al.* 1999; Zhang *et al.* 2000; Feng *et al.* 2000) (see Richards 2005, 2008 as an example) was avoided. Although this inferential method has merit in some circumstances, a more cautious, evidentiary approach that minimises the chance of calls being misidentified was preferred in the present survey.

- Absolute abundance of each species or call type at a site cannot be estimated from bat detector recordings because it is not possible to distinguish between relatively few bats passing the detector but contributing many calls, and a larger number of individuals passing the detector with each contributing relatively few calls. If sufficient site replication (multiple nightly sessions) in each locality is available, a measure of relative abundance of each call type can be derived. This value represents the proportional occurrence of each species / call type across replicate recording sessions, and gives a rough indication of 'commonness'.

- Finally, it should be noted that in all acoustic surveys (regardless of bat detector brand and model) the detectability of each species is determined to some extent by characteristics of their echolocation calls. In particular, species that produce ultra-high frequency (> 100 kHz) calls or those that produce calls with low amplitude (e.g. long-eared bats *Nyctophilus* spp.) will have relatively short detection distances, which will lead to their being under-represented or even missed altogether in an acoustic survey. The detectability of different call types is also influenced by atmospheric conditions, most notably relative humidity and temperature that act together to attenuate ultrasound, the effects of which are dramatic at higher frequencies (e.g. Armstrong and Kerry 2011). Thus, acoustic detection represents only one component of a comprehensive survey approach for bats, and targeted effort is required for species with lower acoustic detectability.

4.0 RESULTS AND DISCUSSION

A total of 13 informative AnaBat sessions were made on the two field surveys. All represent a full night of passive stationary recording at one of the survey localities. A total of 14 different call types was distinguished, and six call types could be allocated to species level through comparison with available reference calls (Tables 2 and 6). The remaining eight call types could not be assigned to either species or genus level, though possibilities are given in Table 5.

The replication of passive recording sites in the Suai locality allowed for the calculation of a species accumulation curve and the relative abundance of each species in that locality. Similar patterns could not be derived for the other sites because only one or two nights were available for each. The accumulation curve was calculated on the basis of the number of recording sites rather than survey nights to make it easier to display the pattern taken over two separate survey periods that were separated by around one month (Figure 2). Where several recordings (=sites) were made on the same night, those with cumulatively additional species were plotted first. Relative abundance of each species / call type is calculated as the proportion of nightly recordings that contain signals of that taxon (Table 6).

The accumulation curve reached eight species / call types after four bat detector nights in December 2011, and the addition of a further six survey nights in February 2012 added five species. While the curve appears to be approaching an asymptote, the plot also suggests that further taxa might still be added with additional survey nights because the asymptote is based on survey sites rather than nights. Obviously effort to detect non-echolocating fruit bats will likely add more chiropteran species, but further survey work will also help determine firstly whether there are additional echolocating bat species present and secondly what the unidentified call types may be attributed to if they can be captured.

At Suai, there were seven of 13 species with relatively high abundance (values of 0.8 and above). These included two species that forage widely in the open spaces above treetops (*21 sh.cFM, 25 cFM*; attributable to species of *Saccolaimus* and *Taphozous*, see Table 5); four species that forage in gaps and open spaces around stands of vegetation (*37 st.cFM, 41 st.cFM, 54 st.cFM, 63 st.cFM Miniopterus australis*) and one species that forages within and among stands of vegetation (*72 lCF Rhinolophus canuti timoriensis*). Most of these species roost in trees, suggesting that this resource is well supported in the locality, and also that caves are nearby for at least one of the species (*72 lCF Rhinolophus canuti timoriensis*). The other species present at lower abundance all roost in caves (*28 lCF Rhinolophus* aff. *philippinensis, 47 st.cFM, 55 sCF Hipposideros diadema, 86 lCF Rhinilophus celebensis parvus*), the latter has reduced detection potential because of its relatively high frequency. Thus, the values of relative abundance at Suai also reflect the more minor but important contribution of nearby cave habitats.

Species of conservation significance include two cave roosting species of horseshoe bat (Canut's horseshoe bat *Rhinolophus canuti timoriensis;* Timorese horseshoe bat *Rhinolophus montanus*). The recording of *R. montanus* is significant since it has only been recorded on two previous occasions: the site of first collection near Lequi Mia, south of Ermera (7-8 individuals; by Goodwin 1979), and calls from the Ira Chaupiti watercourse on the southern side of the Paitchau Range (Armstrong 2007). Canut's horseshoe bat *R. canuti* was

commonly encountered in the acoustic and trapping surveys of Pavey and Milne (2004) and Armstrong (2007), but there is no information on how widespread this species is outside of the most forested areas in the east of Timor-Leste. It roosts in caves during the day, and will be dependent on them for persistence in a local area. Both this and other species of horseshoe bat are likely to be sensitive to human disturbance of colonies in caves.

The presence of *Rhinolophus* species plus the Diadem leaf-nosed bat *Hipposideros diadema* also suggests that other cave roosting bat species are present at Suai. While no calls of the other two *Hipposideros* were recorded, the survey effort to date is possibly insufficient to rule out their presence, and their apparent absence may also be partly a function of their ultra-high frequency calls (over 100 kHz in both cases) that cannot be detected at the same distance as the lower frequency calls of other species. There is also likely to be one or more species of bent-winged bat *Miniopterus* sp. present and some of the unallocated call types are almost certainly attributable to this genus. Bent-winged bats tend to have large home ranges and are known to migrate in other countries (e.g. Dwyer 1969; Cardinal and Christidis 2000; Rodrigues et al. 2010), so the roost site of any *Miniopterus* identified in the project area could be a reasonable distance away. Conversely, the presence of *Hipposideros* or *Rhinolophus* would suggest that caves are relatively close by, given their flight morphology that is typical of agile fliers that do not travel large distances nightly (e.g. Norberg and Rayner 1987; Kingston et al. 2003).

There was a general paucity of species that forage within stands of vegetation, with the exception of the species of horseshoe bat *Rhinolophus* spp. encountered. Calls of relatively short duration and large bandwidth (calls types *bFM*, *st.sFM.d*) suitable for foraging in this structural habitat (e.g. Denzinger et al. 2004) and that could be attributable to taxonomically unresolved species of *Harpiocephalus, Kerivoula, Murina* and *Nyctophilus* were not detected, possibly because the habitats surveyed were not suitable for these species, but it could also reflect the relatively low survey effort or call detectability. Such call types are typically emitted at relatively low amplitude, and are thus less detectable (have a shorter detection range) than other call types, requiring greater effort to encounter them.

The low frequency calls (< 30 kHz) attributed to species of sheath-tailed bats *Saccolaimus saccolaimus* and tomb bats *Taphozous achates* and *T. melanopogon* were difficult to distinguish because of the variability in call structure and characteristic frequency. It is likely that all three species were present, though better quality anonymous recordings and reference calls would help with identification in the future. While there were only three candidate species for the three unallocated low frequency call types, the characteristic frequency of *T. achates* is not known, and *S. saccolaimus* produces calls with a characteristic frequency ranging by 5 kHz or more across its range throughout South East Asia and Australasia (Milne et al. 2009; Corben 2010), overlapping with one of the two *Taphozous* species in this case. All three species were commonly recorded foraging in the open spaces above the sites, though roost sites might be some distance away given their good capacity for relatively long distance flight.

The calls of many vespertilionids and miniopterids are often difficult to distinguish because of their similar structure (*st.cFM*), undocumented characteristic frequencies and geographic variation preventing direct comparison with the same species on other islands. It is possible that several species attributable to *Miniopterus, Pipistrellus, Scotophilus* and *Scotorepens*

were present based on the observation of the six *st.cFM* call types. Further good quality recordings and capture effort will likely help with the attribution of species names to some of the call types documented in the survey. While all species to which this general call type are attributable are not listed in a Threatened conservation category, several of them (*Miniopterus* spp.) form large colonies in caves and may be vulnerable to disturbance if this habitat is removed or modified, or if an increase in human presence because of the project activities leads to increased cave visitation and thus colony disturbance.

5.0 CONCLUSIONS

1. At least 14 echolocating bat species are present at the survey sites (6 -13 species depending on the site and taking into account survey effort), representing six species that were able to be identified, and eight species that need some additional follow up capture work to confirm their identity. The latter can be identified retrospectively at each site based on the call classification system used.

2. One of the detected species is listed in a Threatened category: Canut's horseshoe bat *Rhinolophus canuti timoriensis* (Vulnerable B1ab(iii)), which is also represented as an endemic taxon (at subspecies level) on Timor. It had high relative abundance at Suai, suggesting the presence of nearby caves containing colonies of reasonable size, and was also present at Betano and Viqueque.

3. Four species that are not currently listed by the IUCN for lack of information were either confirmed as being present—*Rhinolophus montanus* (DD)—or considered likely to be present pending further confirmation by fieldwork and attribution of echolocation call types—*Taphozous achates* (DD); *Rhinolophus* aff. *philippinensis* (NE); *Pipistrellus* sp. aff. *tenuis* (NE). While these species are not currently listed, they may represent endemics, have limited distribution on the island and be subject to threatening processes that have not yet been identified formally.

4. The number of endemic species or subspecies confirmed from the project area was three—*Rhinolophus canuti timoriensis, Rhinolophus montanus, Rhinolophus celebensis parvus*; while a further two might be present if their identification from echolocation calls and taxonomy can be confirmed—*Rhinolophus* aff. *philippinensis*; *Pipistrellus* sp. aff. *tenuis.* The list of other endemics that might also be present pending further survey (and taxonomic) effort includes: cave roosting species *Hipposideros bicolor hilli* and *Hipposideros sumbae rotiensis*; and forest roosting species *Harpiocephalus* aff. *harpia, Kerivoula* sp., *Murina* aff. *florium,* and *Nyctophilus* sp.

5. The diversity of echolocating bat species in the project was relatively high and indicative of reasonably intact habitats, though species that prefer primary undisturbed forest or thicker stands of vegetation were absent. To some degree this might be a function of their detectability (because of their low amplitude calls), but further survey effort would provide better evidence of their apparent absence.

6. At least six species of cave roosting bat were recorded and identified to species (species of *Rhinolophus; Hipposideros* diadema, *Miniopterus australis*), with several others likely (other *Miniopterus* spp.; *Taphozous* spp.). Thus, at least half of the 14 echolocating bat species recorded on the survey use caves for daytime roosting. Careful management of cave habitat will be an important consideration in the proposed project because of the presence of endemics, Threatened species, taxonomically unresolved forms with undefined conservation status, large aggregations (bat colonies) with high vulnerability to a single event of human disturbance, and the long term importance of such structures for animal populations in a landscape that may have limited replication (i.e. alternative habitat) elsewhere.

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Table 1. Summary of bat species known from the island of Timor, with notes on their identification and IUCN conservation status.

Species[1]	**Comment on taxonomy, identification and presence on Timor**	**IUCN status**[2]
Family Pteropodidae (Fruit bats and flying-foxes)		
Sunda fruit bat *Acerodon mackloti*	Confirmed, recently collected by Helgen (2004) near Lospalos.	Vulnerable A3cd
Indonesian short-nosed fruit bat *Cynopterus titthaecheilus*	Captured by both Pavey and Milne (2004) and Armstrong (2007), accepted to be on Timor.	LC
Moluccan naked-backed fruit bat *Dobsonia moluccensis*	Unpublished observations on a single museum specimen by Helgen (2004), no published accounts, record doubtful. Closest record is Roti Island (Corbet and Hill 1992).	LC
Western naked-backed fruit bat *Dobsonia peronii peronii*	Observed at Lenahara cave by Pavey and Milne (2004), accepted to be on Timor.	LC
Lesser dawn bat *Eonycteris spelaea*	Captured by Pavey and Milne (2004), accepted to be on Timor.	LC
Dagger-toothed long-nosed fruit bat *Macroglossus minimus*	Captured by Armstrong (2007), accepted to be on Timor.	LC
Keast's tube-nosed fruit bat *Nyctimene keasti*	No records on Timor since Andersen (1912 cited in Goodwin 1979). See Simmons (2005) for taxonomy cf. *N. cephalotes.*	Vulnerable B1ab(ii,iii)
Gray flying-fox *Pteropus griseus*	Records accepted (Goodwin 1979, Corbet and Hill 1992, Simmons 2005). Collected by Pavey and Milne (2004).	DD
Lombok flying-fox *Pteropus lombocensis*	Not included by Corbet and Hill (1992) but present according to Kitchener and Suyanto (1996), review of Simmons (2005).	DD
Temminck's flying-fox *Pteropus temminckii*	Record doubtful (Simmons 2005).	Vulnerable A2c
Large flying-fox *Pteropus vampyrus*	Records accepted (Goodwin 1979, Corbet and Hill 1992).	NT
Geoffroy's rousette *Rousettus amplexicaudatus*	Captured by both Pavey and Milne (2004) and Armstrong (2007), accepted to be on Timor.	LC

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Table 1. Summary of bat species known from the island of Timor, *continued*.

Species[1]	Comment on taxonomy, identification and presence on Timor	IUCN status[2]
Family Emballonuridae (Sheath-tailed bats)		
Bare-rumped sheath-tailed bat *Saccolaimus saccolaimus*	Accepted to be on Timor (Simmons 2005)	LC
Indonesian tomb bat *Taphozous achates*	Collected from West Timor (Kitchener and Suyanto 1995). Nominate species on other islands in Nusa Tenggara.	DD
Black-bearded tomb bat *Taphozous melanopogon*	Accepted to be on Timor (Simmons 2005).	LC
Family Rhinolophidae (Horseshoe bats)		
Canut's horseshoe bat *Rhinolophus canuti timoriensis*	Captured by both Pavey and Milne (2004) and Armstrong (2007), accepted to be on Timor. Taxonomy follows Csorba et al. (2003).	Vulnerable B1ab(iii) *E
Sulawesi horseshoe bat *Rhinolophus celebensis parvus*	Captured by Pavey and Milne (2004) and echolocation calls recorded by Armstrong (2007), accepted to be on Timor. Taxonomy follows Csorba et al. (2003).	LC *E
Timorese horseshoe bat *Rhinolophus montanus*	Described by Goodwin (1979) as a taxon distinct from *R. philippinensis*, elevated to species status by Csorba (2002) and Csorba et al. (2003). Echolocation calls recorded by Armstrong (2007), endemic to Timor.	DD *E
Unidentified Large-eared horseshoe bat *Rhinolophus* aff. *philippinensis*	Captured, and echolocation calls recorded by Armstrong (2007), currently under taxonomic investigation (Armstrong et al. ms in prep.). Calls distinct from *R. montanus*. Might be referrable to either *R. p. achilles*, *R. p. maros* or a new taxon.	NE *E?
Family Hipposideridae (Leaf-nosed bats)		
Bicoloured leaf-nosed bat *Hipposideros bicolor hilli*	Captured by both Pavey and Milne (2004) and Armstrong (2007), accepted to be on Timor (Goodwin 1979; Kitchener et al. 1996).	LC *E
Diadem leaf-nosed bat *Hipposideros diadema diadema*	Captured by both Pavey and Milne (2004) and Armstrong (2007), accepted to be on Timor (Simmons 2005). Timor is the type locality of this species.	LC
Sumban leaf-nosed bat *Hipposideros sumbae* aff. *rotiensis*	Captured by both Pavey and Milne (2004) and Armstrong (2007), accepted to be on Timor. Kitchener and Maryanto (1993) examined a single specimen from Campalong in West Timor and referred it to the subspecies *rotienesis*, pending further collection.	LC *E?

Continued next page ...

Table 1. Summary of bat species known from the island of Timor, *continued*. *See over for footnotes ...*

Species[1]	Comment on taxonomy, identification and presence on Timor	IUCN status[2]
Family Vespertilionidae (Evening bats)		
Unidentified Hairy-winged bat *Harpiocephalus* aff. *harpia*	Captured by both Pavey and Milne (2004) and Armstrong (2007) and designated as *Murina* aff. *cyclotis*. Subsequent examination shows this to be either *Harpiocephalus harpia* or a related new species on the basis of skull features (Armstrong et al. ms in prep.).	NE *[E?]
Unidentified woolly bat *Kerivoula* sp.	Captured by both Pavey and Milne (2004) and Armstrong (2007). Species status still under investigation (Armstrong et al. ms in prep.).	NE *[E?]
Unidentified tube-nosed bat *Murina* aff. *florium*	First captured by Pavey and Milne (2004), specimens undergoing further examination (Armstrong et al. ms in prep.).	NE *[E?]
Large-footed myotis *Myotis adversus adversus*	Recorded to date from West Timor only (Kitchener et al. 1995).	LC
Unidentified long-eared bat *Nyctophilus* sp.	Specimens collected from near Maubisse (Helgen 2004) are possibly *Nyctophilus heran* which is on Lembata Island (Kitchener et al. 1991b), unlikely to be the same species as in Australasia, which was until recently (Parnaby 2009) known as *N. timoriensis*.	NE *[E?]
Unidentified pipistrelle *Pipistrellus sp.*	Widespread, occurs around villages, see comments in Goodwin (1979), Simmons (2005). Genetic studies recently suggested that the form resembling *P. tenuis* captured by Armstrong (2007) is not this taxon, and taxonomic status is undergoing further examination (Armstrong et al. ms in prep.).	NE *[E?]
Sody's yellow house bat *Scotophilus collinus*	See Simmons (2005) for taxonomic summary – *S. kuhlii* not on Timor. Captured by Pavey and Milne (2004) but misidentified as a possible new species of *Taphozous*.	LC
Northern broad-nosed bat *Scotorepens sanborni*	Collected from West Timor only (Kitchener et al. 1994). Present in New Guinea (Bonaccorso 1998) and northern Australia (Churchill 2008), likely to be found across Timor.	LC
Greater bamboo bat *Tylonycteris robustula*	Present on basis of two historical specimens in the BMNH (London) labelled as being from Timor (Goodwin 1979). No other records.	LC
Family Miniopteridae (Bent-winged bats)		
Little bent-winged bat *Miniopterus australis*	Captured by both Pavey and Milne (2004) and Armstrong (2007), accepted to be on Timor.	LC
Large bent-winged bat *Miniopterus magnater*	Present according to Simmons (2005).	LC
Australasian bent-winged bat *Miniopterus oceanensis*	Captured by both Pavey and Milne (2004) and Armstrong (2007). Previously referred to as *M. schreibersii*, updated according to Appleton et al. (2004) and Tian et al. (2004).	LC
Small bent-winged bat *Miniopterus pusillus*	Captured by Pavey and Milne (2004), distinct subspecies on Timor (Kitchener and Suyanto 2002; Simmons 2005).	LC

[1] Nomenclature follows IUCN (2012) preferentially, then Simmons (2005). [2] IUCN (International Union for Conservation of Nature) conservation status (IUCN 2012). DD: Data Deficient; LC: Least Concern; NT: Near Threatened; NE: Not Evaluated, no conservation status yet available. Taxa that are potentially new to science are given a status of NE. *[E] denotes endemic species or subspecies on Timor island, and *[E?] denotes possible endemic taxon, pending further taxonomic study (e.g. Armstrong et al ms in prep.).

Table 2. Species identified at each site from overnight recordings made with AnaBat detectors (raw results; NC: needs confirmation).

Date	Serial	Site	Site code	Habitat	UTM	*18 sh.cFM*	*21 sh.cFM*	*25 cFM*	*32 st.cFM*	*37 st.cFM*	*28 ICF R. aff. philippinensis*	*38 ICF Rhinolophus montanus*	*41 st.cFM*	*47 st.cFM*	*54 st.cFM*	*55 sCF Hipposideros diadema*	*63 st.cFM Miniopterus australis*	*72 ICF Rhinolophus canuti*	*86 ICF Rhinolophus celebensis*
10/12/2011	5334	Suai	–	–	–	◆	◆	◆	–	◆		–	◆		–	–	–	–	–
11/12/2011	80095	Suai	–	–	–	–	◆	◆	–	–		–	◆		◆	–	◆	◆	–
12/12/2011	5334	Suai	–	–	–	◆	◆	◆	–	◆		–	◆		◆	–	◆	–	–
12/12/2011	80095	Suai	–	–	–	◆	◆	◆	–	◆		–	◆		◆	–	◆	◆	–
16/12/2011	80095	Betano	AN9	Hilltop / woodland	51L 802026 8986789	◆	◆	◆	◆	◆		◆	◆		◆	◆	◆	◆	◆
16/12/2011	81220	Betano	AN8	Woodland	51L 802663 8986322	–	◆	◆	–	◆		–	◆		◆	–	◆	–	◆
19/12/2011	5334	Beacu	AN14	Near coastal scrub	51L 217134 9010159	◆	◆	◆	–	–		–	◆		◆	–	◆	–	–
7/02/2012	5334	Suai	AN15	Woodland	51L 752256 8971670	–	◆	◆	◆	◆	–	–	◆	–	◆	–	◆	◆	◆
7/02/2012	80095	Suai	AN16	Woodland	51L 753670 8972774	–	◆	◆	◆	◆	–	–	◆	◆	◆	◆	◆	◆	◆
8/02/2012	5334	Suai	AN15	Woodland	51L 752256 8971670	–	◆	◆	–	◆	–	–	◆	–	◆	–	◆	◆	–
8/02/2012	80100	Suai	AN17	Open water / dam	51L 755080 8971473	–	◆	–	◆	◆	–	–	◆	◆	◆	◆	◆	◆	◆
8/02/2012	81220	Suai	AN18	Large fig trees	51L 754700 8972975	–	◆	◆	◆	–	NC	–	◆	–	◆	–	◆	◆	◆
13/02/2012	80100	Viqueque	AN23	Low hill / grassland	52L 211964 9018060	–	◆	◆	◆	◆	–	–	◆	◆	◆	◆	◆	◆	◆

Table 3. Summary of variables from representative call sequences of the species identified and the call types recognised.

Species (FM body type)	**s,p[1]**	**Duration (msec)[2]**	**Max Frequency (kHz)[2]**	**Char frequency (kHz)[2]**
18 sh.cFM	7,30	11.3 ± 3.3 7.1 – 20.6	18.8 ± 1.7 16.3 – 21.0	17.9 ± 1.4 15.8 – 19.9
21 sh.cFM	4,17	10.1 ± 2.1 7.1 – 14.3	22.9 ± 1.0 21.4 – 25.1	21.5 ± 0.4 20.6 – 22.1
25 cFM	3,13	8.2 ± 2.2 4.7 – 12.3	27.7 ± 2.1 26.0 – 32.4	24.8 ± 0.8 23.7 – 26.3
32 st.cFM	4,84	5.8 ± 1.6 3.0 – 10.3	40.4 ± 7.8 31.1 – 60.2	31.8 ± 0.8 29.5 – 33.5
37 st.cFM	4,35	4.9 ± 1.3 3.2 – 8.1	41.6 ± 3.6 37.0 – 51.6	37.3 ± 0.7 36.4 – 39.2
41 st.cFM	9,82	6.5 ± 2.3 3.1 – 14.0	46.4 ± 6.0 41.0 – 64.0	41.5 ± 1.0 39.0 – 44.4
47 st.cFM	3,39	5.0 ± 1.1 3.0 – 7.1	50.0 ± 3.8 44.9 – 59.3	46.5 ± 1.7 44.0 – 49.7
54 st.cFM	7,50	3.4 ± 0.6 2.0 – 5.4	65.2 ± 6.0 54.1 – 80.0	54.0 ± 0.9 51.3 – 55.9
63 st.cFM Little long-fingered bat *Miniopterus australis*	9,50	4.8 ± 1.4 3.1 – 9.8	70.5 ± 5.1 62.5 – 82.5	62.7 ± 1.1 60.6 – 65.0
Species (CF body type)	**s,p[1]**	**Duration (msec)[3]**		**Char frequency (kHz)[4]**
28 lCF Large-eared Horseshoe bat *Rhinolophus* aff. *philippinensis*	1,1	50+	—	27.8
38 lCF Timorese horseshoe bat *Rhinolophus montanus*	4,10	69+	—	38.1 ± 0.8 36.4 – 39.8
55 sCF Diadem leaf-nosed bat *Hipposideros diadema diadema*	5,24	13.5 ± 2.2 10.4 – 18.2	—	54.6 ± 0.4 53.7 – 55.2
72 lCF Canut's horseshoe bat *Rhinolophus canuti timoriensis*	5,58	9.2 ± 17.1 0.2 – 65.2	—	71.1 ± 0.8 69.6 – 72.7
86 lCF Sulawesi horseshoe bat *Rhinolophus celebensis parvus*	1,3	36+	—	86.0 ± 0.6 85.1 – 87.9

[1] s,p: number of sequences measured, combined total number of pulses measured; [2] Mean ± SD; range; [3] Mean ± SD; range; partial calls only were available for some species; [4] The frequency with the greatest or peak number of cycles, designated as 'Fpz' in AnalookW; Mean ± SD; range.

Table 4. Echolocation call categories based on the morphology of the dominant type of search-phase pulses in high quality sequences (adapted from de Oliveira (1998a,b) and Corben and O'Farrell (1999); examples are not scaled equally). Pulses generally consist of three main sections: an initial frequency sweep (IFS), followed by the main body (BST: Body Sub Type), and ending in a terminating frequency sweep (TFS). The shape of the pulse is represented by the codes in the form '*IFS.BST.TFS*', prefixed by a value representing the mean characteristic frequency in kHz. Note that most CF pulses have a recognisable initial upward frequency sweep, and all have a terminating frequency sweep, so the IFS and TFS descriptors are not used for this Body Sub Type.

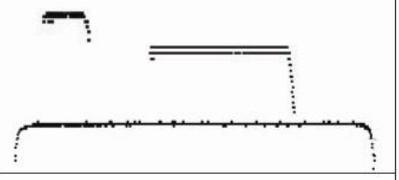
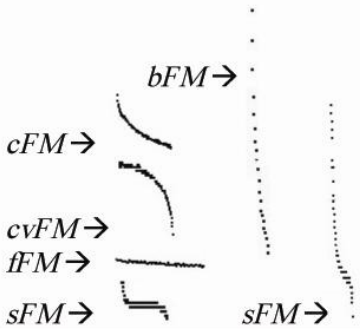
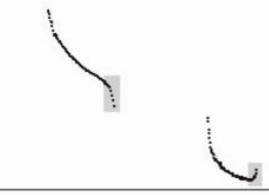
Code	Description	Example
CF	**Constant Frequency main Body Sub Type (BST)**	
sCF	Short duration (<15 ms)	
mCF	Medium duration (15 – 30 ms)	
lCF	Long duration (>30 ms)	
FM	**Frequency Modulated main Body Sub Type (BST)**	
bFM	Broadband, slightest degree of curvature only, no significant development of serpentine component (*sFM*)	*bFM*→
cFM	Curved, simple or curvilinear trace	*cFM*→
cvFM	Convex curved, essentially cFM rotated 180°	*cvFM*→
fFM	Flat or with a very slight curve, narrowband, not *CF*	*fFM*→
sFM	Serpentine, generally S-shaped	*sFM*→ *sFM*→
	Initial Frequency Sweep (IFS)	
i.	Inclined, a narrowband increasing frequency sweep	
sh.	Short, shallow or narrowband frequency sweep	
st.	Steeply decreasing, broadband frequency sweep	
	Terminating Frequency Sweep (TFS)	
.d	Drooped, decreasing frequency sweep following the characteristic frequency in the main body of the call	
.h	Hooked, increasing in frequency following the characteristic frequency	

Table 5. Comments on the taxonomic identification of the bat call types defined in this survey.

18 sh.cFM	Most likely attributable to the bare-rumped sheath-tailed bat *Saccolaimus saccolaimus* on the basis of call frequency, and also the commonly observed pattern of alternating the characteristic frequency in successive pulses (e.g. Milne et al. 2009). Capture or observation in a spotlight of bats in flight would be required for confirmation.
21 sh.cFM	Attributable to one of the sheath-tailed bats on Timor: either the Indonesian tomb bat *Taphozous achates*, the call of which has not yet been characterised; or the bare-rumped sheath-tailed bat *Saccolaimus saccolaimus*, which produces a variety of call types. One or both of these species might produce this call type. Capture or observation in a spotlight of bats in flight would be required for confirmation.
25 cFM	Most likely attributable to the black-bearded tomb bat *Taphozous melanopogon* based on reference calls described in Pottie et al. (2005) and other unpublished information, however reference calls are not available from Timor, and have not been compared with those from *T. achates*. The call type designation should be used until further information is available for a confident retrospective identification, since there may be geographic variation in characteristic call frequency and/or taxonomic issues that will have a bearing on this identification.
32 st.cFM	Possibly attributable to a large vespertilionid such as Sody's yellow house bat *Scotophilus collinus* (cf. the calls of *S. kuhlii* in Pottie et al. 2005). Capture would be required for identification.
37 st.cFM	Most likely attributable to a large species of bent-winged bat such as the western long-fingered bat *Miniopterus magnater*, based on the similarity of the characteristic frequency with calls of this species in New Guinea (K.P. Aplin and K.N. Armstrong unpublished data), or one of the larger vespertilionids such as *Scotophilus collinus* (cf. the calls of *S. kuhlii* in Pottie et al. 2005). Capture, and possibly DNA barcoding if the bat was a *Miniopterus*, would be required for identification.
28 lCF Rhinolophus* aff. *philippinensis	One very poor quality call sequence had signals with characteristics indicating the possible presence of a previously unrecognised species of *Rhinolophus* in the *philippinensis* group, as first discovered by Armstrong (2007). The taxonomic affiliation of this form has yet to be established, and it may be referrable to *R. philippinensis achilles*, *R. p. maros*, or a taxon new to science.
38 lCF Rhinolophus montanus	Attributable with high confidence to the Timorese horseshoe bat *Rhinolophus montanus* based on the remarkably low characteristic frequency and long duration of calls. While reference calls are not available for *R. montanus*, this species belongs to the *philippinensis* group of *Rhinolophus* that typically produce calls with a characteristic frequency somewhere below 45 kHz. The other undescribed *philippinensis*-group *Rhinolophus* also present on Timor is larger and produces calls with a characteristic frequency of c. 27 kHz (Armstrong et al. ms in prep.), allowing *R. montanus* to be identified through a process of elimination.

Continued next page ...

Table 5. Comments on the taxonomic identification of the bat call types, *continued*.

41 st.cFM	One of several candidate species in the Miniopteridae or Vespertilionidae. Capture, and possibly DNA barcoding if the bat was a *Miniopterus*, would be required for identification.
47 st.cFM	One of several candidate species in the Miniopteridae or Vespertilionidae. Some echolocation calls had a body type of *sFM*, typical of *Miniopterus*. Capture, and possibly DNA barcoding if the bat was a *Miniopterus*, would be required for identification.
54 st.cFM	One of several candidate species in the Miniopteridae or Vespertilionidae. Capture, and possibly DNA barcoding if the bat was a *Miniopterus*, would be required for identification.
63 st.cFM Miniopterus australis	One of several candidate species in the Miniopteridae or Vespertilionidae. Based on reference calls collected by Armstrong (2007), this call could be attributable to the little long-fingered bat *Miniopterus australis*. Capture, and possibly DNA barcoding if the bat was a *Miniopterus*, would be required for identification.
55 sCF Hipposideros diadema diadema	Attributable based on reference calls collected by Armstrong (2007) and elsewhere such as in Papua New Guinea (Leary and Pennay 2011).
72 lCF Rhinolophus canuti timoriensis	Attributable based on reference calls collected by Armstrong (2007).
86 lCF Rhinolophus celebensis parvus	Attributable based on calls collected by Pavey and Milne (2004) and Armstrong (2007).

Table 6. Summary of species identified at each locality from overnight recordings made with AnaBat detectors (NC: needs confirmation). The relative abundance (RA) of each species is given for Suai, based on the proportion of observations over 9 AnaBat recording nights.

	Beacu	**Betano**	**Suai**	**(RA)**	**Viqueque**
18 sh.cFM	◆	◆	◆	0.3	–
21 sh.cFM	◆	◆	◆	1	◆
25 cFM	◆	◆	◆	0.9	◆
32 st.cFM	–	◆	◆	0.4	◆
37 st.cFM	–	◆	◆	0.8	◆
28 lCF R. aff. *philippinensis*	–	–	NC	0.1	–
38 lCF Rhinolophus montanus	–	◆	–	0	–
41 st.cFM	◆	◆	◆	1	◆
47 st.cFM	–	–	◆	0.2	◆
54 st.cFM	◆	◆	◆	0.9	◆
55 sCF Hipposideros diadema	–	◆	◆	0.2	◆
63 st.cFM Miniopterus australis	◆	◆	◆	0.9	◆
72 lCF Rhinolophus canuti	–	◆	◆	0.8	◆
86 lCF Rhinolophus celebensis	–	◆	◆	0.4	◆
No. AnaBat nights	1	2	9		1
Total richness	6	12	13		11

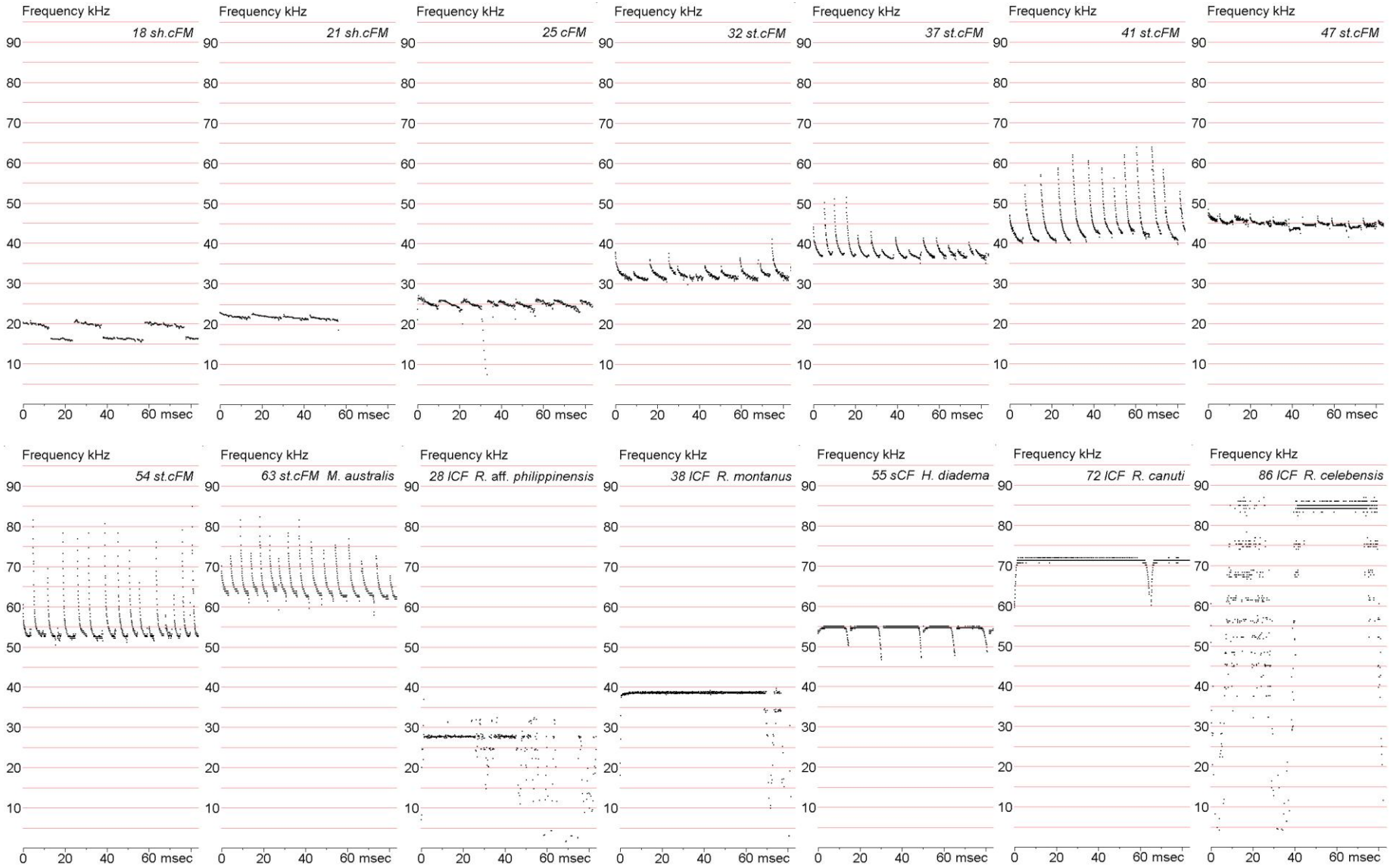


Figure 1. Representative call sequences of the species identified (time is compressed between pulses).

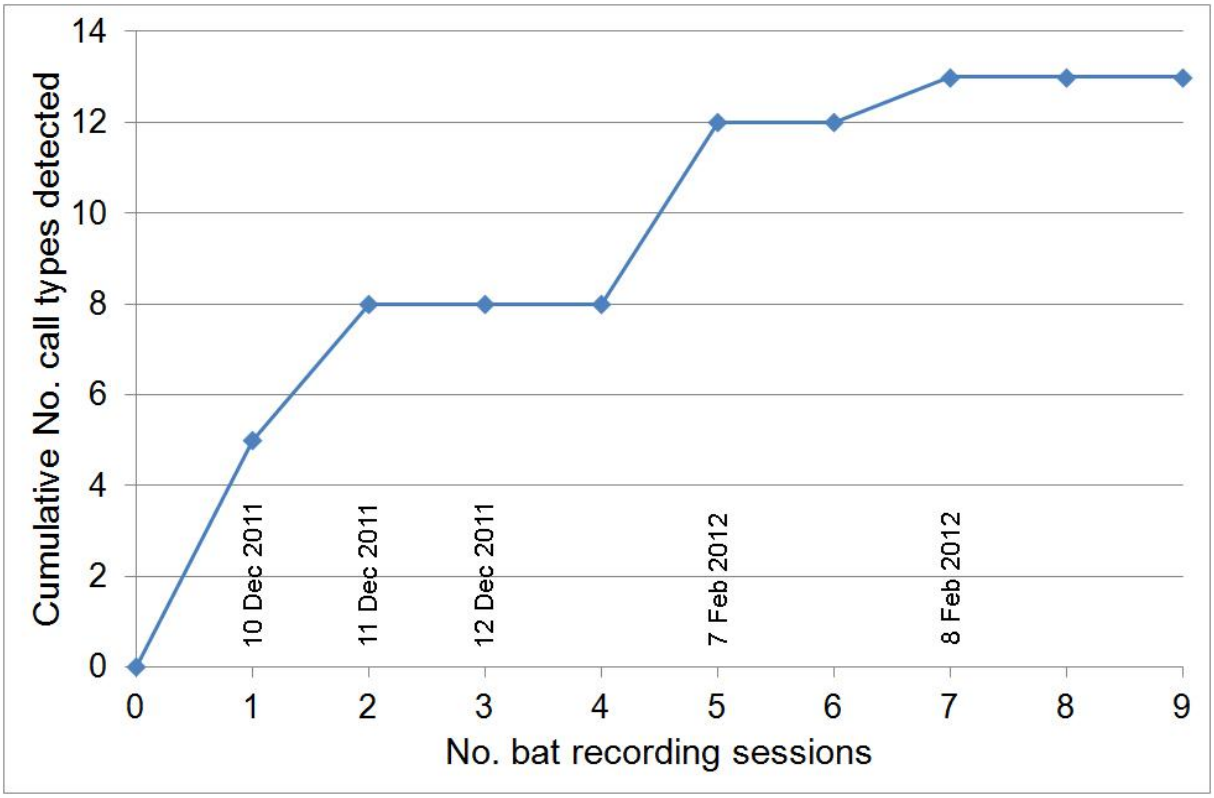


Figure 2. Species accumulation curve for Suai, based on surveys in December 2011 and February 2012. Multiple deployments were in different habitats at Suai on 12 Dec 2011, 7 Feb 2012 and 8 Feb 2012.

Appendix 7 – Conservation Significant Fauna Species Risk Assessment

Species	Conservation Significance				Distribution and Ecology	Regional Context	Likelihood of Occurrence
	IUCN	Endemic	CITES	Introduced			
Mauremys reevesii Reeves' Turtle	EN			x	*Mauremys reevesii* is native to most of temperate and subtropical China, North Korea and South Korea; populations also occur in Taiwan, Hong Kong and Japan, though these may be historic introductions by humans (Fong and Chen 2010). Populations recorded from Timor (Indonesia), Timor-Leste and Palau certainly originated from human introductions. Historically a common and widespread species, *Mauremys reevesii* is now a rare species in the wild. This species natural habitat includes shallow wetlands and the land that immediately surrounds them.	This species presence in Timor-Leste is due to historic human introduction and is far outside its nominal distribution. No wetland habitat type exists in the project area suitable for this species to become resident.	Unlikely
Fregata andrewsi Christmas Island Frigatebird	CR		App I		The Christmas Island Frigatebird *Fregata andrewsi* is the rarest of the five species of the family Fregatidae and breeds only on Christmas Island. When not breeding, Christmas Island Frigatebirds range widely around South-east Asia and the Indian Ocean, and are occasional visitors to the shores of Java, Sumatra, Bali, Borneo, the Andaman Is, Darwin and the Cocos (Keeling) Islands (Gore 1968, Marchant and Higgins 1990). It is possible the young birds are nomadic and wander widely until they reach breeding age; however, adults have also been seen far away from the island. It	An uncommon vagrant to Timor-Leste. There have been two recent records for Timor-Leste: a male at Cristo Rei 1 March 2003 and a female at Comoro River on 11 March 2006.	Possible

Species	Conservation Significance				Distribution and Ecology	Regional Context	Likelihood of Occurrence
	IUCN	Endemic	CITES	Introduced			
					has been speculated they may breed somewhere in the Anamba-Natuna islands (Chasen 1933, Gibson-Hill 1947), but this was based only on sightings in the vicinity of these islands.		
Esacus magnirostris Beach Thick-knee	NT				The Beach Thick-knee is widespread around coasts from the Andaman Islands, India, Mergui Archipelago, Myanmar, islands off peninsular Thailand, and Peninsular Malaysia through Indonesia, Brunei, the Philippines, Papua New Guinea, the Solomon Islands, Vanuatu, New Caledonia (to France) and Australia. Pairs may be found on most beaches within its range; including short stretches of muddy sand among mangroves, coralline sands on atolls and prime surf beaches (Garnett and Crowley 2000). Beaches associated with estuaries and mangroves are particularly favoured. Adults are sedentary, although the species has a tendency for wide-ranging vagrancy. It lays a single egg in a scrape in the sand at the landward edge of the beach, often using the same area repeatedly. It forages mainly in the intertidal zone on crustaceans and other invertebrates (Garnett and Crowley 2000). This species qualifies as Near Threatened because it has a small population. If the population is found to be in decline it might qualify for up listing	One individual was recorded at one location within the Suai development area; this record was in the coastal mangroves of the development area. The project area lies within this species expected distribution. The Beach Thick-knee is expected to be found within the marine coastal environments / habitats of the project area.	Recorded

Species	Conservation Significance				Distribution and Ecology	Regional Context	Likelihood of Occurrence
	IUCN	Endemic	CITES	Introduced			
					to a higher threat category.		
Charadrius peronii Malaysian Plover	NT				The Malaysian Plover is a breeding resident in Vietnam (scarce in Cochinchina), Cambodia (rare), peninsular Thailand (local and uncommon), Peninsular Malaysia (scarce to locally common), East Malaysia, Singapore (rare), Brunei (apparently declining), Philippines (widespread but uncommon) and Indonesia (local around coasts and offshore islands of Sumatra, uncommon on and around Borneo and Bali, very rare on mainland Java; uncommon and sparsely distributed in the Lesser Sundas and the Sulawesi subregion). It frequents quiet sandy bays, coral sand beaches, open dunes and artificial sand-fills, where it lives in pairs, generally not mixing with other waders. This species is classified as Near Threatened because it is likely to have a moderately small population which, owing to the development pressures on the coastal areas it inhabits, is likely to be undergoing a decline.	This species typical distribution and migratory pathways are outside the project area and its general vicinity. Potential to be an uncommon vagrant.	Possible
Charadrius javanicus Javan Plover	NT				The Javan Plover is typically restricted to Java and the Kangean Islands in Indonesia; this species may be found as a vagrant in Timor Leste. The taxonomic status of this species is extremely unclear and records attributable to it are therefore sparse;	This species may be an uncommon vagrant to Timor Leste. Suitable marine coastal foraging habitat is	Possible

Species	Conservation Significance				Distribution and Ecology	Regional Context	Likelihood of Occurrence
	IUCN	Endemic	CITES	Introduced			
					nevertheless, it was recently found common in southern Madura. Whilst it may prove widespread, its population is likely to be small and declining. It occurs on sandy beaches, mudflats and adjacent open areas around the coasts. This species has a narrow range in which development and recreation are putting pressure on critical breeding habitats. It is likely to have a moderately small population, and this is thought to be declining; it is consequently classified as Near Threatened.	present	
Numenius madagascariensis Far Eastern Curlew	VU				The Far Eastern Curlew breeds in eastern Russia, from the upper reaches of the Nizhnyaya Tunguska river east though the Verkhoyarsk mountains to Kamchatka, and south to Primorye and north-eastern Mongolia. It has been recorded as a non-breeding visitor to Japan, North Korea, South Korea, mainland China, Hong Kong (China), Brunei, Bangladesh, Thailand, Vietnam, Philippines, Malaysia, Singapore, with most birds wintering in Australia, but also in Taiwan, Indonesia, Papua New Guinea, and New Zealand (del Hoyo *et al.* 1996). The species breeds on open mossy or transitional bogs, moss-lichen bogs and wet meadows, and on the swampy shores of small lakes; in the non-breeding season it is essentially coastal, occurring at estuaries,	Suitable foraging / sheltering habitat is present in the project area and within this species distribution and migratory pathways. This species may be expected to be found foraging and sheltering during its annual migration.	Likely

Species	Conservation Significance				Distribution and Ecology	Regional Context	Likelihood of Occurrence
	IUCN	Endemic	CITES	Introduced			
					mangrove swamps, saltmarshes and intertidal flats, particularly those with extensive seagrass (Zosteraceae) meadows. It often roosts in salt-marshes, behind mangroves, or on sandy beaches (del Hoyo *et al.* 1996). This species has been up listed to Vulnerable owing to a rapid population decline which is suspected to have been primarily driven by habitat loss and deterioration. Further proposed reclamation projects are predicted to cause additional declines in the future.		
Numenius arquata Eurasian Curlew	VU				Eurasian Curlew is widely distributed breeding across Europe from the British Isles, through north-western Europe and Scandinavia into Russia extending east into Siberia, east of Lake Baikal. It winters around the coasts of north-west Europe, the Mediterranean, Africa, the Middle East, the Indian Subcontinent, South-East Asia, Japan and the Sundas. The species breeds on upland moors, peat bogs, swampy and dry heathlands, fens, open grassy or boggy areas in forests, damp grasslands, meadows (del Hoyo et al. 1996), non-intensive farmland in river valleys (Hayman et al. 1986), dune valleys and coastal marshlands (del Hoyo et al. 1996). Non-breeding During the winter the species frequents muddy coasts, bays and estuaries	Suitable foraging / sheltering habitat is present in the project area and within this species distribution and migratory pathways. This species may be expected to be found foraging and sheltering during its annual migration.	Likely

Species	Conservation Significance				Distribution and Ecology	Regional Context	Likelihood of Occurrence
	IUCN	Endemic	CITES	Introduced			
					(del Hoyo et al. 1996) with tidal mudflats and sandflats (Snow and Perrins 1998), rocky and sandy beaches with many pools (Johnsgard 1981, Snow and Perrins 1998), mangroves, saltmarshes (Snow and Perrins 1998), coastal meadows (Johnsgard 1981)and muddy shores of coastal lagoons8, inland lakes and rivers (del Hoyo et al. 1996). This widespread species remains common in many parts of its range, and determining population trends is problematic. Nevertheless, declines have been recorded in several key populations and overall a moderately rapid global decline is estimated. As a result, the species has been uplisted to Near Threatened.		
Limosa limosa Black-tailed Godwit	NT				The Black-tailed Godwit has a large discontinuous breeding range extending from Iceland to the Russian far east, with wintering populations in Europe, Africa, the Middle East and Australasia (del Hoyo *et al*. (1996). The species migrates southwards between late-June and October Australasia (del Hoyo *et al*. (1996). In its breeding range it mostly inhabits areas with high grass and soft soil (del Hoyo *et al*. 1996, Johnsgard 1981), occasionally using sandy areas (Johnsgard 1981). This species tends to winter in freshwater habitats (del Hoyo *et al*.	Suitable foraging / sheltering habitat is present in the project area and within this species distribution and migratory pathways. This species may be expected to be found foraging and sheltering during its annual migration.	Likely

Species	Conservation Significance				Distribution and Ecology	Regional Context	Likelihood of Occurrence
	IUCN	Endemic	CITES	Introduced			
					(1996), including swampy lake shores, pools, flooded grassland and irrigated rice fields (del Hoyo *et al*. (1996). Subspecies *islandica* and *melanuroides*, however, often winter in brackish habitats (del Hoyo *et al*. (1996) such as sheltered estuaries and lagoons with large intertidal mudflats (Johnsgard 1981), sandy beaches, salt-marshes and salt-flats (del Hoyo *et al*. 1996). Although this species is widespread and has a large global population, its numbers have declined rapidly in parts of its range owing to changes in agricultural practices. Overall, the global population is estimated to be declining at such a rate that the species qualifies as Near Threatened.		
Calidris tenuirostris Great Knot	VU				The Great Knot breeds in north-east Siberia, Russia, wintering throughout the coastline of South-East Asia, and also on the coasts of Australia, India, Bangladesh, Pakistan, and the eastern coast of the Arabian Peninsula (del Hoyo *et al*. 1996). The species breeds on gravelly areas covered with lichen and patches of herbs, heather (del Hoyo *et al*. 1996), *Empetrum* spp., *Dryas* spp. and *Vaccinium* spp. (Johnsgard 1981), or alternatively on areas with a continuous layer of lichen and scattered stunted larch *Larix* spp. or dwarf pine *Pinus pumila* (del Hoyo *et al*. 1996). In	Suitable foraging / sheltering habitat is present in the project area and within this species distribution and migratory pathways. This species may be expected to be found foraging and sheltering during its annual migration.	Likely

Species	Conservation Significance				Distribution and Ecology	Regional Context	Likelihood of Occurrence
	IUCN	Endemic	CITES	Introduced			
					its wintering range the species occurs in sheltered coastal habitats such as inlets, bays, harbours, estuaries and lagoons with large intertidal mud and sandflats, oceanic sandy beaches with nearby mudflats (del Hoyo *et al*. 1996, Higgins and Davies 1996), sandy spits and islets, muddy shorelines with mangroves and occasionally exposed reefs or rock platforms (Higgins and Davies 1996). This species has been uplisted to Vulnerable owing to a rapid population decline caused by the reclamation of non-breeding stopover grounds, and under the assumption that further proposed reclamation projects will cause additional declines in the future.		
Limnodromus semipalmatus Asian Dowitcher	NT				Asian Dowitcher has a disjunct breeding range in the steppe regions that extend from west to east Siberia, Russia, and south into Mongolia and Heilongjiang in north-east China. It has been recorded as a non-breeding visitor to Japan, North Korea, South Korea, mainland China, Hong Kong (China), Taiwan (China), Kazakhstan, Uzbekistan, India, Bangladesh, Sri Lanka, Myanmar, Thailand, Vietnam, Philippines, Malaysia, Singapore, Brunei, Indonesia, Papua New Guinea, Australia and New Zealand. It breeds in extensive freshwater wetlands in the steppe and forest steppe	Suitable foraging / sheltering habitat is present in the project area and within this species distribution and migratory pathways. This species may be expected to be found foraging and sheltering during its annual migration.	Likely

Species	Conservation Significance				Distribution and Ecology	Regional Context	Likelihood of Occurrence
	IUCN	Endemic	CITES	Introduced			
					zones. Suitable habitats include lake shores, river deltas, flooded meadows and grassy bogs along rivers with short grass and sedge vegetation (del Hoyo *et al*. 1996), and areas of bare mud (Johnsgard 1981). During the non-breeding season it occurs in sheltered coastal environments, primarily estuarine and intertidal mudflats, lagoons, creeks and saltworks (del Hoyo *et al*. 1996). It will also roost on sandy beaches or in shallow lagoons during this season (del Hoyo *et al*. 1996). This species is classified as Near Threatened because, although it is quite widespread, it has a moderately small population overall and this is thought to be in decline, owing primarily to destruction of its wintering grounds. An even more rapid population decline may take place in the future owing to climate change.		
Turacoena modesta Slaty Cuckoo-Dove	NT				The Slaty Cuckoo-dove is restricted to Timor-Leste, West Timor and Wetar, Nusa Tenggara, Indonesia, where it is generally uncommon or rare. Historical records indicate that it was once fairly common, at least locally on Wetar and in West Timor, even near settlements. A paucity of recent records, despite extensive searching, suggests that a marked decline has occurred in West Timor. However, recent	The Slaty Cuckoo-dove was recorded on five occasions at Suai development area. This species is expected to forage and nest within the deciduous forest and woodlands of the project area.	Recorded

Species	Conservation Significance				Distribution and Ecology	Regional Context	Likelihood of Occurrence
	IUCN	Endemic	CITES	Introduced			
					survey work in Timor-Leste revealed it to be frequent in a wide range of habitats (Trainor *et al*. (2004). It inhabits primary and tall secondary monsoon-forest, often where this habitat is drier or more open, and also vine thickets, thickly vegetated gullies and eucalyptus woodland with dense understorey, from sea-level to 1,770 m (Trainor *et al*. 2007a, Mauro 2003). As it has been found in "more or less open areas near villages", it probably has a degree of tolerance to habitat degradation, and in Timor-Leste appears to be more common in patchy landscapes (forest edge, secondary forest, woodland with scattered figs, Eucalyptus savanna or non-Eucalyptus woodlands with tropical forest trees in gullies or on scattered rock outcrops) (Trainor *et al*. 2007a). This species is classified as Near Threatened because recent surveys in Timor-Leste have shown it to be more abundant than once feared, and to inhabit a wider range of habitats. However, it is still suspected to be declining moderately rapidly owing to the levels of hunting and rates of habitat loss, and it is therefore classified as Near Threatened.		
Gallicolumba hoedtii Wetar Ground-Dove	EN				The Wetar Ground Dove occurs in West Timor and Wetar, Nusa Tenggara, Indonesia, and Timor-Leste. This species is	This highly rare pigeon was recorded 20 km to	Possible

Species	Conservation Significance				Distribution and Ecology	Regional Context	Likelihood of Occurrence
	IUCN	Endemic	CITES	Introduced			
					one of the rarest pigeons in the world (Timor and Wetar) and may have specialised habitat requirements. In Timor-Leste, it was found in 2005 in spring forest at Foho Lulik, on the south coast near the Indonesian border (Lambert *et al.* 2006). No other regular sites are known anywhere, but traders in Dili indicated that captured birds were obtained from the Natarbora area, which includes a wild area of swamp forests, secondary forests and wetlands in the Sungai Clere region of Manufahi (Same) and Manatuto districts. Birds seen appeared to have a strong association with the spring habitat, but more survey work is needed on the broad coastal plain on Timor-Leste's south coast. It is believed to be absent from Nino Konis Santana National Park in the far-east (Lambert *et al.* 2006). It inhabits lowland monsoon-forest, and possibly woodland, up to 950 m. In West Timor two of the three records have been from "forest near a clearing" and "fairly undisturbed hill forest". Its habitat receives highly seasonal rainfall, but it is not known whether it makes any dispersive movements, e.g. in response to bamboo seeding events, as in several of its congeners (Trainor *et al.* 2007b). It is possible that this species is associated with bamboo, and thus partly nomadic (Lambert *et al.* 2006). Birds found recently in Timor-	the west of the Suai development area. Suitable habitat is present in the project area and despite being extremely rare this species can be expected to occur. Considering the rare appearance of this species in the wild determines that it may 'possibly' occur as opposed to 'likely'.	

Species	Conservation Significance				Distribution and Ecology	Regional Context	Likelihood of Occurrence
	IUCN	Endemic	CITES	Introduced			
					Leste were only found within gallery forest and remnant trees bordering a wide stream, suggesting wet forest - possibly even only that associated with flowing water - is important breeding habitat (Lambert *et al.* 2006). It has been presumed to be largely solitary and to forage on the ground like its congeners but it appears to call from, and nest in, the canopy (Lambert *et al.* 2006). It appears to be a dry-season breeder. This species qualifies as Endangered because it has suffered a very rapid population decline which is expected to continue as a result of severe lowland habitat loss and hunting. A healthy population may survive on Wetar, but further surveys are required to establish its current status.		
Treron psittaceus Timor Green-Pigeon	EN				The Timor Green-pigeon is endemic to Timor-Leste, West Timor and its satellite islands, Semau (though there is no recent data) and Roti, Nusa Tenggara, Indonesia, where it appears to be uncommon or rare, and apparently very local. It has been infrequently recorded during recent fieldwork, although it is perhaps overlooked owing to its inconspicuous and very wary disposition. It inhabits primary and tall secondary, lowland dry and monsoon-forest, mostly in the extreme lowlands, straggling up to 1,000 m (Mauro 2003,	This species is typical localised in their distribution and may be nomadic in response to the fruiting cycle of Fig trees. Suitable habitat is present in the project area and general vicinity, it is expected that this species may occur.	Likely

Species	Conservation Significance				Distribution and Ecology	Regional Context	Likelihood of Occurrence
	IUCN	Endemic	CITES	Introduced			
					Trainor and Soares 2004 and Trainor *et al.* 2007a). It may be nomadic in response to the fruiting cycle of figs, and is usually encountered in small flocks containing tens of birds, exceptionally up to 140 individuals (Trainor *et al.* 2007a). It is thought to have declined recently throughout West Timor, but is more common in Timor-Leste (Trainor *et al*. 2004). The population of this species is suspected to be declining very rapidly, concurrent with the rapid reduction in its lowland forest habitat. As a result, it is classified as Endangered.		
Ducula rosacea Pink-headed Imperial-Pigeon	NT				The Pink-headed Imperial Pigeon is restricted to Indonesia and Timor-Leste, where it occurs in four Endemic Bird Areas (Northern Nusa Tenggara; Timor and Wetar; Banda Sea Islands; Northern Maluku) and five Secondary Areas (Seribu Islands; Masalembu; Kangean; Salayar and Bonerate Islands; Tukangbesi Islands). It inhabits forest, scrub and farmland up to 600 m. Despite this wide range, the species appears to have become very rare at least in some areas, and rather uncommon elsewhere. Although it has quite wide range, this species is uncommon and probably has a moderately small population, hence its classification as Near Threatened. It is much sought after by hunters and suffers	Two individuals were recorded perched at Betano. This species is expected to occur at all three sites in habitats that provide foraging, sheltering and nesting potential.	Recorded

Species	Conservation Significance				Distribution and Ecology	Regional Context	Likelihood of Occurrence
	IUCN	Endemic	CITES	Introduced			
					from the effects of habitat degradation and is therefore thought to be declining.		
Ducula cineracea Timor Imperial-Pigeon	EN				The Timor Imperial-pigeon is endemic to the mountains of Timor-Leste, and West Timor and Wetar, Nusa Tenggara, Indonesia, with recent reports from only three localities. It is locally common, but presumed to be declining as available habitat continues to shrink. It is presumably resident, perhaps making local altitudinal movements, in Montane forest and monsoon woodland between 600 m and 2,200 m. It is reportedly common in native eucalyptus forest. This pigeon qualifies as Endangered because it has a small population within a very small range (with only four recent locations), and this is suffering severe habitat loss, degradation and fragmentation, such that continuing population declines are likely.	This species is a highland specialist (Montane Forest) and is not expected to occur in the coastal environments of the project area	Unlikely
Cacatua sulphurea Yellow-crested Cockatoo	CR				The Yellow-crested Cockatoo is endemic to Timor-Leste and Indonesia, where it was formerly common throughout Nusa Tenggara (from Bali to Timor), on Sulawesi and its satellite islands, and the Masalembu Islands (in the Java Sea). It has undergone a dramatic decline, particularly in the last quarter of the 20th century, such that it is now extinct on many islands and close to extinction on most others. It inhabits forest	Generally highly localised in response to suitable habitat. Up to 11 individuals were recorded on five occasions within the Suai development area only.Generally this species was	Recorded

Species	Conservation Significance				Distribution and Ecology	Regional Context	Likelihood of Occurrence
	IUCN	Endemic	CITES	Introduced			
					(including evergreen, moist deciduous, monsoon and semi-evergreen), forest edge, scrub and agriculture up to 500 m on Sulawesi, and 800 m (sometimes 1,500 m) in Nusa Tenggara. On at least some islands (e.g. Sumba), it appears heavily dependent on closed-canopy primary forest. On others, it survives despite the total clearance of original vegetation, indicating that its habitat requirements are somewhat flexible. Breeding takes place from September to May on Sumba (Walker *et al*. 2005). It nests in tree cavities with specific requirements, tending use chink in the trunk or branch, or a pre-existing nest-hole made by another species, often in dead, snagged or rotting trees (Walker *et al*. 2005). This species of cockatoo has suffered (and may continue to suffer) an extremely rapid population decline, owing to unsustainable trapping for the cagebird trade. It therefore qualifies as Critically Endangered.	recorded foraging and roosting in Sheoak (*Casuarina equisitifolia*) as well as individuals seen flying overhead. This species upon local advice generally translocate up and down the coast.	
Psitteuteles iris Iris Lorikeet	NT				Iris Lorikeet is restricted to Timor and Wetar, Indonesia and Timor-Leste. This species is reported to be not uncommon on Timor-Leste, it still survives in reasonable numbers in West Timor and it is, or at least once was, locally not uncommon on Wetar. It occurs in monsoon forest up to 1,500 m, and also in open eucalypt savannah. This	Suitable foraging, sheltering and nesting habitat exist in the project area for this species, as well as being in the typical distribution boundary and is	Likely

Species	Conservation Significance				Distribution and Ecology	Regional Context	Likelihood of Occurrence
	IUCN	Endemic	CITES	Introduced			
					poorly known species has a moderately small population, and it is likely to be declining owing to trapping and habitat loss; it therefore qualifies as Near Threatened.	therefore expected to occur.	
Aprosmictus jonquillaceus Olive-shouldered Parrot	NT				The Olive-shouldered Parrot is restricted to Timor and Wetar, Indonesia and Timor-Leste, where it occurs on Timor, Wetar and Roti. The species is found up to 2,600 m in monsoon forest, acacia savanna, lightly wooded cultivation and scrubby second growth. This species is listed as Near Threatened because it is believed to have a moderately small, fragmented population, and to be undergoing a continuing decline owing possibly to trapping and forest loss. However, little is currently known about the population size and structure of, and threats to, this species. Further information may indicate it is more threatened.	This species of parrot occurs over a wide range of mostly lowland habitats, and appears to be commonest in *Eucalyptus* woodlands, open forests and coastal environments typical of the project area.	Likely
Todiramphus australasia Cinnamon-banded Kingfisher	NT				The Cinnamon Banded-kingfisher is restricted to four Endemic Bird Areas (Northern Nusa Tenggara; Sumba; Timor and Wetar; and the Banda Sea Islands, the first three with nominate *australasia*, the last one with races *dammeriana* and *odites*), in Indonesia and Timor-Leste. Its distribution within this fairly wide area is, however, very patchy, and it is generally uncommon. This species is a closed-canopy specialist,	It is expected that this species will be found in suitable habitats across all project areas.	Likely

Species	Conservation Significance				Distribution and Ecology	Regional Context	Likelihood of Occurrence
	IUCN	Endemic	CITES	Introduced			
					occurring in monsoon forest at 0-700 m. It is also found in secondary habitats such as gardens and cultivated areas, provided that sufficient canopy cover remains. This species is listed as Near Threatened as it has a moderately small and fragmented population which is likely to be declining owing to habitat loss.		
Bradypterus timoriensis Timor Bush-Warbler	NT				The Timor Bush-warbler is endemic to the island of Timor, Lesser Sundas, and is only known from two specimens collected at 1,800 m on Gunung Mutis, West Timor, in 1932, and a sight record (August 1972) from forest at 1,800 m near to Same, Timor-Leste (Dickinson *et al*. 2001). There have been a number of searches by competent observers, although it is likely to be very skulking and easily overlooked (Trainor *et al*. 2007a, Lambert *et al*. 2006). This very poorly known species has been classified as Near Threatened owing to concerns that burning and grazing may be causing a moderately rapid decline in the area of habitat suitable for it. However, rediscovery and subsequent fieldwork may provide data which lead to this threat status being amended.	The project area does not contain any Montane Forest type habitat; given the study areas' proximity in the landscape specifically coastal and near coastal, it is highly unlikely this highly cryptic and poorly documented species occurs.	Unlikely
Heleia muelleri Timor White-eye	NT	x			The Timor White-eye is restricted to Timor, Indonesia and Timor-Leste, where it is	Suitable habitat does occur in the	Possible

Species	Conservation Significance				Distribution and Ecology	Regional Context	Likelihood of Occurrence
	IUCN	Endemic	CITES	Introduced			
					generally uncommon and local, although it can be moderately common in ideal habitat. This species occurs up to 1,300 m in monsoon forest. It appears to favour lower-lying areas with closed-canopy forest, and may not persist in secondary habitats. This species is scarce and local within its restricted range, and is likely to have a small global population size. It is suspected to be declining moderately rapidly owing to ongoing habitat loss. It is currently considered Near Threatened, and further studies are urgently required in order to clarify the magnitude of threats facing it.	project study areas and despite this species being highly cryptic and difficult to identify it is expected this species should occur	
Ficedula timorensis Black-banded Flycatcher	NT	x			The Black-banded Flycatcher is restricted to Timor, Indonesia and Timor-Leste where it appears to be uncommon or locally common, but may be frequently overlooked. It occurs up to 1,200 m in the dense undergrowth of monsoon forest, apparently preferring areas with limestone boulders and rocky scree slopes. Although it has been found in degraded forest patches, it shows a preference for primary habitats. It typically forages alone or in pairs, within 2 m of the ground in dense undergrowth, gleaning insects or making short sallying flights. This species has a moderately small range within which moderately rapid declines are owing to ongoing loss and	This species shows a preference for primary forests but has also been recorded in degraded habitat types. Generally speaking the project area contains very little primary forest but does contain secondary forests and plantation / agriculture habitat opportunities. It is expected that this	Possible

Species	Conservation Significance				Distribution and Ecology	Regional Context	Likelihood of Occurrence
	IUCN	Endemic	CITES	Introduced			
					clearance of lowland forest. As a result it is classified as Near Threatened.	species may occur in low abundance.	
Saxicola gutturalis Timor Bushchat	NT				Timor Bushchat is restricted to the island of Timor (Indonesia and Timor-Leste) and its satellite islands of Roti and Semau (nominate *gutturalis* on Timor and Roti, race *luctuosa* on Semau). Given its restricted range the total population is not thought to be large. It occurs up to 1,200 m in monsoon forest and scrubby savanna. In West Timor it is present even in very small remnant pockets of woodland but is largely excluded from savanna and open scrub by the Pied Bushchat *S. caprata*. It forages on insects by gleaning and sallying in the canopy and in tall shrubbery beneath. It nests mainly October-November, but also May-June. This species is listed as Near Threatened because it may have a moderately small, fragmented population that is undergoing a continuing decline owing to extensive forest loss within its restricted range. However, little is currently known about its population size; further information may indicate its status warrants evaluation.	One individual at Suai development area was recorded. The disparity of records for this species might be a reflection of little survey work conducting for this species and for avian species as a whole. It is expected that this species may occur broadly across suitable habitat types for the south-coast of Timor-Leste.	Recorded
Zoothera dohertyi Chestnut-backed Thrush	NT				Chestnut-backed Thrush is restricted to three Endemic Bird Areas (Northern Nusa Tenggara; Sumba; Timor and Wetar) in	The project area does not contain habitat suitable for	Unlikely

Species	Conservation Significance				Distribution and Ecology	Regional Context	Likelihood of Occurrence
	IUCN	Endemic	CITES	Introduced			
					Indonesia and Timor-Leste. It is considered generally uncommon to rare, only locally common at higher elevations, and is probably already extinct on Lombok and close to extinction on Sumbawa. It occurs at 400-1,700 m in semi-evergreen, lower Montane and Montane forest, occurring at highest densities within primary forest. It is usually solitary but may assemble when at a food source. It has been recorded associating with Chestnut-capped Thrush *Z. interpres*. It is generally less shy and retiring than other *Zoothera* thrushes in the region. It typically forages on the ground. Juveniles have been recorded from July-September but singing within this period suggests an extended breeding season. This species is listed as Near Threatened because there are some indications that its population is fragmented and undergoing a continuing moderately rapid decline owing to trapping. However, little is currently known about the population size and structure of, and threats to, this species. Further information may indicate it is more threatened.	this species specifically a lack of Montane Forest. This elusive bird is generally found at an altitude above 1,100 m and given the project area is coastal and near coastal in origin suggests this species is highly unlikely to occur.	
Zoothera peronii Orange-banded Thrush	NT				The Orange-banded Thrush is restricted to the Banda Sea Islands, Indonesia and Timor-Leste, where it is generally common on Roti and West Timor (race *peronii*), Timor-Leste, Wetar and Romang, Babar	This species of thrush occurs in a wide variety of forest types including secondary forests	Likely

Species	Conservation Significance				Distribution and Ecology	Regional Context	Likelihood of Occurrence
	IUCN	Endemic	CITES	Introduced			
					and Damar (race *audacis*). It occurs up to 1,200 m in forest (including monsoon forest). Although it has been found in degraded patches, it appears to favour areas with closed-canopy forest, which are constantly diminishing. It is largely terrestrial and solitary but will aggregate in small numbers if feeding in fruiting trees. Seen in the mid and upper canopies as well as on the ground. This species is listed as Near Threatened because there are some indications that its population is fragmented and undergoing a continuing moderately rapid decline owing to trapping and loss of lowland forest. However, little is currently known about the population size of and the threats to this species. Further information may indicate it is more threatened.	and occasionally regenerating swidden fields suggests this species is likely to occur.	
Lonchura fuscata Timor Sparrow	NT				The Timor Sparrow is restricted to Timor-Leste, West Timor, and its outlying islands, Semau and Roti, Indonesia, where it is widespread, but generally sparsely and patchily distributed. It is locally moderately common, being described as uncommon to abundant in Timor-Leste (Trainor *et al*. 2004) where recent surveys at two sites along the Laivai River located several groups of 30-50 birds within a few hectares in a short period at both sites, suggesting a likely population total in the thousands for	This species have been found in substantial populations in dry degraded savanna-woodland landscapes (especially river valleys associated with irrigated ricefields) specifically on the	Possible

Species	Conservation Significance				Distribution and Ecology	Regional Context	Likelihood of Occurrence
	IUCN	Endemic	CITES	Introduced			
					the entire river region (Trainor *et al*. 2004). It mainly frequents the extreme lowlands, sometimes ascending hills to around 700 m, where it regularly occurs as individuals or in small groups of three to five birds, occasionally mixed with other granivorous birds, and can form larger flocks with groups of 30-50 recently recorded (Trainor *et al*. 2004). It forages on or near the ground in grassland, lightly wooded cattle-pasture, scrub, overgrown gardens, deciduous or degraded monsoon-forest and the margins of cultivation, and in Timor-Leste was found in *Eucalyptus alba* savanna, ricefields, severely degraded coastal shrublands and riparian woodland dominated by *Casuarina* (Trainor *et al*. 2004). This species is listed as Near Threatened because recent assessments suggest that the population may experience a moderately rapid decline as a result of habitat loss and increasing exploitation for the cagebird trade.	north coast of Timor Leste but is not restricted to this location. Further survey effort and research into this species will give a greater understanding of its ecological requirements.	
Acerodon mackloti Sunda Fruit bat	VU				A coastal species occurring from sea level up to 450 m asl, and roosts in colonies of 300-500 individuals in secondary forest and gardens.	Distributed throughout the large islands of Nusa Tenggara, its presence on Timor has been confirmed recently (Helgen 2004). Large	Possible

Species	Conservation Significance				Distribution and Ecology	Regional Context	Likelihood of Occurrence
	IUCN	Endemic	CITES	Introduced			
						colonies of this species would be significant if present in the project area.	
Nyctimene keasti Keast's Tube Nosed Fruit Bat	VU				Roosts and forages in tall vegetation, gardens, feeding on fruit; very little information is available for this species.	No records on Timor since Andersen (1912 cited in Goodwin 1979). Found elsewhere in Indonesia, but the poorly known taxonomic relationships in this genus limit knowledge of distributions and conservation advice.	Unlikely
Pteropus temminckii Temminick's Flying-fox	VU		App II		Reported from tropical moist forest, not likely to occur in large colonies.	Found in the central Moluccan islands, Simmons (2005) regards its distribution on Timor-Leste as doubtful.	Unlikely
Pteropus vampyrus Large Flying-fox	NT		App II		This species generally ranges through much of continental and insular Southeast Asia. On the mainland, it has been reported from	This species occurs in primary and secondary forests	Possible

Species	Conservation Significance				Distribution and Ecology	Regional Context	Likelihood of Occurrence
	IUCN	Endemic	CITES	Introduced			
					southern Myanmar, southern Vietnam (possibly southern Cambodia), through much of Peninsular Malaysia to Singapore. The species is found over much of Indonesia, being recorded from the islands of Sumatra, Bangka, the Mentawi Islands (Sipura, North Pagai and South Pagai), the Krakatau Islands, Java, Bali, Lombok, Sumbawa, Sumba, Savu, the Anamba Islands, the Natuna Islands (Bunguran Besar) and Siantan. It is present on the island of Timor (Timor-Leste and Indonesia), and on Borneo (Brunei, Indonesia and Malaysia). This tree roosting species is tolerant to some habitat disturbance; it occurs in primary and secondary forest and uses adjacent agricultural areas for feeding (Bates *et al*. 2008). In view of the species wide range, it seems probable that it is present in many protected areas. There is a need to protect important roosting sites for this species, and to regulate any hunting pressure.	and thus should be expected to occur in such habitat types of the project area.	
Rhinolophus canuti timoriensis Canut's Horseshoe Bat	VU				Roosts in caves, and has been recorded foraging in a variety of habitats including intact primary forest, riparian zones and over grasslands adjacent to rocky outcrop (Armstrong 2007).	Distinct subspecies found on Timor, other distributional records in Java, Nusa Barong and Bali, where it is apparently	Recorded

Species	Conservation Significance				Distribution and Ecology	Regional Context	Likelihood of Occurrence
	IUCN	Endemic	CITES	Introduced			
						uncommon. Possibility of occurrence if rocky outcrop and caves are nearby, records in the project area are significant. This species was recorded at Suai and Betano.	
Sus celebensis Sulawesi Warty Pig	NT			x	The Sulawesi Warty-pig is found in the lower east portion of the oriental region and the upper west portion of the Australian region. *Sus celebensis* is common in the northern, central and eastern Sulawesi Island. Available evidence supports that this species formerly occurred throughout Sulawesi, as well as the neighboring islands of Selayer, Muna, Buton, Peleng, Lembeh and the Togain Islands. The species is now scarce in Southern Sulawesi and may also be extinct on the nearby Selayar due to the virtual deforestation of these areas. Wild pigs referred to as feral *S. celebensis* have been extensively introduced in Indonesia on the islands of Halmahera, Flores, Timor, Lendu, Simeuleu, and Nias Islands, and the domesticated forms of *S. celebensis* can be seen on the islands of Roti and Savur. (Macdonald 1993). Celebes wild boars are	This species may have been introduced to Timor-Leste and may possibly be expected to occur as a domestic animal in subsistence agriculture.	Possible

Species	Conservation Significance				Distribution and Ecology	Regional Context	Likelihood of Occurrence
	IUCN	Endemic	CITES	Introduced			
					reported to occur in a wide variety of habitats on the Indonesian Islands, including rainforests, swamps, high grassland terrains, and agricultural areas. They are found at altitudes up to moss forest at about 2300 m, but they prefer valleys. (Huffman, 1999, Parker, 1990).		
Rusa timorensis Javan Rusa	VU			x	The Javan Rusa is believed to be native only to Java and Bali in Indonesia. It has been introduced to many other islands of the Indo-Pacific region. Some introductions apparently took place in antiquity within present-day Indonesia, to the Lesser Sunda islands, Maluku (= Molucca) islands (including Buru and Seram), Sulawesi, and Timor. This species is essentially a tropical and subtropical grassland species but is highly flexible, with successful populations in forests, mountains, shrublands and marshes.	Despite being listed as Vulnerable upon the IUCN Red List, this species is historically an introduced species from neighbouring Indonesia. Introduced populations are not assessed as being conservation significant.	Likely
Bos javanicus Banteng	EN			x	The Banteng (*Bos javanicus*), also known as tembadau, is a species of wild cattle found in Southeast Asia. Banteng have been domesticated in several places in Southeast Asia, and there are around 1.5 million domestic Banteng, which are called Bali cattle. These animals are used as working animals and for their meat. Bali has been introduced to Timor-Leste, where they	This species was intermittently recorded across the three project areas. Despite being listed as Endangered upon the IUCN Red List, this species is historically an	Recorded

Species	Conservation Significance				Distribution and Ecology	Regional Context	Likelihood of Occurrence
	IUCN	Endemic	CITES	Introduced			
					have established stable feral populations.	introduced species from neighbouring Indonesia. Introduced populations are not assessed as being conservation significant.	

REPUBLICA DEMOCRATICA DE TIMOR-LESTE
SECRETARIA DE ESTADO DOS RECURSOS NATURAIS

ATTACHMENT 2

Tasi Mane Project - Suai Supply Base EIA

Marine Ecology and Fisheries

Final Technical Report

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May 2012

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SECRETARIA DE ESTADO DOS RECURSOS NATURAIS

GOVERNMENT OF TIMOR-LESTE, THROUGH THE SECRETARIA DE ESTADO DOS RECURSOS NATURAIS
TASI MANE PROJECT – SUAI SUPPLY BASE EIA
MARINE ECOLOGY AND FISHERIES TECHNICAL REPORT

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PROJECT 301012-01406-EN-R – TIMOR LESTE SOUTH COAST EIA

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1. INTRODUCTION

The Tasi Mane Project is a multi-year development of three industrial clusters on the south coast of Timor. The project will involve development of a coastal zone from Suai to Beaco providing the infrastructure required to support a growing domestic petroleum industry. Tasi Mane will include the Suai Supply Base cluster, the Betano Refinery and Petrochemical Industry cluster, and the Beaco LNG-Plant cluster (SDP 2011) (Figure 1-1).

WorleyParsons was commissioned by the Secretaria de Estado dos Recursos Naturais (SERN), on behalf of the Government of Timor-Leste (GoTL), on December 2011, to prepare an Environmental Impact Assessment (EIA) to describe the likely environmental and social impacts associated with the proposed development.

As part of the EIA, WorleyParsons undertook marine environmental surveys at each of the three development sites. This report presents data for the Suai development area. Data from the Betano and Beaco development areas will be presented in a separate report.

1.1 Project Setting

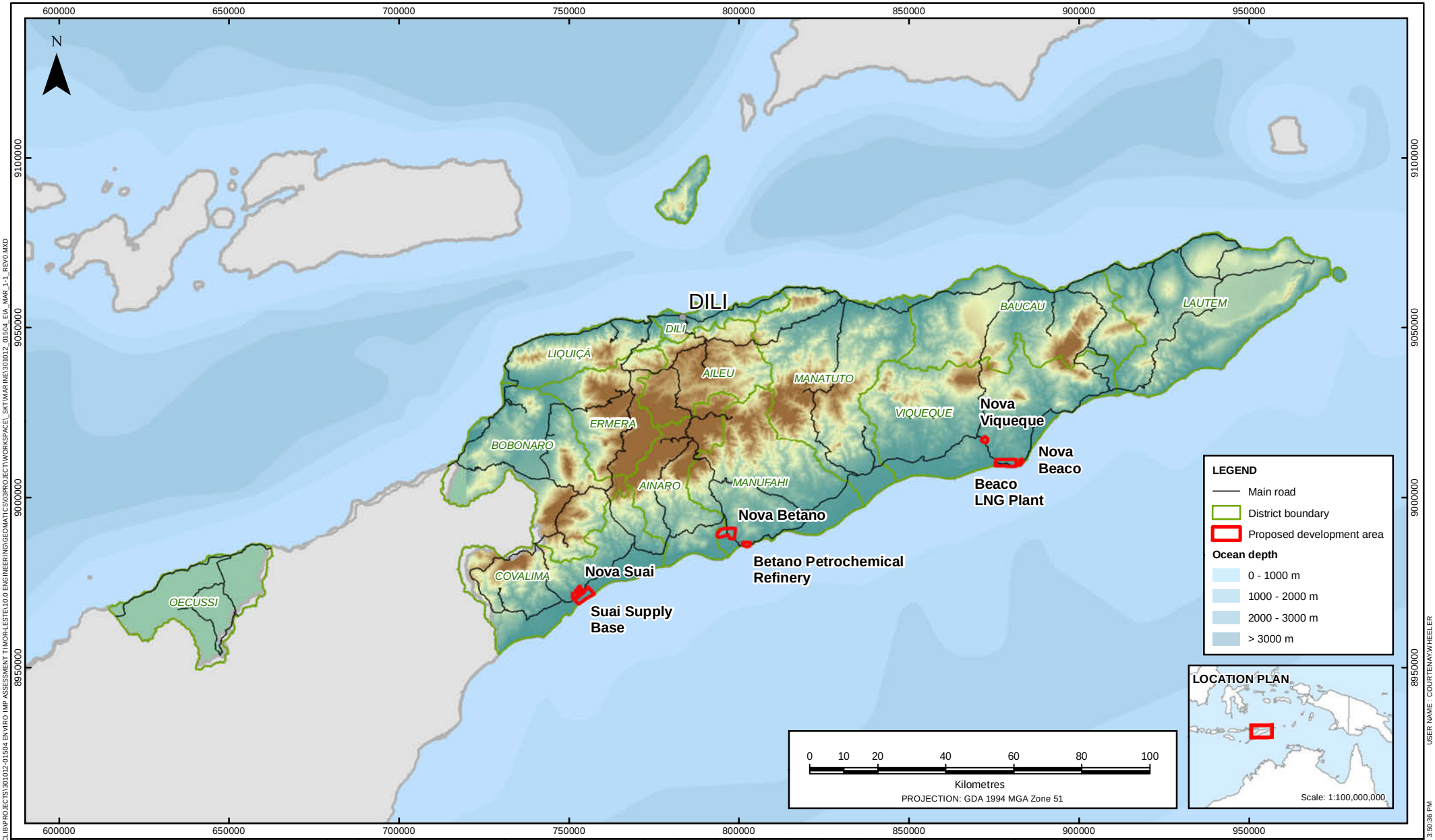
The scope for this study is the supply base component of the Tasi Mane project, herein referred to as the Tasi Mane – Suai Supply Base Project ('the project').

The project comprises the following components:

- Supply Base.
- Industrial estate.
- A new town, Nova Suai.
- Upgrade to the existing Suai Airport.
- Two crocodile reserves.

1.2 Study Objectives

This study was undertaken to provide a baseline description of the marine environment within and adjacent to the proposed development at Suai. The collection of baseline data was undertaken to address the paucity of existing knowledge from the southern coastline of Timor-Leste and also forms the basis for assessment of impacts associated with the project.



NOTES:
This map consists of:
1. DEM: SRTM (2011)
2. District boundary's: GIGTimorLeste (2010)
3. Rivers: GIGTimorLeste (2010)
4. Roads: DivaGIS (2010)

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TASI MANE PROJECT - SUAI SUPPLY BASE
MARINE ENVIRONMENT TECHNICAL REPORT

Figure 1-1
Tasi Mane Project overview

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In addition, the assessment was undertaken to provide sufficient information to meet the GoTL objectives for the protection of the environment.

The scope of work included undertaking the following tasks:

- Describing the condition and extent of benthic marine habitats that occur within the vicinity of the study area;
- Describing ambient marine water quality, including both physiochemical and chemical properties from the coastal waters within the study area;
- Describing sediment quality of surface sediments from within the study area;
- Describing the abundance and diversity of benthic infauna from within the study area; and
- Describing the marine fish larvae, eggs and plankton present within the study area.

1.3 Regulatory Context

The Democratic Republic of Timor-Leste (RDTL) became a signatory to the United Nations Convention on Biological Diversity (UNCBD) in 2007. A thematic assessment report of Timor-Leste was prepared for the UNCBD by Alves (2007). Under this Convention, countries are obliged to develop a National Biodiversity Strategy and Action Plan (NBSAP) which involves identifying actions and measures for conservation of biodiversity. Timor-Leste is yet to develop regulations and policy documents specifically addressing biodiversity conservation.

There are several laws and regulations from previous administrations (United Nations Transitional Administration in East Timor (UNTAET) and Indonesian) that concern environmental protection and biodiversity conservation in Timor-Leste:

- Law No. 5, 1990 on Conservation of Biological Resources and their Ecosystems;
- Law No. 5, 1994 Concerning Biodiversity;
- Government Regulation No. 28, 1985 on Forest Protection;
- Government Regulation No. 51, 1993 on Environmental Impact Analysis;
- UNTAET Regulation No. 2000/17; and
- UNTAET Regulation No. 2000/19.

UNTAET Regulation No. 2000/19 on protected places (30 June 2000) was in place for the purpose of protecting designated areas, endangered species, wetlands, mangrove areas, historic, cultural and artistic sites, conservation of biodiversity and protection of the biological resources of Timor-Leste. Fifteen natural areas were protected under this regulation and have been designated as Protected

Natural Areas (PNAs). The majority comprise primary forest areas, coral reefs, mangroves, wetland habitat and mountain summits above 2,000 m.

The State Secretariat for the Environment (SEMA), under the Ministry of Economy and Development, and the Ministry of Agriculture, Forestry and Fisheries (MAFF) are the two government agencies with primary responsibilities for the environment. SEMA deals with the environmental issues in the sectors, and MAF deals with resource management, including; forests, fisheries, and biodiversity conservation.

With the change in government administration from the United Nations (UN) to Timor-Leste, there is no environmental legislation currently in place in Timor-Leste. The aforementioned legislation from the previous administration, however, will provide some guidance as to the expected legislation that will be developed for GoTL.

2. REGIONAL PERSPECTIVE

Physical, biological and environmental data for the marine and coastal environment in Timor-Leste is very scarce (Sandlund et al., 2001). The information presented within this section provides regional context to the project area and is taken directly from the data compiled as part of oil and gas approvals documentation for areas located in the southern section of Timor-Leste territorial waters (Eni 2007, 20010a, 2010b).

2.1 Climate

Timor-Leste has two annual seasons and three climatic zones which are the result of monsoon activity. The two distinct seasons are the Northwest Monsoon (wet season) from November to May and the Southeast Monsoon (dry season) from April to September with brief transitional periods in between (Timor-Leste, 2006).

High rainfall is associated with the Northwest Monsoon and low rainfall with the Southeast Monsoon. Heavy rainfalls are also associated with tropical cyclones and thunderstorm activity. Mean annual rainfall for the Timor Sea region is 1,770mm (Heyward et al., 1997).

The majority of cyclones occur in the region between January and March, with the most severe cyclones most often occurring in the months December to April (SKM, 2001). Most (75%) of these cyclones are not fully mature, having an estimated wind speed of less than 80 km/h. Severe cyclones, with wind speeds exceeding 100km/h occur, on average, once every 2.6 years (Heyward et al., 1997).

2.2 Biogeography

The island of Timor-Leste is part of the Malay Archipelago, representing the largest and easternmost of the Lesser Sunda Islands (World Bank, 2009). The island is non-volcanic, part of the Outer Banda Arc, derived from the basement of rocks of the Australian continental margin (Audley Charles, 1993 in Rhee et al. 2004) and is characteristically limestone with karst formations. The terrain in Timor-Leste is almost consistently steep and as a result has a number of large fast flowing rivers running to the sea. Rainfall is fairly uniform throughout the year over the mountain range that runs through the middle of the country.

Keefer (2000) reported that rainfall intensity is usually greatest during the North West Monsoon (December-March) period, particularly those in northern locations, while in the southern sites many of the high daily rain totals were recorded in the May-August period. Rivers originating in the mountains and flowing into the sea on the southern side of Timor-Leste, therefore, have consistent flow for the majority of the year.

The rates of fluvial sediment flux on the island and the broader region are naturally high as a result of the mountainous terrain, highly erodible strata and the high seasonal rainfall. The lack of estuaries, along with the narrow width of coastal shelf along East Timor's south coast implies that river discharge is likely to discharge sediment directly to the slope and deeper offshore waters (Milliman et al., 1999).

2.3 Bathymetry

Only limited bathymetrical information of the Timor-Leste coastline is available.

A review of the *Australia – East Timor, Timor Sea, Dillon Shoal to East Timor* chart (AUS charts 902 and 903 produced by RAN), navigation chart shows the seabed to slope rapidly from the shoreline to deep water. This steep slope was also confirmed during the field surveys within the project footprint. In some places water depths of 200m can be found less than 1km offshore (*Australia – East Timor, Timor Sea, Dillon Shoal to East Timor* chart).

2.4 Tides

The Timor Sea region is influenced by the Pacific-Indian Ocean Throughflow. This produces a current moving at a rate of between 0.1 and 0.4 m/s throughout the year in the Timor Sea between Timor-Leste and northern Australia (Molcard et al., 1996).

Tidal currents in the region are anti-clockwise rotational, commencing flood towards the NE and ebb towards the SW. Speeds will range from about 0.02 m/s on neap tides to 0.1 m/s on springs.

Surface currents are expected to reflect seasonal wind regimes. Local wind-driven surface currents may attain maximum speeds of 0.7 ms-1 during extreme wind surges. More typically speeds would be in the range of 0.2 ms-1 to 0.4 ms-1.

2.5 Water Temperature

Seawater temperatures in the Timor Sea region range from 25ºC to 31ºC at the surface and 22ºC to 25ºC below 150 m (OMV, 2003) and down to 10ºC at the seafloor (Heyward et al., 1997).

2.6 Coastal Processes

There is little known about the coastal processes along the Timor-Leste coastline. Ocean currents have been found to flow from east to west through the Timor Trench and Timor Sea up to a maximum of 0.7 m/s (MetOcean Engineers, 2004). The predominant wave direction for Timor-Leste is from the East (MetOcean Engineers, 2004) which is most likely to create net littoral movement of material from east to west.

The recent field surveys confirmed that sections of coastline inspected between Suai, Betano and Beaco consist of a combination of sandy beaches and limestone rock ledges which extend from the shoreline as intertidal reef flats and slope down steeply towards the seabed. The sandy beaches consist of medium to fine sand with silt. Heavy rains produce significant runoff from the large rivers generating extensive turbid plumes in the coastal environment.

2.7 Biological Environment

Habitats vary along the coastline because of the local influences of seasonal rainfall, local geology and topography, river discharges, and regional offshore oceanographic features, as well as the impact of human occupation. This results in spatial differences in marine habitats, with the north coast being different from the south coast and with the eastern edge of the island having attributes that differ from those to the west (GoTL 2006d).

Timor-Leste has been identified as part of the Wallacea region in Southeast Asia which has been identified as a biodiversity 'hotspot' (CI, 2007). The most ecologically important marine habitats in the Timor Sea region, in terms of biodiversity and productivity can be grouped into:

- The various submerged banks or shoals on the northern Australian continental shelf and shelf slope;
- The coastal intertidal coral reefs and shallow (20m to 30 m) reefs; and
- The mangrove and seagrass areas located along the Timor and northern Australian coast and islands (Sandlund et al. 2001; SKM 2001).

2.7.1 Mangroves

Mangroves occupy approximately 7,500 acres along the coastline of Timor-Leste. On the south coast, they tend to form small communities at the mouths of streams and in marshy or swampy terrain (timorNET, 2007). The mangroves species that occur along the coast of Timor-Leste include, *Bruguiera parvifolia, Sonneratia alba, Rhizophora conjugata, Excoecaria agallocha, Avicennia marina, Aegiceras corniculatum, Acanthus ilicifolius, Lumnitzera racemosa, Heritiera litoralis, Acanthus ilicifolius, Achrosticum aureum, Xylocarpus granatum, Corypha utan, Pandanus odoratissimus, Cycas circinalis, Dolichandrone spathacea* and *Melaleuca leucadendron* (timorNET, 2007).

2.7.2 Intertidal

Wyatt (2004) surveyed a small area of the nearshore coastal marine environment on the south coast of Timor-Leste. Brittle stars (*ophiuroids*) and other mobile organisms as well as a total of 27 taxa, mostly sessile species, were identified as inhabiting the reef platform. The main taxa present were algae, sponges (*poriferans*), corals (*scleractinians*), ascidians, anemones and forams.

2.7.3 Coral Reefs

Timor-Leste is near the centre of the global region with the highest coral species diversity (the Wallacea region). A high diversity of coral reefs exist in southern Timor-Leste with 301-500 species identified (Burke et al., 2002).

A series of surveys conducted in Indonesian waters between 1990 and 1998 (Burke et al., 2002) determined that the percentage of coral reefs in good or excellent condition (live coral cover of more than 50%) in eastern Indonesia were 45% compared to only 23% in western Indonesia. Burke et al. (2002) also identified a number of coral reefs along the Timor-Leste coast, including five distinct communities along the south coast of Timor-Leste, that were considered to be at Medium to High risk of impact from the combined effects of coastal development, marine-based pollution, sedimentation, overfishing and destructive fishing.

2.7.4 Offshore Benthic Habitats

Heyward et al. (1997) identified four broad benthic communities for the Big Bank Shoals area, encompassing the shallow banks to the deep water: Halimeda (shallow waters); encrusting sponges (shallow waters); coral filter-feeders (shallow waters); and continental shelf communities (deep water).

With little sea floor topography and hard substrate, such areas offered minimal habitat diversity or niches for animals to occupy. Detritus-feeding crustaceans, holothurians and echinoderms tend to be the dominant epibenthic organisms of these habitats, however, where an area of hard substrate is available filter-feeding heterotrophs, such as sponges, soft corals and gorgonians may occur (Heyward et al., 1997).

2.7.5 Marine Fauna

The marine fauna of the Timor Sea is part of the Indo-West Pacific biogeographical Province. The majority of species are widely distributed in this region (Wilson & Allen, 1987).

A number of whale, dolphin and porpoise species have broad distributions (including the Timor Sea). Of these, a number of whale species are considered endangered, vulnerable or might be encountered due to their migratory habit. These include the Blue whale, Humpback whale, Sperm whale, Bryde's whale, Antarctic Minke whale and Killer whale. Some are very rare (blue whale), or usually restricted to deep or cool waters (Sperm whale), and are very unlikely to be encountered in this region (Bannister et al., 1996). Humpback whales (*Megaptera novaeangliae*), which are seasonally the most abundant whale along the Western Australian coast, complete their northern migration in the Camden Sound area of the West Kimberley (reported in Woodside, 2000).

A number of dolphins may occur within the project area. These species include the Irrawaddy dolphin, the Australian snubfin dolphin, the long snouted spinner dolphin, the spotted bottlenose dolphin, Risso's dolphin, the Indo-Pacific humpback dolphin and the pantropical spotted dolphin.

Dugongs (*Dugong dugon*) occur within Timor-Leste waters. Major concentrations of dugongs tend to occur in areas coinciding with sizeable seagrass beds. These areas are typically in shallow water (depths less than 10m) and are relatively protected (Marsh, 2006).

There are six turtle species that may be encountered, including the Flatback, Olive, Hawksbill, Leatherback and particularly the Loggerhead turtle and the Green turtle. Jaco Island and Tutuala beach have been identified as turtle nesting sites (Nunes, 2001) and other breeding sites may exist on the south coast of Timor-Leste where the appropriate conditions exist.

The distribution of the saltwater crocodile, *Crocodylus porosus*, encompasses Timor-Leste and the islands and coasts surrounding the Timor Sea. The animals usually inhabit territories within tidal river systems and estuaries, sometimes around coastal areas and in freshwater rivers or water bodies and are sometimes found long distances from shore (Ross, 1998). The saltwater crocodile is listed as Low Risk, Least Concern in the International Union for Conservation of Nature (IUCN) Red List.

Sea snakes are expected in the Timor Sea region, with as many as 15 species known to occur in northern Australian waters (Storr et al., 1986).

FishBase (2006) lists 144 marine fish species in 38 families for Timor-Leste waters, with one species, the bigeye tuna (*Thunnus obesus*) listed as Threatened, 18 of the species as being pelagic and 10 of the species as being deep water. Many of the species listed for Timor-Leste are found throughout the tropics and are important commercial species, such as the tunas, mackerels and snappers.

The whale shark (*Rhincodon typus*) is listed in FishBase (2006) as occurring within Timor- Leste waters and is considered threatened. The Great White Shark (*Carcharodon carcharias*) may transit the region (Environment Australia, 2002) and is considered to be vulnerable. There are at least 49 species of sharks identified as occurring within an area which encompasses Australian territorial waters within the Timor Sea (Last & Stevens, 1994). The most prolific of the shark species in the Timor Sea region are the whalers, represented by at least 12 species.

2.7.6 Marine Protected Areas

The nearest currently declared marine conservation zones or marine protected areas to the project area is the Jaco Island Marine Park, at the eastern end of Timor-Leste.

3. FIELD METHODS

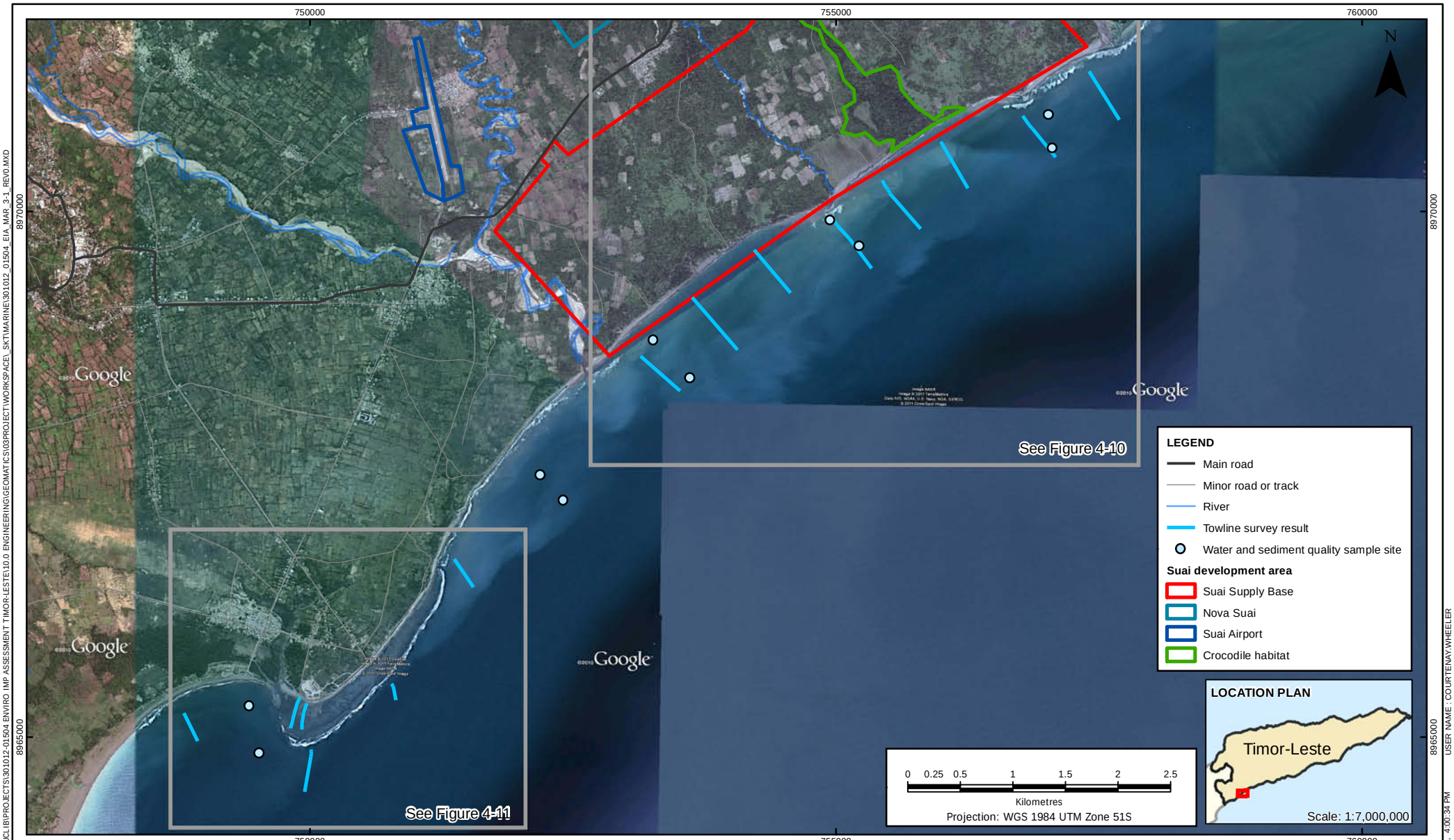
3.1 Sampling Locations

Water quality, sediment quality, benthic infauna and plankton samples were collected at both nearshore (250 m from shore) and offshore (750 m from shore) over a 10 day period between 10 and 20 December 2011 and over a five day period between 18-22nd February 2012. During this period, the sea conditions were calm with 5 to 10 knot winds and 0 to 0.2 m swell. The average temperature was 34°C with rainfall most afternoons. A total of five inshore and five offshore samples were collected at sites adjacent to the proposed supply base at Suai (Figure 3-1). Inshore sites were located between 4 to 8m depth. Offshore sites were in up to 20 m depth.

Video footage, which has been provided to SERN, was collected over a two day period between 10 and 20 December 2011. Towed video footage was used to obtain information on the marine benthic habitat present at the study site. Video transects ranging between 300 to 500 m extended vertically from the shoreline (Figure 3-1). Each transect commenced in a depth of approximately 2.5 m extending out to the 10m depth contour. A total of eight transects were completed at the Suai study site distanced approximately 600 m apart. GPS co-ordinates were collected at each sampling site (using a handheld Garmin GPS) and are presented in Table 3-1.

Table 3-1 Table showing GPS coordinates

Scope	Name	Start_ Latitude	Start_ Longitude	Finish_ Latitude	Finish_ Longitude
Benthic Habitat	T13	-9.322910	125.304583	-9.325875	125.308027
	T14	-9.317825	125.308985	-9.322340	125.312975
	T15	-9.313723	125.314310	-9.317388	125.317523
	T16	-9.311017	125.321140	-9.315273	125.324497
	T17	-9.307683	125.325358	-9.311818	125.328720
	T18	-9.304322	125.330383	-9.308332	125.332778
	T19	-9.302047	125.337477	-9.305573	125.340358
	T20	-9.298175	125.343183	-9.302352	125.345827
Water and Sediment Quality, Benthic Infauna, Fisheries	SBMI1	-9.321541	125.305665		
	SBMO1	-9.324749	125.308861		
	SBMI2	-9.311132	125.320884		
	SBM02	-9.313338	125.323397		
	SBMI3	-9.301943	125.339699		
	SBMO3	-9.304842	125.340077		



NOTES:
This map contains:
1. Imagery Suai: SRTM (2011)
2. Imagery: DigitalGlobe (2008 - 2010)
3. Rivers: GIGTimorLeste (2010)
4. Roads: DivaGIS (2010)

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Figure 3-1
Suai marine study area and sampling sites

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3.2 Water Quality

3.2.1 Physicochemical Profiling

A calibrated multi parameter water quality logger (Hydrolab Mulitparameter DSX5) was used to measure physicochemical properties. A physicochemical water quality profile was obtained by recording measurements at 1m intervals from the water surface to the seabed at each of the sampling sites. The water quality logger was lowered and raised at a speed of approximately one meter per five seconds. Two depth profiles were recorded at each sampling site.

The following parameters were measured:

- Temperature (°C);
- Salinity (parts per thousand (ppt));
- pH;
- Conductivity (µS.cm-1);
- Dissolved Oxygen (DO; % Saturation and mg.L-1); and
- Turbidity (nephelometric turbidity units [NTU]).

3.2.2 Chemical Sampling

At each sampling site, a mid-water column sample was collected using a 1L Van Dorn sampler. Each sample was transferred into parameter specific sample bottles and placed on ice.

- Total Metals (Cd, Cr, Cu, Hg, Pb, Ni, Zn); and
- Dissolved Metals (Cd, Cr, Cu, Hg, Pb, Ni, Zn), Ammonia, Total Nitrogen, Total Phosphorus, TPH, PAH, BOD, TSS, E.coli, Chlorophyll, Nitrate, Nitrite, TKN, Reactive phosphorus.

Dissolved metal samples were filtered in the field through a 0.45µm filter.

3.2.3 Water Quality Criteria

As no water quality guidelines exist for Timor-Leste, ANZECC/ARMCANZ guidelines (2000) for marine environments (Tropical Australia) were adopted for water quality monitoring, analysis and reporting. All toxicants were compared to the 99% species protection trigger levels.

3.2.4 Data Analysis

Physicochemical data collected was analysed by calculating descriptive statistics for each parameter. Chemical data was tabulated and compared to adopted guideline levels.

3.3 Sediment Quality

3.3.1 Sample Collection

Surface sediment samples (0-0.3 m) were collected using a Van Veen grab sampler. The Van Veen sampler was lowered to the seabed before being retrieved with a grab sample. Sediment samples were then geophysically logged. The sample was then homogenised in a stainless steel mixing bowl before being transferred into a sterilised 250 mL glass jar and a 250 ml plastic bag. Each sample was then stored at 4°C and couriered to a NATA accredited laboratory in Perth, Australia for analysis.

3.3.2 Chemical Testing

Parameters identified for laboratory analysis were developed based on likely contaminants to be encountered during construction and operation of a port and associated facilities. Sediment samples were analysed for the following parameters:

- Metals (Al, As, Cd, Cr, Cu, Fe, Pb, Hg, Ni and Zn);
- Nutrients (Nitrate, Nitrite, Total Nitrogen, Total Phosphorus and Sulphate); and
- Particle Size Distribution (PSD).

3.3.3 Sediment Quality Criteria

As no sediment quality guidelines exist for Timor-Leste, the interim sediment quality guideline (ISQG) found in ANZECC/ARMCANZ (2000) were used as a basis for comparing relative metal concentrations. Sediment nutrient concentration results from Suai were compared against relevant published literature as there are no comparable benchmarks within the ANZECC/ARMCANZ (2000) guidelines.

PSD is a measure of the relative proportion of particle size classes within a given sediment sample. Results have been presented based on the classifications displayed in Figure 4-9.

3.3.4 Data Analysis

Laboratory results were collated, concentrations were tabulated and any spatial trends identified. All values were then compared with relevant sediment quality criteria.

3.4 Benthic Habitat

3.4.1 Data Collection and Mapping

A total of eight transects were completed at the Suai study site. Transects were approximately 600m apart covering a 5 km section of coastline.

The benthic habitat was recorded using an underwater video camera (Splash Cam) (Plate 3-1). The remotely operated video camera was towed behind a vessel travelling at a speed of 1 knot or less. The camera was attached to a swimming device, permitting the camera to face forward and travel in a straight direction. High definition video footage was taken approximately 50 cm above the substratum and recorded to a hard drive. Co-ordinates of the video transects were tracked using a GPS (Starfish) and overlayed onto the video along with time and date information to allow geo-referencing of the processed habitat data.

The video footage was analysed by marine scientists experienced in classifying benthic habitats. Maps displaying the distribution of habitats, including substrate and biota were then produced across the study area.

3.4.2 Data Analysis

A customised WorleyParsons system for benthic habitat classification was adapted from the national intertidal and subtidal benthic habitat classification scheme (Mount et al., 2007) and used to classify the observed habitats. The level of taxonomic detail that can be classified was restricted by environmental condition such as water visibility, sea state and tide. For the purpose of generating a habitat map, biota was defined as:

- Hard coral;
- Invertebrates;
- Algae;
- Seagrass; and
- Substrate was classified as sediment (soft) or reef (hard).

A qualitative classification method was applied to define the cover (density) of specific biota and substrata types as dense (>75%), medium (25-75%) or sparse (0-25%). Substrate type was defined using the Wentworth grade scale of particle sizes (Wentworth, 1922).

Plate 3-1 Picture showing the video camera being deployed for the benthic habitat video tows

Plate 3-2 Photograph showing small sea ripples in the sediment

3.5 Plankton

3.5.1 Sample Collection

A plankton net was towed behind a vessel travelling at <1 knot over a 100m transect at each site. The plankton net comprised of a 0.8 m diameter with 800 µm mesh sieve. Once the sample had been collected in the sieve, the contents were then transferred to a sample vial. Ethanol (100%) was added to the vial to preserve the sampled larvae.

3.5.2 Laboratory Analysis

The plankton fauna was removed from the plastic sampling vial and placed in a 125µm sieve. The excess ethanol used for preservation of the samples was then captured in a storage container for chemical disposal. Water was then flushed over the sample, to remove any remaining ethanol. The entire sample was placed in Ward Counting Wheel, with the corresponding site label. The Ward Counting Wheel was placed under a Stereo-Microscope (Olympus SZ61 Microscope) and slowly turned under the microscope allowing the fauna to be counted and identified. Taxonomy identification was conducted using the most up to date references available for the geographic region. Taxonomic names and abundances were recorded on laboratory sheets for each site. After taxonomy identification was completed the fauna was returned to the vial with 70% ethanol for long term storage.

As plankton samples collected presented with very low abundance, the sorting methodology adopted did not following the standard plankton sub-sampling methods. Instead 100% of the sample volume was sorted for plankton, fish eggs and fish larvae.

3.5.3 Statistical Analysis

Statistical analysis of the plankton was conducted using Primer ver.6 (Clarke, 2001). Cluster and multidimensional scaling (MDS) analyses were performed to represent groupings of samples with a similar faunal and community composition.

Both the cluster and MDS were based on a similarity matrix produced using the Bray-Curtis similarity co-efficient, with standardisation and square-root transformation. Standardisation is essential for sampling techniques where exact sampling volumes are unknown and sampling bias can occur between replicates.

Transformations are required for datasets where more common fauna could potentially outweigh the rarer fauna when determining similarity between samples. Applying a transformation will define a balance between the contribution of common and rarer fauna (Clarke, 2001).

The adequacy of an MDS plot is represented by a stress value, in the range of 0.0 to >0.3. Interpretation of the stress value was as follows:

- <0.05 gives an excellent representation of sites;
- <0.1 is a good ordination with no real prospect of misleading interpretation;
- <0.2 still gives a potentially useful ordination, although values at the upper end of this scale should not be relied upon in great detail; and
- >0.3 indicates that the points are close to being arbitrary and placement of sites within the ordination are completely random (Clarke, 2001).

An Analysis of Similarities (ANOSIM) is used in conjunction with a cluster and MDS to provide a significant value (p=0.05) for differences between samples and grouping seen in the MDS ordination. SIMPER analysis is used to determine which species contribute the most to the differences between sites and the construction of the MDS ordination.

3.6 Infauna

3.6.1 Sample Collection

Surface sediment samples (0-0.3 m) were collected using a Van Veen grab. A total of three replicates were collected per sample location. Upon collection of each replicate sample, the samples were combined and sieved through a 1 mm mesh sieve. All samples were transferred to a sample container and preserved in 100% ethanol.

3.6.2 Laboratory Method

Macroinvertebrate samples were processed and fauna identified at Benthic Australia laboratories. The sediment and fauna were placed in a 125µm sieve. The excess ethanol used for preservation of the samples was captured in a storage container for chemical disposal. Water was flushed through the sediment in the 125µm sieve, to remove any remaining ethanol from the sample. The entire sample was placed in a large petri-dish with the corresponding site label. The petri-dish was placed under a Stereo-Microscope (Olympus SZ61 Microscope). A level 5 grade forceps was used to systematically sort through the sediment and remove all fauna that was found. Fauna were placed in a vial with 70% ethanol, and a label with the corresponding site information. Once all the sediment from the site was sorted, the vial of fauna was placed to one side awaiting taxonomic identification.

The specimens were then placed into a small petri-dish for taxonomic identification under a stereo-microscope, (Olympus SZ61 Microscope). Taxonomy was conducted using the most up to date references available for the geographic region. Taxonomic names and abundances were recorded on

laboratory sheets for each site. After taxonomy was completed the fauna was returned to the vial with 70% ethanol for long term storage.

3.6.3 Statistical Analysis

Statistical analysis of the marine benthic fauna was conducted using the same methods as plankton.

Statistical analysis of the plankton was conducted using Primer ver.6 (Clarke, 2001). Cluster and multidimensional scaling (MDS) analyses were performed to represent groupings of samples with a similar faunal and community composition.

Both the cluster and MDS were based on a similarity matrix produced using the Bray-Curtis similarity co-efficient, with standardisation and square-root transformation. Standardisation is essential for sampling techniques where exact sampling volumes are unknown and sampling bias can occur between replicates.

An Analysis of Similarities (ANOSIM) is used in conjunction with a cluster and MDS to provide a significant value (p=0.05) for differences between samples and grouping seen in the MDS ordination. SIMPER analysis is used to determine which species contribute the most to the differences between sites and the construction of the MDS ordination.

3.7 Quality Control and Assurance

All sampling equipment was deployed from the side of the vessel, to ensure the risk of contamination from the engine, discharge was reduced. Engines were also switched off where practicable to minimize further risk of contamination. Personnel undertaking water and sediment collection for sampling wore latex gloves at all times to prevent cross-contamination, all sampling equipment was cleaned with Decon90 prior to use and rinsed with seawater between samples.

The multi-parameter water quality logger was calibrated to manufacture specifications and using standardised solutions in field. A minimum of two depth profiles were recorded at each site to improve data accuracy. The water quality logger and Van Dorn sampler were weighted down to counteract the effects of the currents pulling the equipment horizontally through the water column.

Water and sediment quality samples were analysed by ALS Group. ALS has NATA certification for all analyses requested and QA/QC plans and protocols to support this certification. The integrity of the samples was assured by the use of Chain of Custody (CoC) documentation, which accompanied the samples from the time of collection until receipt by ALS. Samples were chilled on collection and dispatched to the laboratory frozen in chilled containers.

As part of the NATA requirements, the laboratory analyses for water and sediment quality included quality control testing of samples, including duplicate samples (the same sample analysed more than once), blanks (containing no levels of the analytes to be analysed), spiked samples (containing known additions of the analytes to appropriate matrices) and standard samples (samples containing known concentrations of the analytes - also known as reference standards). All samples were analysed within laboratory holding times.

QA/QC was conducted on five benthic infauna samples. This method requires five samples to be sorted twice. On the second sort any missed fauna are collected in a separate vial. The total missed fauna is divided by the total collected in the first sort and a percentage error calculated. The error is expected to be below 10%. If the sorting error is above 10% then each additional samples is checked until the percentage error is below 10%. QA\QC was not used on the plankton samples due to insufficient sample numbers.

4. RESULTS

4.1 Water Quality

Vertical profiles of physicochemical water quality recorded at each sampling site have been graphically presented in in the sections below. Laboratory data for chemical water quality, including nutrients, metals and hydrocarbons were also analysed, with a summary of results presented separately below. Comparisons of results with ANZECC/ARMCANZ (2000) are based on default trigger values provided for Tropical Australia (Inshore Waters).

4.1.1 Physicochemical Water Quality

A summary of the physicochemical water quality data collected at each site is presented in Table 4-1. Sites have been classified according to nearshore or offshore locations. Trends in the data set have been provided where relevant and differences in data between nearshore and offshore sites identified.

Temperature

Temperatures recorded at nearshore and offshore sites were similar, ranging between 30.2°C and 31.6°C. Maximum nearshore and offshore temperatures were observed at SMBI2 and S2O respectively (Table 4-1; Figure 4-1).

Vertical profiles of the mean temperature values for nearshore and offshore sites are shown in Figure 4-1. Both nearshore and offshore areas experienced a slight decrease in mean temperature with an increase in depth. Surface temperatures for the nearshore sites ranged between 31.3 °C (surface) and 31°C (seabed), and 31.1 °C (surface) and 30.5 (near seabed) for the offshore sites. Slight variation in temperature was identified at offshore sites between 16m and 18m.

pH

A mean pH of 8.1 was observed at both the nearshore and offshore sites. Inshore sites ranged between 8.0 and 8.2 while offshore sites showed less variability, ranging between 8.0 and 8.1. (Table 4-1; Figure 4-2).

A higher variation in pH was observed at nearshore sites compared with offshore sites. Low variation was generally observed at all offshore sites (Figure 4-3).

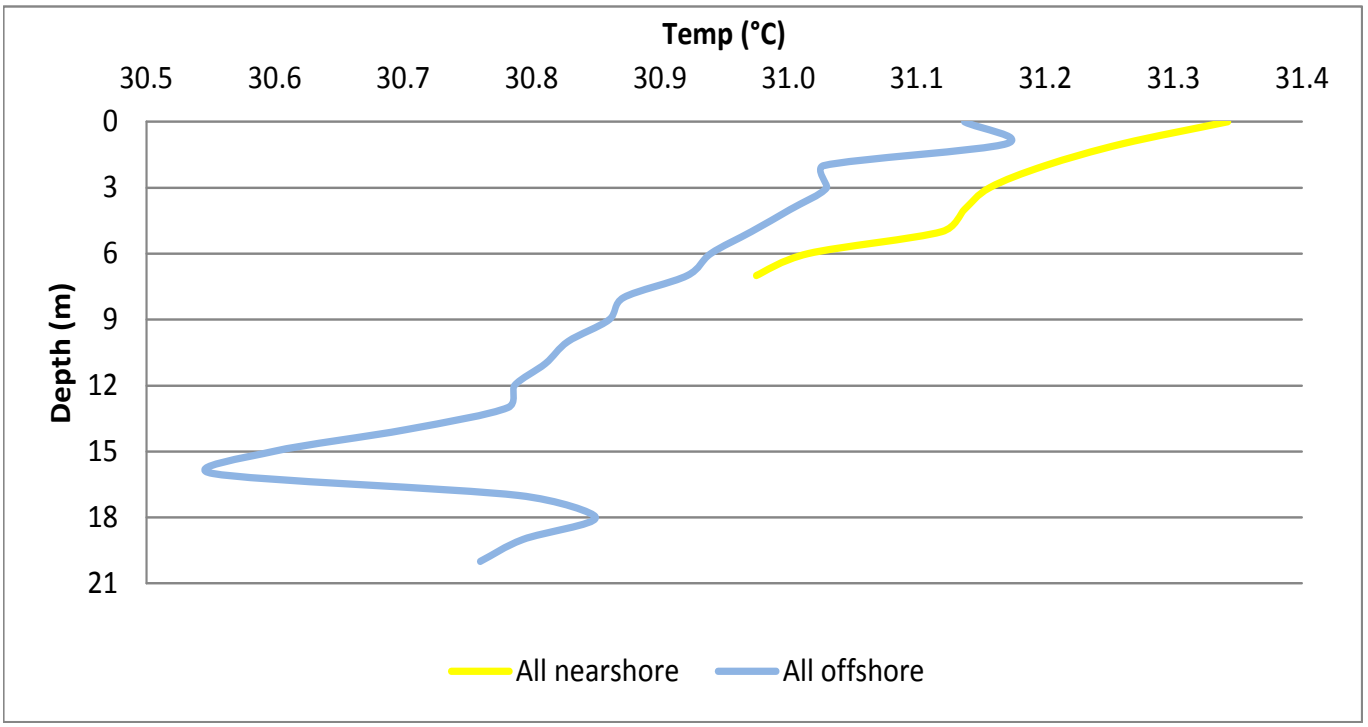

Figure 4-1 Mean temperature (°C) levels for nearshore and offshore sites

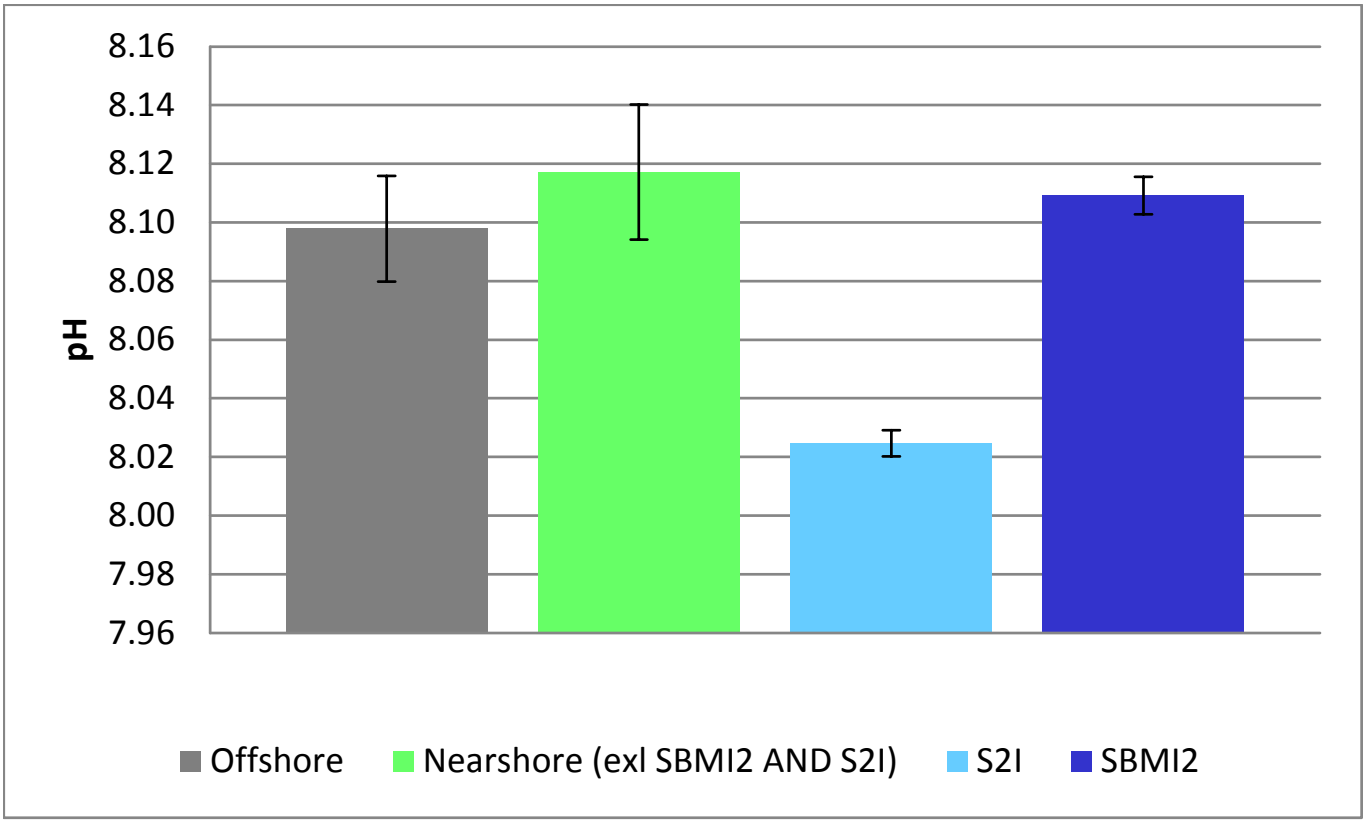

Figure 4-2 Comparison of average pH levels for offshore sites, outliers from nearshore sites as well as the average nearshore levels

NOTES:	0	2/05/2012	FOR FINAL ISSUE	CW	JG	CS	-	GH		A4 SHEET	TASI MANE PROJECT – SUAI SUPPLY BASE MARINE ENVIRONMENT TECHNICAL REPORT
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PLOT DATE AND TIME: 2 May 2012, 9:19 AM Creator: Courtenay Wheeler

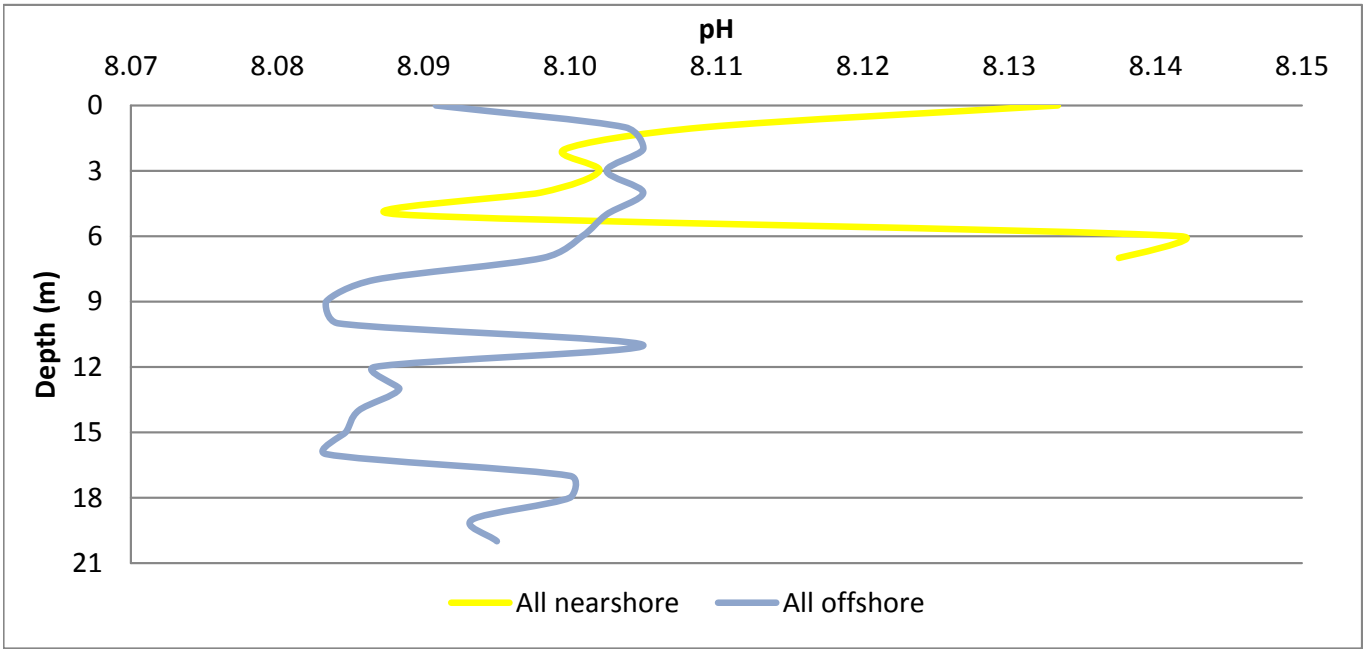

Figure 4-3 Mean pH levels for nearshore and offshore sites

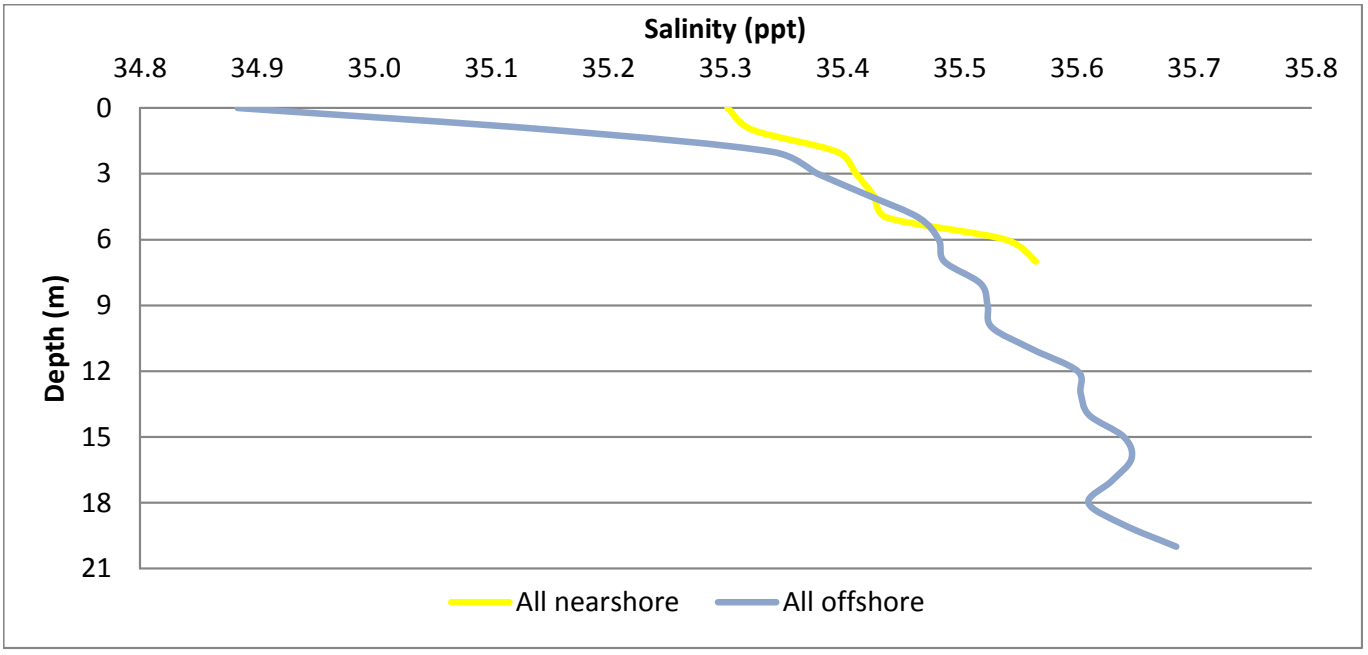

Figure 4-4 Average salinity (ppt) levels for nearshore and offshore sites

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Creator: Courtenay Wheeler

Salinity

Variations in salinity levels were observed spatially between the nearshore and offshore sites, and by depth (Table 4-1). Figure 4-4 shows a gradual increase in salinity with increase in depth for both nearshore and offshore sites. Salinity recorded at nearshore sites varied between 35.1 ppt and 35.6 ppt while offshore sites displayed greater variability ranging between 34.8 ppt and 35.7 ppt (Table 4-1). Maximum nearshore and offshore salinity was observed at SMBI3 and SBMO3 sites respectively. No variation was found in mean salinity at nearshore and offshore sites (35.4 ppt) (Table 4-1) Salinity recorded at SBMI2 was considerably lower than mean salinity at nearshore and offshore sites ranging between 35.0 ppt and 35.2 ppt (Figure 4-4).

Turbidity

Turbidity recorded at nearshore and offshore sites displayed large variability. Nearshore sites varied between 0.6 NTU and 47.4 NTU while offshore sites ranged between 3.1 NTU to 20.0 NTU. Maximum turbidity displayed at nearshore and offshore sites were observed at SMBI3 and SBMO3 respectively. These levels were substantially higher than other nearshore and offshore sites which displayed maximum turbidity levels ranging between 7.1 NTU to 14.0 NTU respectively (Table 4-1).

Higher turbidity was recorded at site SBMI3 compared with all other nearshore sites, ranging between 10 to 40 NTU (Figure 4-5). Generally, nearshore turbidity levels ranged between 1 and 7 NTU. Turbidity levels offshore were found to increase with depth, increasing from around 4 NTU near the surface to 12 NTU near the seabed.

Turbidity values were generally less than the ANZECC/ARMCANZ (2000) guideline of 1-20 NTU (Table 4-1). Higher values were most likely associated with high rainfall events and associated run-off.

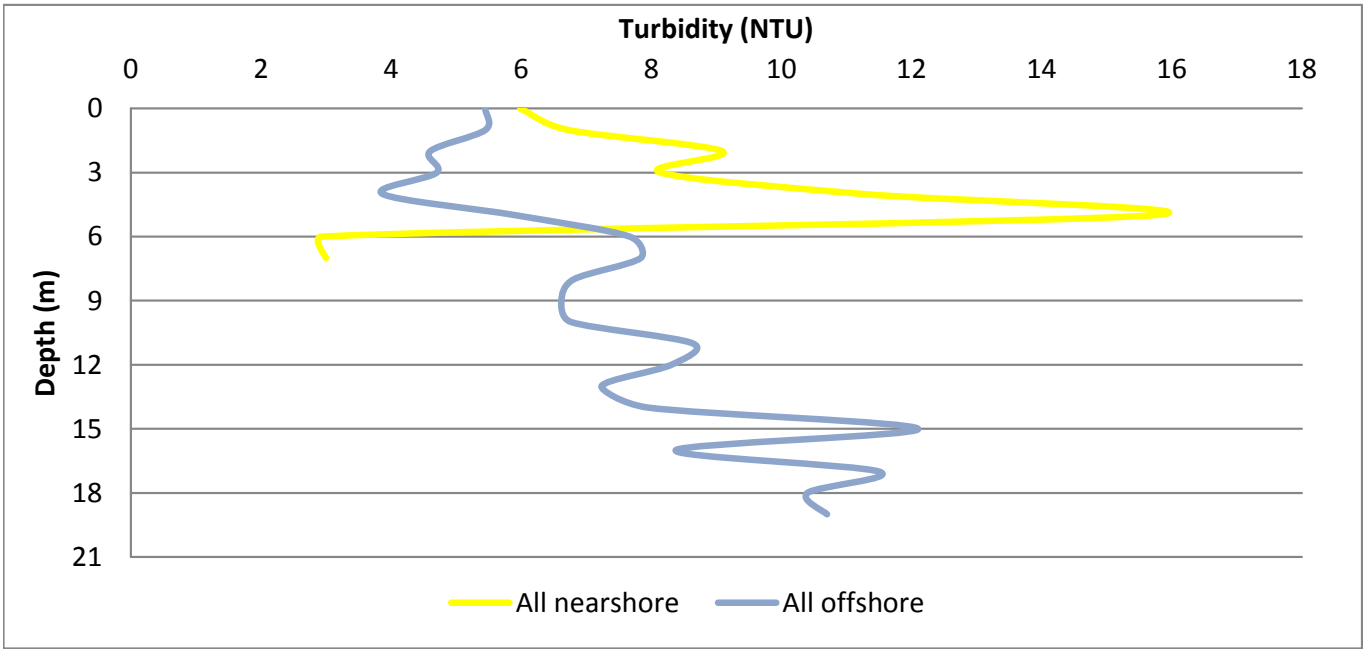

Figure 4-5 Turbidity (NTU) levels for nearshore sites (A); Mean turbidity (NTU) levels for inshore and offshore sites (B)

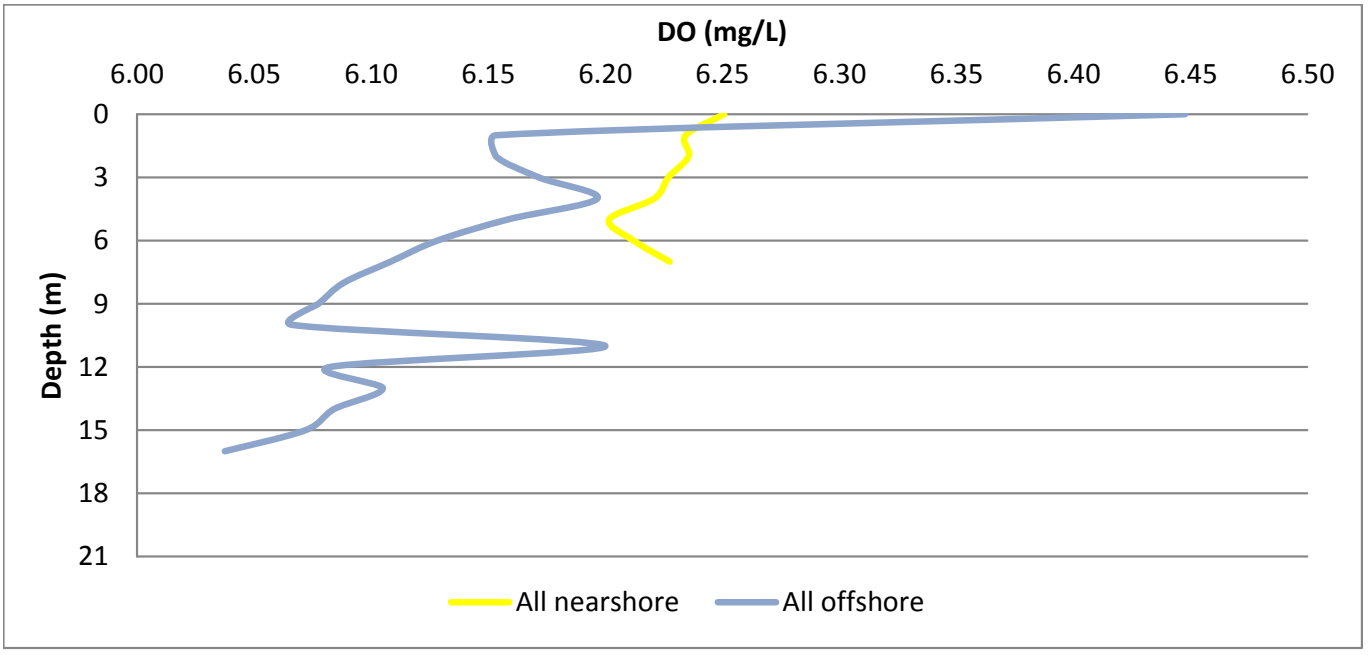

Figure 4-6 Mean dissolved oxygen (% sat) for nearshore and offshore sites

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Dissolved Oxygen

Dissolved oxygen levels recorded at nearshore sites ranged between 99.0% and 103.07% saturation while offshore sites displayed slightly more variability ranging between 95.3% and 101.5% saturation. Maximum nearshore and offshore dissolved oxygen levels were observed at SI1 and SBMO3 respectively.

Dissolved oxygen levels decreased with increasing depth at both nearshore and offshore sites. Figure 4-6 shows dissolved oxygen levels (% saturation) to be lower at offshore sites compared to nearshore sites. Mean dissolved oxygen values were 101.3% saturation for the nearshore sites, compared with 98.2% saturation at the offshore sites (Table 4-1).

Table 4-1 Physiochemical water quality parameters for nearshore and offshore sites at Suai, 17 December 2011

		Minimum Value	Maximum Value	Median	Mean	20th Percentile	80th Percentile	Standard Deviation
Temperature (°C)	Nearshore	30.78	31.59	31.21	31.24	30.96	31.52	0.04
	Offshore	30.20	31.47	30.89	30.92	30.73	31.05	0.08
pH	Nearshore	8.02	8.17	8.12	8.10	8.05	8.13	0.01
	Offshore	8.04	8.14	8.11	8.10	8.07	8.13	0.00
Conductivity (mS/cm)	Nearshore	53.05	53.80	53.60	53.49	53.32	53.70	0.05
	Offshore	52.63	53.93	53.60	53.54	53.35	53.84	0.05
Salinity (ppt)	Nearshore	35.08	35.60	35.47	35.40	35.28	35.53	0.04
	Offshore	34.76	35.73	35.48	35.43	35.28	35.63	0.03
Turbidity (NTU)	Nearshore	0.60	47.37	5.90	9.00	3.67	12.50	5.88
	Offshore	3.10	20.00	6.22	6.95	4.10	10.18	1.64
Dissolved Oxygen (% Sat)	Nearshore	99.03	103.07	101.13	101.22	100.28	101.81	0.30
	Offshore	95.25	101.50	98.04	98.80	96.25	100.56	0.61
Dissolved Oxygen (mg/L)	Nearshore	6.12	6.33	6.20	6.22	6.16	6.24	0.02
	Offshore	5.91	6.73	6.10	6.14	6.01	6.21	0.02

Suspended Solids

Suspended solids (TSS) at nearshore sites had an average concentration of 32.6 mg/L while offshore sites displayed a higher average concentration 35.8 mg/L. These TSS values are consistent with turbidity results from both inshore and offshore sites and confirm that ambient turbidity is relatively high, although within the range expected for coastal areas receiving high rainfall runoff. Maximum nearshore and offshore suspended solids were observed at SBMI3 and SO1 respectively (Table 4-2). There are no default trigger values for TSS in ANZECC/ARMCANZ (2000).

Table 4-2 Summary of Total Suspended Solids (TSS) for nearshore and offshore sites, Suai

	Site	TSS (mg/L)
	LOR *	**5**
Nearshore	SBMI1	17
	SBMI2	30
	SBMI3	54
	SI1	41
	SI2	21
Offshore	SBM01	22
	SBM02	30
	SBM03	27
	S01	55
	S02	45

*Limit of Reporting

4.1.2 Chemical Water Quality

Nutrients

A summary of results describing nutrient water quality parameters for nearshore and offshore sites are presented in **Table 4-3**.

Ammonia recorded at nearshore sites varied between 0.02 mg/L and 0.03 mg/L while offshore sites displayed more variability ranging between <0.02 mg/L and 0.1 mg/L. Maximum nearshore ammonia concentrations were observed at SI1 and SBMI1 while maximum ammonia concentrations offshore was recorded at SO1. All sites exceeded the ANZECC/ARMCANZ (2000) guideline value of 10µg/L.

Nitrite and Nitrate (NO_x) concentrations were below the LOR (0.01 mg/L) at all sites both nearshore and offshore sites. The ANZECC/ARMCANZ (2000) guideline value for NO_x is 0.008 mg/L (8µg/L).

Total nitrogen (TN) concentrations recorded at nearshore sites were similar to TN concentrations recorded offshore. Nearshore TN concentrations ranged between <0.1 mg/L and 1.1 mg/L while offshore sites ranged between <0.1 mg/L and 0.9 mg/L. Maximum nearshore and offshore total nitrogen was observed at SBMI2 and SO1 respectively. Five of the ten sites exceeded the ANZECC/ARMCANZ (2000) guideline value of 0.1 mg/L (100µg/L).

Given that nitrate and nitrite levels were below the LOR, total nitrogen concentrations were comprised entirely of the organic nitrogen TKN for samples. Consequently, the summary statistics calculated for TN were identical to those concentrations calculated for TKN. Generally TN and TKBN concentrations were similar across all sites both nearshore and offshore.

Total phosphorus recorded sites varied between <0.05 mg/L and 0.05 mg/L. No variability was observed between nearshore and offshore sites. Maximum total phosphorus concentrations were observed at near shore site SBMI3 and offshore site SO1. All concentrations were equal to or less than the limit of reporting of 0.05 mg/L. The LOR is higher than the ANZECC/ARMCANZ (2000) guideline value of 0.015 mg/L (or 15µg/L).

Reactive phosphorus concentrations recorded at both the nearshore and offshore sites measured below the LOR of 0.01 mg/L. The LOR is higher than the ANZECC/ARMCANZ (2000) guideline value of 0.005 mg/L (or 5µg/L).

Chlorophyll a and Biochemical Oxygen Demand

Both nearshore and offshore chlorophyll a concentrations were negligible, all reporting less than the LOR of 1 mg/m³ and below the ANZECC/ARMCANZ (2000) guideline level of 1.4 mg/m³ (Table 4-4).

Table 4-3 Nutrient water quality parameters for nearshore and offshore sites, Suai.

Nutrients	Site	Ammonia	Nox	TKN	TN	TP	RP
		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
	LOR *	**0.01**	**0.10**	**0.10**	**0.10**	**0.01**	**0.01**
	ANZECC	0.01	0.008	-	0.1	0.015	0.5
Nearshore	SBMI1	**0.03**	<0.01	0.5	**0.5**	<0.05	<0.01
	SBMI2	**0.02**	<0.01	1.1	**1.1**	<0.05	<0.01
	SBMI3	**0.02**	<0.01	<0.5	<0.1	**0.05**	<0.01
	SI1	**0.03**	<0.01	0.5	**0.5**	<0.05	<0.01
	SI2	**0.02**	<0.01	<0.5	<0.1	<0.05	<0.01
Offshore	SBM01	**0.07**	<0.01	<0.5	<0.1	<0.05	<0.01
	SBM02	**0.04**	<0.01	<0.5	<0.1	<0.05	<0.01
	SBM03	**0.05**	<0.01	0.7	**0.7**	<0.05	<0.01
	S01	**0.1**	<0.01	0.9	**0.9**	**0.05**	<0.01
	S02	**0.02**	<0.01	<0.5	<0.1	<0.05	<0.01

* Limit of Reporting
Bold indicates values above the ANZECC limit

Biochemical Oxygen Demand (BOD) is used as an indicator of organic loading based on the amount of dissolved oxygen needed by aerobic biological organisms to break down organic material within a body of water. BOD levels were below the LOR at all sites with the exception of one offshore site (SO2) where a value of 21 mg/L was recorded. All other sites measured BOD levels <2 mg/L.

Table 4-4 Chlorophyll a and BOD values, Nearshore and offshore sites, Suai

	Site	Chl a	BOD
		mg/m^3	mg/L
	LOR *	**1**	**2**
	ANZECC	**1.40**	**n/a**
Nearshore	SBMI1	<1	<2
	SBMI2	-	<2
	SBMI3	<1	<2
	SI1	<1	<2
	SI2	<1	<2
Offshore	SBM01	<1	<2
	SBM02	<1	<2
	SBM03	<1	<2
	S01	<1	<2
	S02	<1	21

* Limit of Reporting
Bold indicates values above ANZECC

Metals

Total and dissolved metal concentrations recorded from the near shore and offshore sampling sites are presented in Table 4-5 and Table 4-6, respectively. All data was then compared with the ANZECC/ARMCANZ (2000) guideline values. Results were also averaged for nearshore and offshore sites with mean values presented below.

Table 4-5 Total metal concentrations for near shore and offshore sites, Suai

	Site	Mercury	Cadmium	Chromium	Copper	Lead	Nickel	Zinc
Metals		mg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
	LOR*	0.0001	0.2	0.5	1.0	0.2	0.5	5
	ANZECC	0.1	0.7	7.7	0.3	2.2	7	7
Nearshore	SBMI1	<0.0001	<0.20	<0.5	**2**	<0.2	<0.5	<5
	SBMI2	<0.0001	<0.20	<0.5	**2.1**	0.3	<0.5	<5
	SBMI3	<0.0001	<0.20	0.6	**1.6**	0.2	0.8	<5
	SI1	<0.0001	<0.20	0.5	**6.4**	<0.2	<0.5	**8**
	SI2	<0.0001	<0.20	0.8	<1.0	<0.2	0.6	<5
Offshore	SBM01	<0.0001	<0.20	0.6	**1.6**	0.2	<0.5	<5
	SBM02	<0.0001	<0.20	<0.5	**1.1**	<0.2	<0.5	<5
	SBM03	<0.0001	<0.20	<0.5	**1.2**	0.3	0.6	**10**
	S01	<0.0001	<0.20	0.5	**1.4**	<0.2	<0.5	<5
	S02	<0.0001	<0.20	0.7	**4.5**	0.8	0.8	<5

* Limit of Reporting

Bold indicates values above ANZECC

Table 4-6 Dissolved metal concentrations for nearshore and offshore sites, Suai

	Site	Mercury	Cadmium	Chromium	Copper	Lead	Nickel	Zinc
Metals		mg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
	LOR*	0.0001	0.2	0.5	1.0	0.2	0.5	5
	ANZECC	0.1	0.7	7.7	0.3	2.2	7	7
Nearshore	SBMI1	<0.0001	<0.20	<0.5	<1.0	0.20	0.60	<5
	SBMI2	<0.0001	<0.20	<0.5	<1.0	0.30	0.50	5
	SBMI3	<0.0001	<0.20	0.50	**1.10**	<0.2	<0.5	<5
	SI1	<0.0001	<0.20	0.50	**3.60**	<0.2	<0.5	<5
	SI2	<0.0001	<0.20	0.50	<1.0	<0.2	<0.5	<5
Offshore	SBM01	<0.0001	<0.20	<0.5	**2.60**	<0.2	0.50	<5
	SBM02	<0.0001	<0.20	<0.5	<1.0	<0.2	<0.5	<5
	SBM03	<0.0001	<0.20	0.60	<1.0	<0.2	0.50	<5
	S01	<0.0001	<0.20	0.50	**2.00**	<0.2	0.60	<5
	S02	0.0001	<0.20	0.50	**1.80**	0.40	0.50	<5

* Limit of Reporting

Bold indicates values above ANZECC

Dissolved and total mercury concentrations were below the LOR of 0.0001 mg/L at all sites. One offshore site displayed a mercury concentration of 0.0001 mg/L identical to the ANZECC/ARMCANZ (2000) trigger level.

Dissolved and total concentrations of cadmium were <0.20µg/L at both nearshore and offshore sites, and therefore less than the ANZECC/ARMCANZ (2000) trigger value of 0.7µg/L.

Dissolved chromium concentrations collected from nearshore samples were similar to concentrations displayed from offshore sites. Maximum nearshore dissolved chromium concentrations were observed

at SBMI3, SI1 and SI2, while maximum offshore concentrations were recorded at SMB03. All sites were less than the ANZECC/ARMCANZ (2000) trigger value of 7.7µg/L.

Dissolved copper concentrations collected from nearshore samples varied between <1.0µg/L and 3.6µg/L while offshore sites displayed less variability ranging between <1.0µg/L and 2.6µg/L. Maximum nearshore and offshore dissolved copper concentrations were observed at SI1 and SBM01 respectively. SBMI2, SBMO2, SBMI3 AND SBMO3 all exceeded the ANZECC/ARMCANZ (2000) trigger value of 0.3µg/L.

Total copper concentrations collected from nearshore samples varied between <1.0µg/L and 6.4µg/L while offshore sites displayed less variability ranging between <1.0µg/L and 4.5µg/L. Maximum nearshore and offshore total copper concentrations were observed at SI1 and S02 respectively. Results confirm that most of the copper present in water is attached to particulates.

Dissolved lead concentrations were above the LOR of 0.1µg/L at two nearshore sites (SMBI1 and SMBI2) and one offshore site (S2O). Total lead concentrations comparable between sites ranging between 0.2µg/L and 0.3µg/L nearshore and <0.2µg/L to 0.4µg/L for offshore sites. All sites were below the ANZECC/ARMCANZ (2000) trigger value of 2.2µg/L (Table 4-6).

Dissolved nickel concentrations were above the LOR at two sites nearshore (SMBI1 and SMBI2) and four sites offshore (SMB01, SMB03, S1O and S2O), while all remaining sites recorded concentrations below the LOR of 0.5µg/L. Total nickel concentrations were above the LOR at nearshore sites SMBI2 and SMBI3 and at offshore sites SBM03 and S2O (Table 4-6).

Mean total nickel concentrations were similar for nearshore and offshore sites while dissolved nickel concentrations were slightly higher nearshore when compared to offshore. All sites were below the ANZECC/ARMCANZ (2000) trigger value of 7µg/L.

Dissolved zinc concentrations were generally below the LOR of 1µg/L, however a value of 5µg/L was observed at the nearshore site SMBI2, which is above the LOR, but below the ANZECC/ARMCANZ (2000) trigger value of 7µg/L. Concentrations of total zinc however were above the LOR but below the trigger except for SI1 which recorded a total zinc concentration of 8µg/L and offshore site SBM03 which displayed a concentration of 10µg/L (Table 4-6).

Hydrocarbons

Total Petroleum Hydrocarbons (TPH; C10 to C36 Fraction), Total Recoverable Hydrocarbons (TRH; >C10 to C40 Fraction) and Polynuclear Aromatic Hydrocarbons (PAH) were measured at all sites nearshore and offshore. All hydrocarbon concentrations were less than the LOR (Table 4-7).

Table 4-7 Hydrocarbon concentrations for nearshore and offshore sites at Suai

Hydrocarbons	Site	Total TPH	Total TRH	Total PAH
		µg/L	µg/L	µg/L
LOR*		**50**	**100**	**0.5**
Nearshore	SBMI1	<50	<100	<0.5
	SBMI2	<50	<100	<0.5
	SBMI3	<50	<100	<0.5
	SI1	<50	<100	<0.5
	SI2	<50	<100	<0.5
Offshore	SBM01	<50	<100	<0.5
	SBM02	<50	<100	<0.5
	SBM03	<50	<100	<0.5
	S01	<50	<100	<0.5
	S02	<50	<100	<0.5

* Limit of Reporting

4.2 Sediment Quality

4.2.1 Chemical Sediment Quality

Laboratory data for chemical sediment quality including; nutrients, metals and hydrocarbons, was analysed, with a summary of the results presented below.

Nutrients

A summary of sediment nutrient parameter results collected from nearshore and offshore sites are presented in Table 4-8. There are no sediment quality criteria for nutrients.

Table 4-8 Nutrient sediment quality parameters for nearshore and offshore sites, Suai

Nutrients	Site	Ammonia	NOx	TKN	TN	TP
		mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
	LOR*	20	0.1	20	20	2
Nearshore	SBMI1	<20	0.8	170	170	499
	SBMI2	-	-	-	-	-
	SBMI3	<20	<0.1	340	340	403
	SI1	<20	<0.1	100	100	602
	SI2	<20	<0.1	210	210	542
Offshore	SBM01	<20	<0.1	290	290	513
	SBM02	<20	<0.1	260	260	509
	SBM03	<20	<0.1	380	380	431
	S01	<20	<0.1	620	620	516
	S02	20	<0.1	840	840	485

* Limit of Reporting
- No Sample Result

Nitrogen concentrations collected from nearshore samples ranged between 100 mg/kg and 340 mg/kg while offshore sites displayed more variability ranging between 260 mg/kg and 840 mg/kg. Maximum nearshore and offshore nitrogen concentrations were observed at 340 mg/kg and 840 mg/kg respectively.

Total phosphorus concentrations for nearshore and offshore sites are presented in MAR011. Phosphorus concentrations collected from nearshore samples varied between 403 mg/kg and 602 mg/kg while offshore sites displayed less variability ranging between 431 mg/kg and 516 mg/kg. Maximum nearshore and offshore phosphorus concentrations were observed at SI1 and SO1 respectively.

Metals

Metal levels identified within the sediment at nearshore and offshore sites are presented in Table 4-9. All data was compared with ANZECC/ARMCANZ (2000) guideline values. Results that were above the ANZECC guidelines were averaged for nearshore and offshore sites and graphically displayed for comparison.

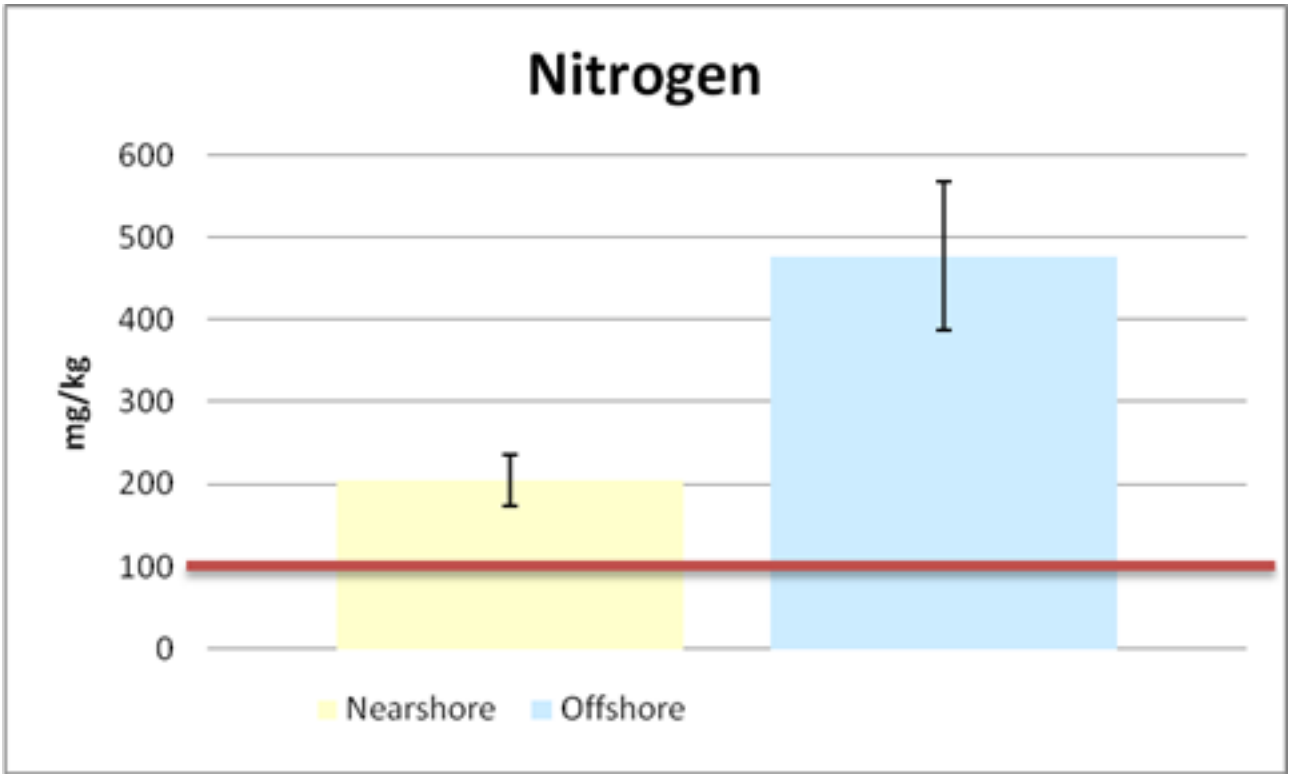

Figure 4-7 Mean nitrogen values for nearshore and offshore sediment, with the ANZECC guideline value shown in red

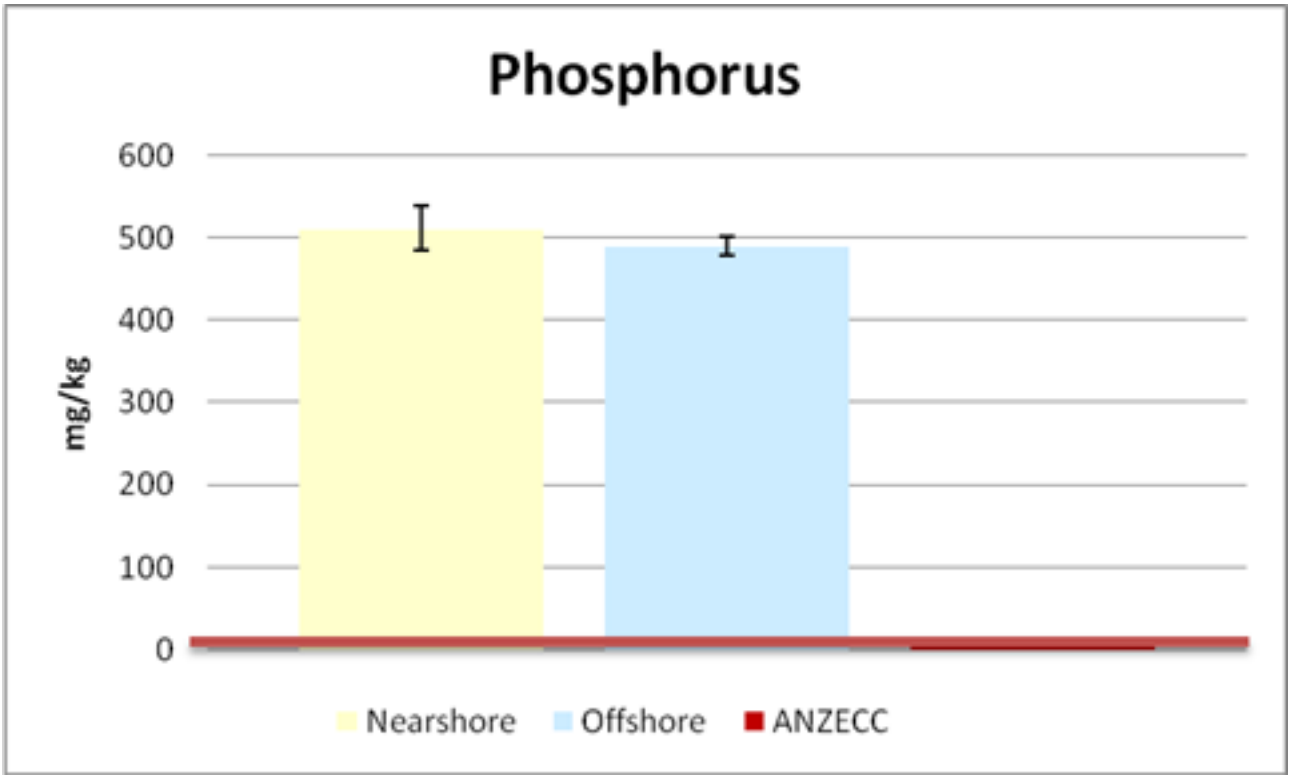

Figure 4-8 Mean values of phosphorus for nearshore and offshore, with the ANZECC guideline value shown in red

Table 4-9 Metal sediment quality parameters for nearshore and offshore sites at Suai

Metals	Site	Cadmium	Chromium	Copper	Lead	Nickel	Zinc	Mercury
		mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
	LOR*	**0.1**	**1**	**1**	**1**	**1**	**1**	**0.01**
	ANZECC	1.5	80	65	50	21	200	0.15
Nearshore	SBMI1	<0.1	16	18	<1.0	**24.4**	32.3	0.01
	SBMI2	-	-	-	-	-	-	-
	SBMI3	<0.1	14.2	29.6	**2.7**	**28.1**	46.5	0.03
	SI1	<0.1	<1.0	<1.0	<1.0	<1.0	<1.0	0.02
	SI2	<0.1	<1.0	<1.0	<1.0	<1.0	<1.0	0.01
Offshore	SBM01	<0.1	14.9	16.5	<1.0	**24.6**	32.2	0.02
	SBM02	<0.1	17.8	17.8	<1.0	**28.9**	38	0.02
	SBM03	<0.1	15.8	28	**1.2**	**27.5**	45.3	0.12
	S01	<0.1	<1.0	<1.0	<1.0	<1.0	<1.0	0.05
	S02	<0.1	<1.0	<1.0	<1.0	<1.0	<1.0	0.04

* Limit of Reporting
- No Sample Result
Bold indicates values above ANZECC

Nickel concentrations collected from nearshore samples and offshore displayed similar variation ranging varied between <1.0 mg/kg and 28.9 mg/kg. Maximum nearshore and offshore nickel concentrations were observed at SBMI3 and SBMO2 respectively. All sites located between the Karoulun and Raiketan Rivers exceeded the adopted ANZECC (2000) guideline value of 21 mg/kg. The remaining sites to the south of these rivers were found at levels less than 1.0 mg/kg (Table 4-9).

Hydrocarbons

A summary of hydrocarbon (TPH, TRH and PAH) concentrations collected from sediment samples from nearshore and offshore environments at Suai are presented in Table 4-10. Hydrocarbon concentrations were below the LOR for all nearshore and offshore sites.

Table 4-10 Summary of hydrocarbon sediment quality parameters for nearshore and offshore sites at Suai

Hydrocarbons	Site	Total TPH	Total TRH	Total PAH
		mg/kg	mg/kg	mg/kg
LOR*		**50**	**50**	**0.5**
Nearshore	SBMI1	<50	<100	<0.5
	SBMI2	<50	<100	<0.5
	SBMI3	<50	<100	<0.5
	SI1	<50	<100	<0.5
	SI2	<50	<100	<0.5
Offshore	SBM01	<50	<100	<0.5
	SBM02	<50	<100	<0.5
	SBM03	<50	<100	<0.5
	S01	<50	<100	<0.5
	S02	<50	<100	<0.5

* Limit of Reporting

4.2.2 Particle Size

Particle size distribution (PSD) at inshore sites was dominated by sand (mean = 71%, *n* =4), with some fines (mean = 29%, *n* = 4) whereas offshore sites were dominated by fines (mean = 63%, *n* = 5), with some sand (mean = 37%, *n* = 5) (Figure 4-9).

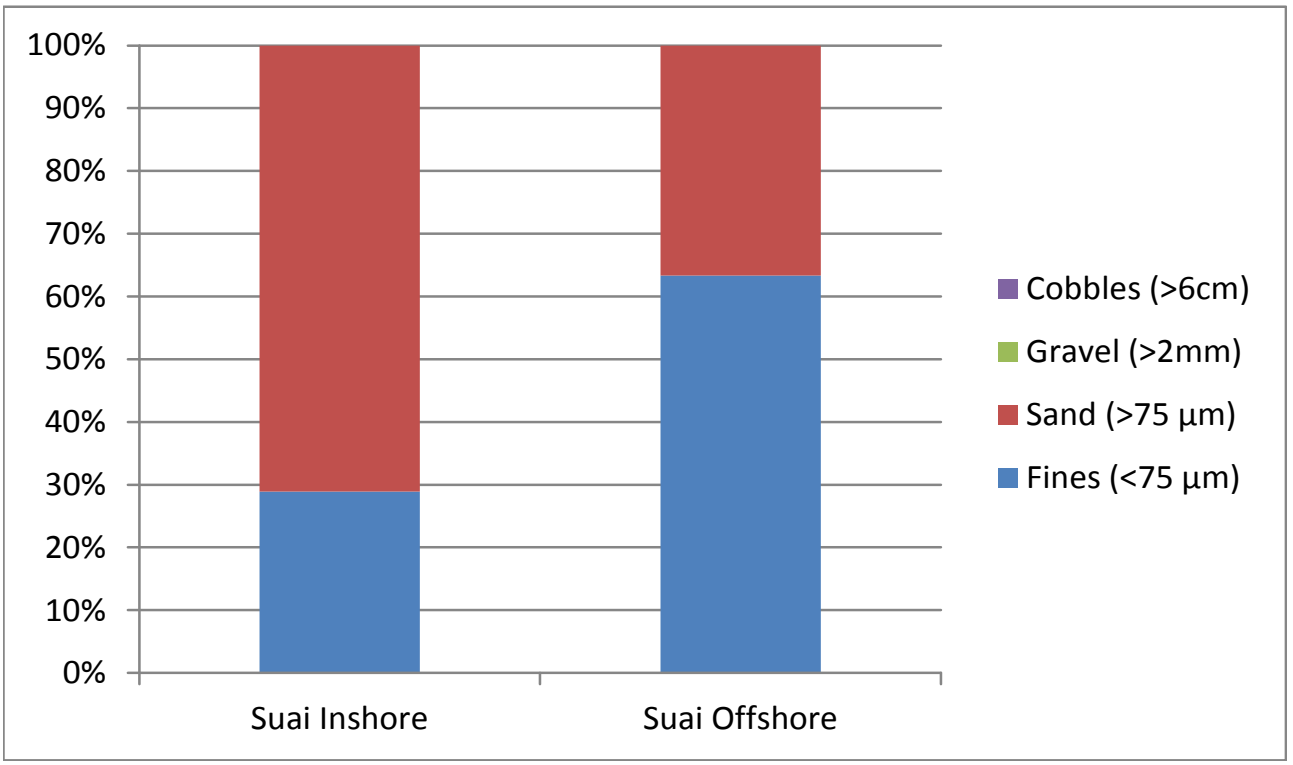

Figure 4-9 Mean particle size distribution at Suai inshore and Suai offshore sites

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4.3 Benthic Habitat

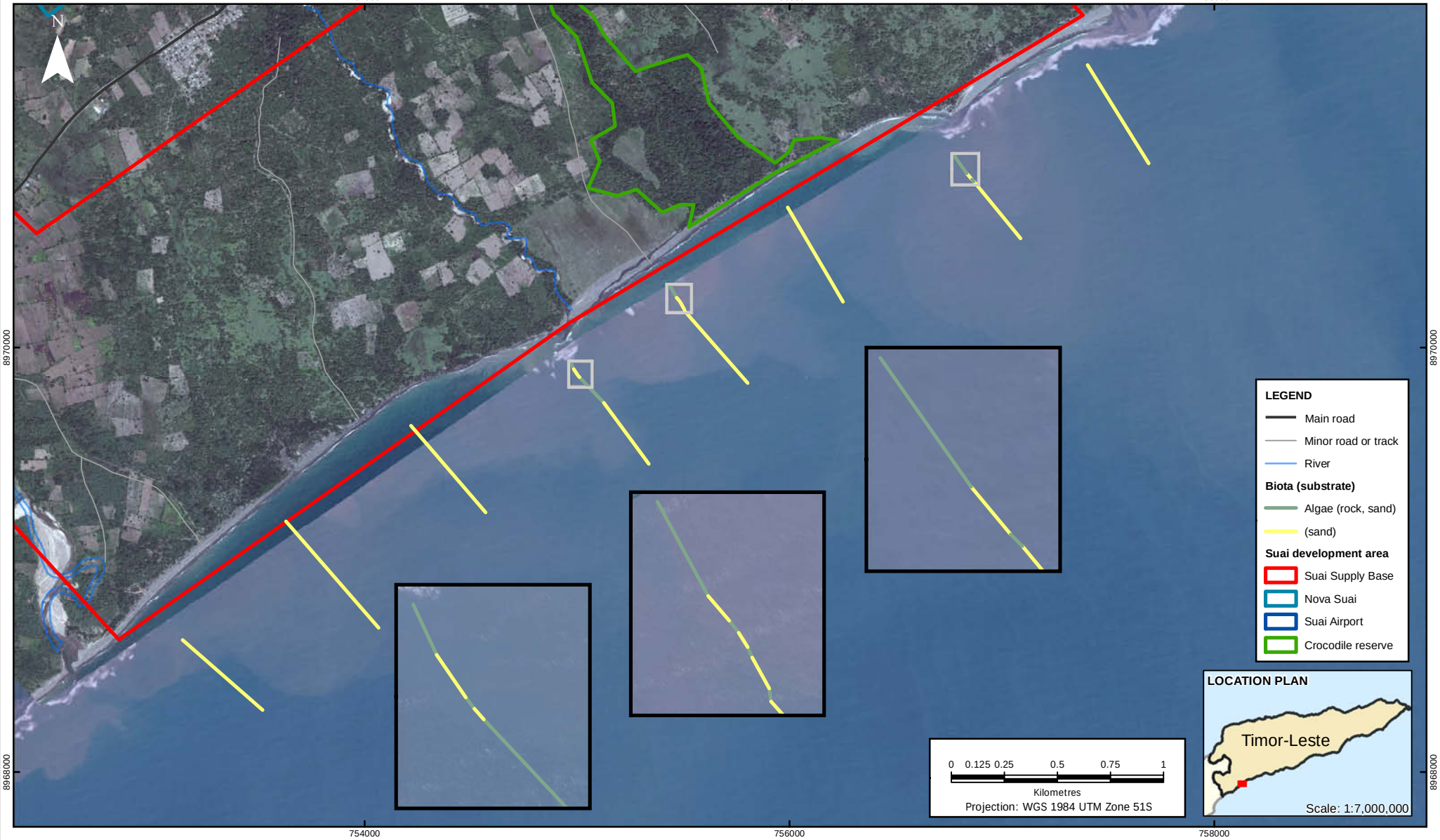
4.3.1 Substrate

The substrate recorded in the study area comprised of either sediment or rock. Sediment substrate was recorded across all surveyed transects, including areas where rock was present. Sediment was the dominant substrate type found within the study area comprising mainly sand and silt. The sediment profile was relatively flat with small ripples (<10 cm) in some areas (Plate 3-2, in Section 3.4.2).

The only hard substrate recorded was rock in the form of cobbles (64-256 mm) and boulders (> 256 mm). Rocks comprised between 10 to 15% of the surveyed transect area and were found to be located close to the shore at a maximum distance of 450 m from the shoreline (Figure 4-10).

4.3.2 Biota

The presence of biota was always associated with the presence of hard substrate (Figure 4-11). The only biota found present on the rocks was turf algae. The density of turf algae covering the rock within transects ranged from sparse (<25%) to dense (>75%), but more commonly covered <25% of the substrate (Figure 4-10).



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PLOT DATE & TIME: 01 MAY 2012, 3:48:29 PM USER NAME: COURTENAY.WHEELER

NOTES:
This map contains:
1. Imagery Suai: SRTM (2011)
2. Imagery: DigitalGlobe (2008 - 2010)
3. Rivers: GIGTimorLeste (2010)
4. Roads: DivaGIS (2010)

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Figure 4-10
Suai benthic habitat tow paths

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2. Imagery: DigitalGlobe (2008 - 2010)

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Figure 4-11
Suai reef area benthic habitat tow paths

4.3.3 Reef Adjacent to Development Area

A coral reef is located approximately 5km to the south west of the Suai development. The reef is predominantly a low diversity reef flat. Limestone rock was the primary substrate of the reef. The main biotic classes found on the reef flat were algae (turf, *Padina*, brown and green), seagrass and sparse patches of soft coral. Dense seagrass meadows were found along the reef flats but were limited in extent.

The reef flat drops steeply into deep water. The greatest coral diversity was generally found within 5 to 8m of the surface which then gradually declined below 8 m. The band of rich coral growth is very narrow, being approximately 50 m wide. The dominant species found were *Acropora* and plating *Porites*.

The dense coral cover gradually changes into a mix of algae and invertebrates found growing on a coral rubble substrate from approximately 8 to 12 m. Brown algae was the main type of algae present with the invertebrates mainly consisting of seawhips, sponges and gorgonians. The band of algae/invertebrates found growing on coral rubble was narrow, being approximately 100 m wide. Generally from a depth 10m sand was observed as part of the substrate until 12 m below surface, where it turned into 100% sand.

4.4 Plankton

A total of 367 planktonic fauna from 17 taxonomic groups were collected during the baseline survey. The most abundant fauna were larvaceans (n=97), followed by copepods (n=93) and pteropods (n=47). Plate 4-2 shows the top three most abundant fauna.

4.4.1 Fish Larvae and Eggs

A total of 4 fish larvae and 13 fish eggs were collected in the plankton trawls (Plate 4-3). The larvae collected were all of similar anatomy, possibly from the same species. Identification of larval fish is difficult; however, following the taxonomic guide of Leis and Carson-Ewart (2004), the fish collected have the following characters:

- Body is very elongated (body depth < 10% of body length); and
- Gut is short < 50% of body length.

This matches Group 3 in Leis and Carson-Ewart (2004), from this group it is most likely the fish larvae are from the family Blennidae.

Plate 4-1 Map showing turf algae present on the rocks, adjacent to the Suai footprint area

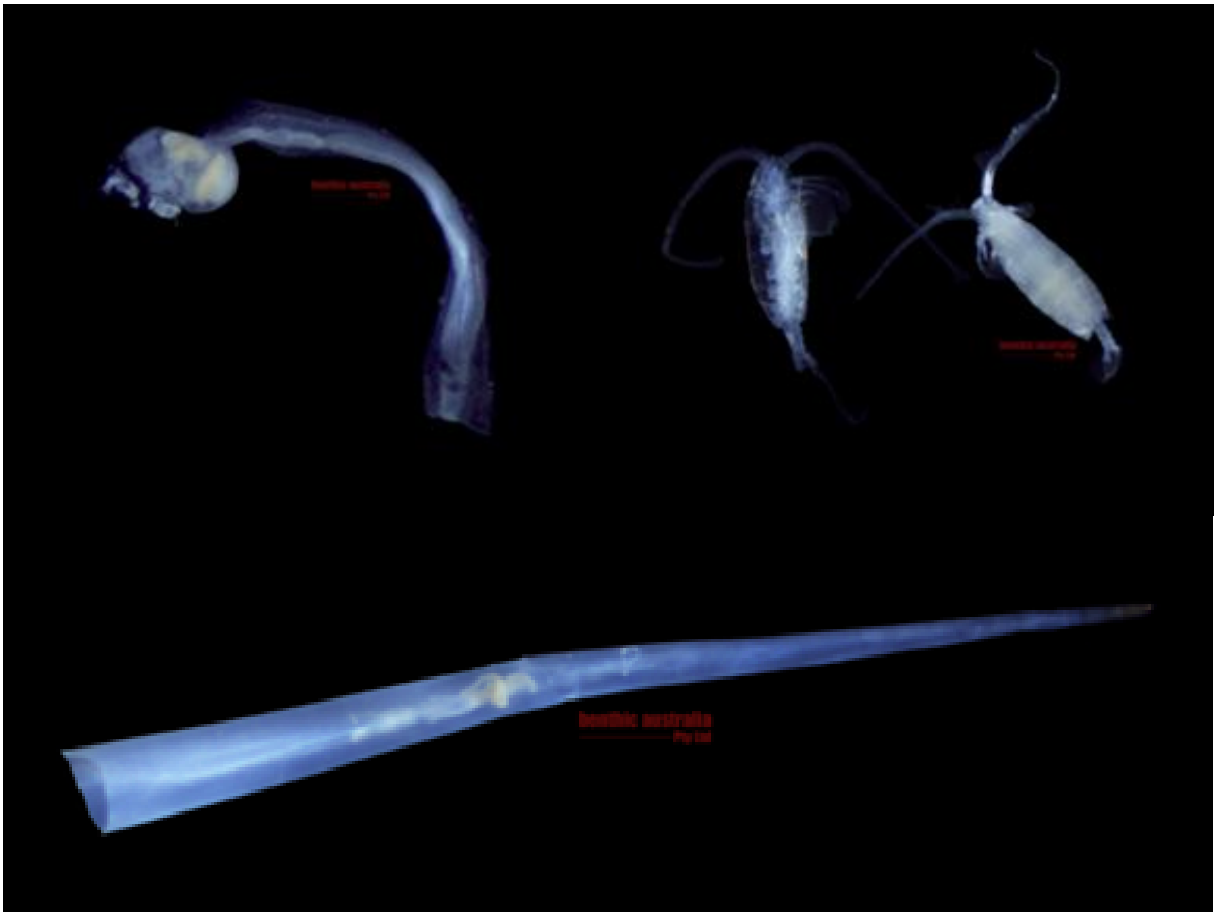

Plate 4-2 Most abundant fauna collected in plankton trawls. (top left - larvaceans; top right – Calanoidea Copopods; bottom – Pteropoda)

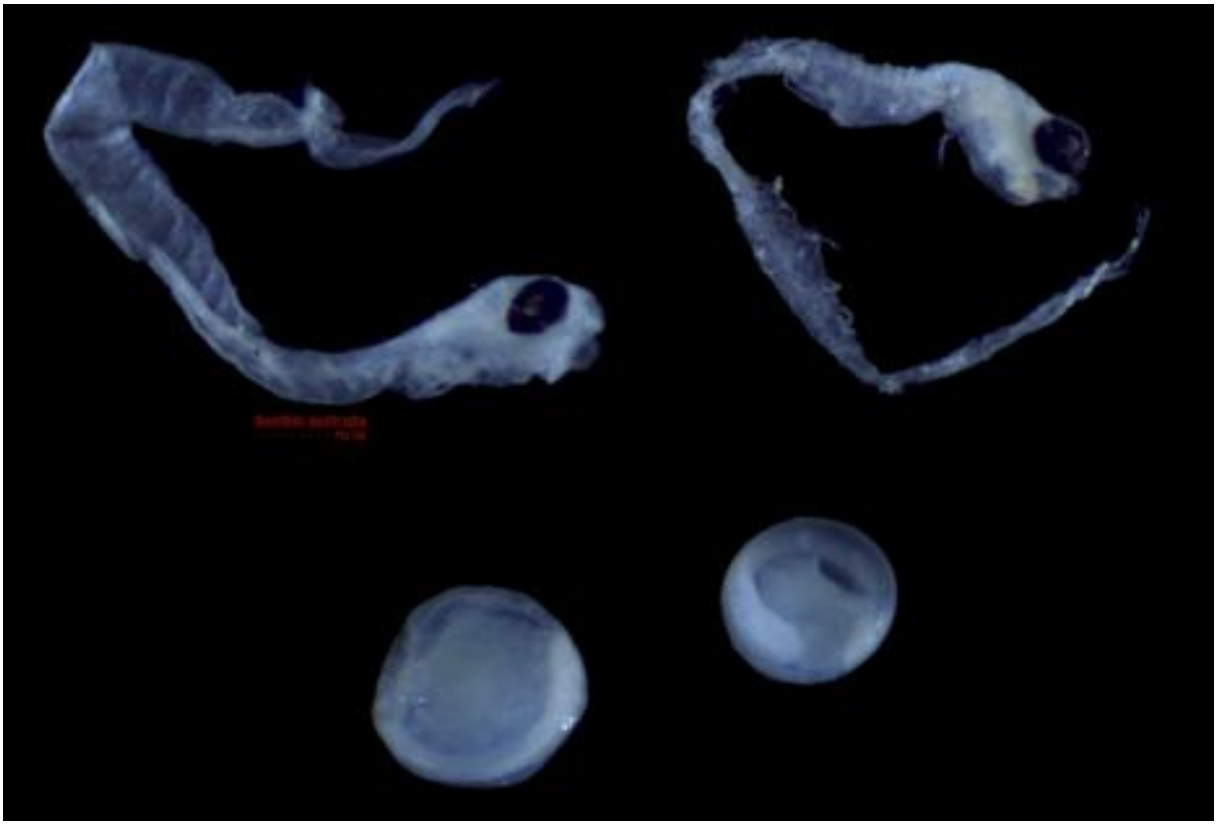

Plate 4-3 Larval fish and eggs collected in plankton trawls (Not to scale); Fish 1-2mm in length; Eggs 0.5 – 1mm in diameter

Plate 4-4 Most abundant fauna collected in benthic grabs. Top left - Hydrozoan; top right – Tellinidae; bottom – Terebellidae (Terebellidae specimen only a representative photograph)

The cluster plot and MDS ordination showed three groupings of sampling sites. The overlay, of the cluster plot onto the MDS ordination showed the majority of sites have a 60% similarity grouping (green circles; Figure 4-15). A one-way ANOSIM comparing each community was not able to be conducted for each site as the survey design did not account for replicate plankton trawls. However, allocating the samples by 'S' location; 'SBM' location and 'SMB' location as indicated by groupings in the MDS ordination, the one-way ANOSIM showed no significant difference between these groups (Global R=0.207; p=0.139; Figure 4-13).

A SIMPER analysis determined the fauna contributing to the differences between sites. The most dominant fauna Calanoids, Pteropoda and Larvaceans had a 60% combined contribution to the difference between sites (Table 4-11).

Table 4-11 SIMPER analysis results for plankton fauna contributing to all site differences

Species	Av.Abund	Contrib%	Cum.%
Calanoid	5.19	39.24	39.24
Pteropoda	3.57	19.45	58.69
Larvaceans	2.89	10.32	69.01
Gastropoda	1.61	6.44	75.45
Fish eggs	1.22	5.7	81.16
Crab Zoea	1.27	4.55	85.71
Chaetognaths	1.64	4.05	89.76
Prawn Larvae	1.14	2.91	92.68

4.5 Infauna

A total of 238 macroinvertebrates from 61 taxonomic groups were collected during this baseline survey. The most abundant family was the Tellinidae bivalves (n=16), followed by the spaghetti worms Terebellidae (n=15) and a branching Hydrozoan (n=14). Plate 4-2 shows the top three most abundant fauna. The Terebellidae specimen shown in Plate 4-2 is only a representative photograph; and not a specimen collected during the survey.

The cluster plot showed no strong groupings of sampling site or replicates (Figure 4-14). This was supported in the MDS ordination which shows all sites generally grouped together. The overlay, of the cluster plot onto the MDS ordination showed the majority of sites have a 40% similarity grouping (green circles; Figure 4-15). A one-way ANOSIM comparing each community, supports the findings that there is no significant difference between the sites, with a global R=0.103 (p=0.148). A SIMPER analysis showed that the fauna contributing to the differences between sites, with the most dominant fauna Tellinidae, having 27.2% contribution to the difference between sites (Table 4-12).

Table 4-12 SIMPER analysis results for fauna contributing to all site differences.

Species	Av.Abund	Contrib%	Cum.%
Tellinidae	1.93	27.22	27.22
Pasiphaeidae	1.61	17.04	44.25
Ampeliscidae	1.29	8.86	53.12
Nephtyidae	1.11	8.26	61.38
Spionidae	1.22	7.41	68.78
Veneridae	0.95	5.68	74.46
Naticidae	0.88	4.62	79.08
Terebellidae	0.89	4.61	83.69
Dentaliidae	0.87	4.06	87.75
Ogyrididae	0.8	2.69	90.43
Sternapsidae	0.68	2.27	92.7
Alphiidae	0.65	1.91	94.62
Pilumnidae	0.55	1.62	96.24
Ocypodidae	0.49	0.96	97.2
Lysianassidae	0.36	0.81	98.01
Sipuncula	0.33	0.69	98.71
Leucosiidae	0.45	0.52	99.23
Portunidae	0.37	0.3	99.53
Sigalionidae	0.24	0.24	99.77
Corbulidae	0.23	0.23	100

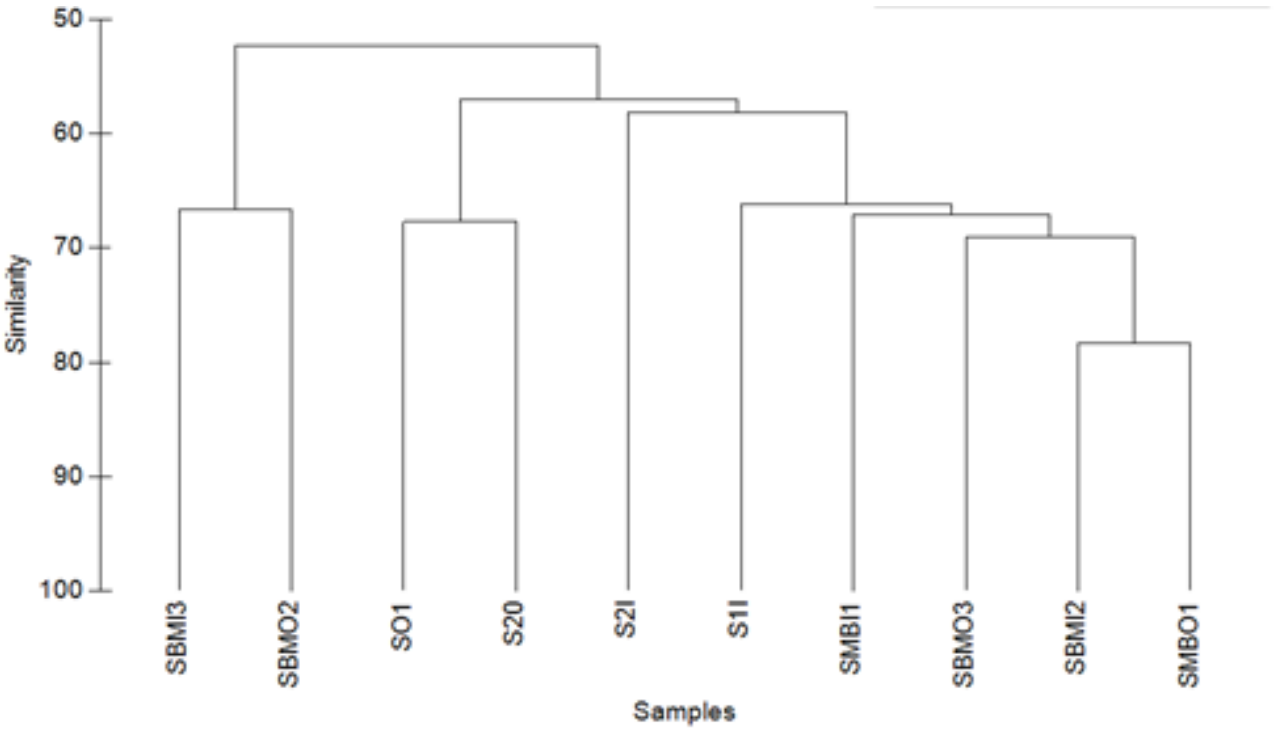

Figure 4-12 Cluster plot showing the similarity of plankton survey sites

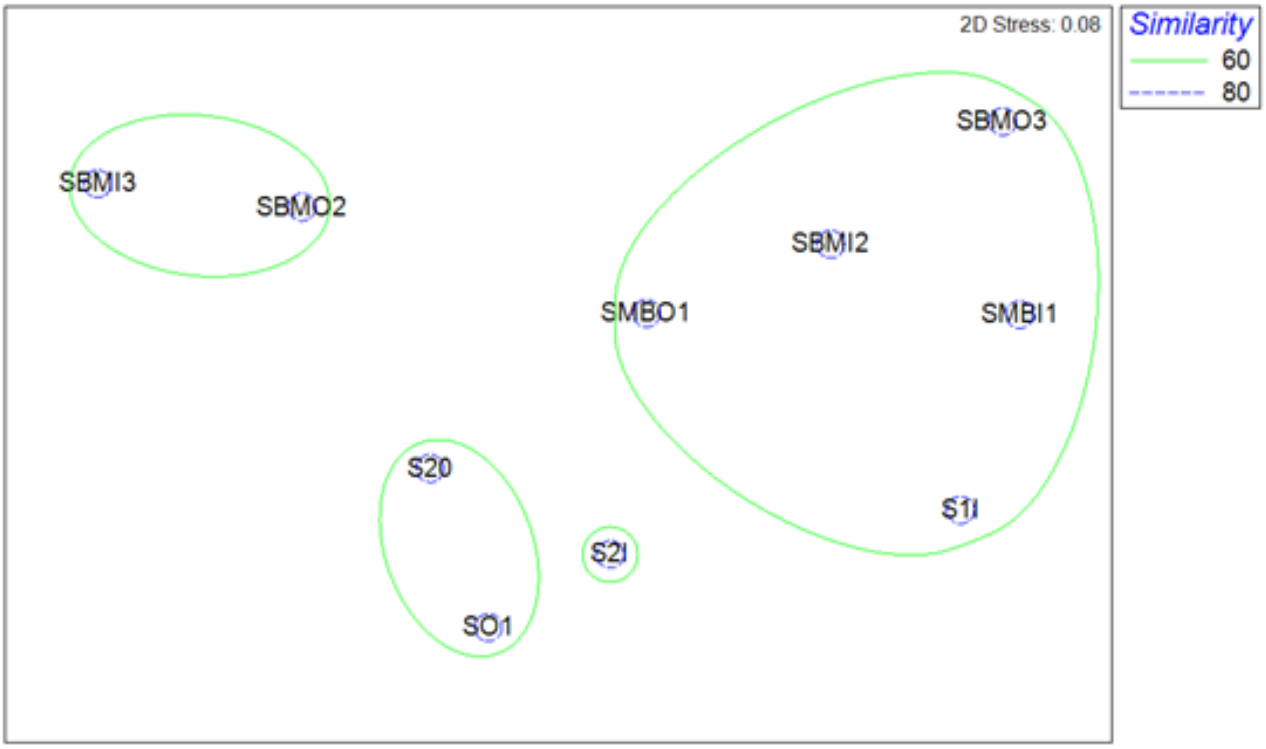

Figure 4-13 MDS ordination of plankton samples. Circles shows similarity groupings from the Cluster analysis

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	WorleyParsons resources & energy		TIMOR GAP, E.P. Timor Gas & Petróleo			REPUBLICA DEMOCRATICA DE TIMOR-LESTE SECRETARIA DE ESTADO DOS RECURSOS NATURAIS				OneWay to zero harm	

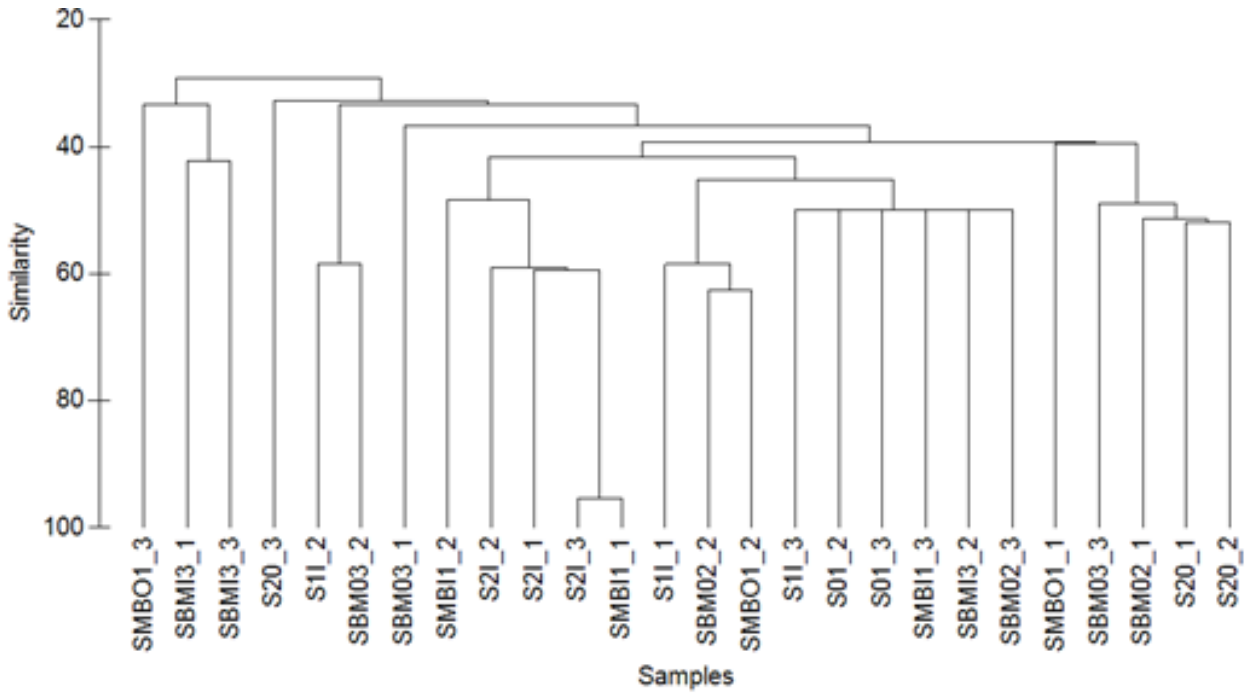

Figure 4-14 Cluster plot showing the similarity of macroinvertebrate survey sites

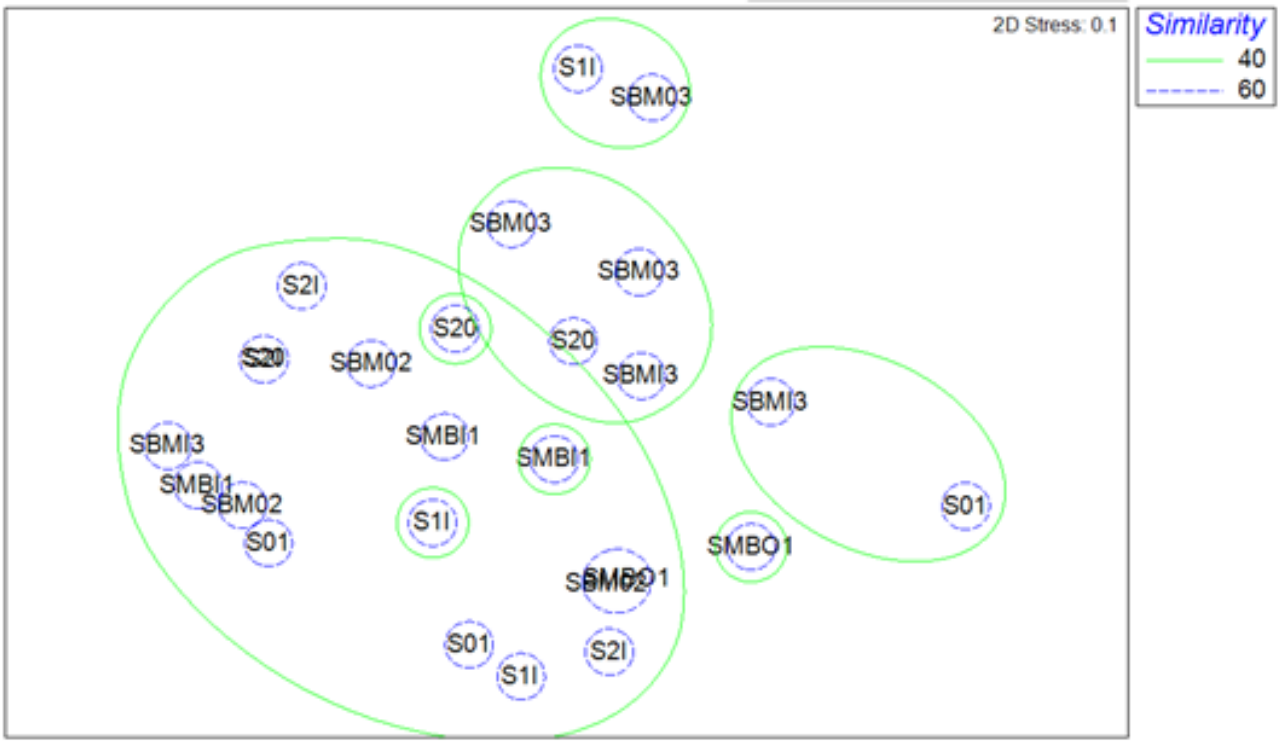

Figure 4-15 MDS ordination of macroinvertebrate samples. Circles show similarity groupings from the Cluster analysis

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PLOT DATE AND TIME: 2 May 2012, 9:48 AM Creator: Courtenay Wheeler

5. DISCUSSION

5.1 Water Quality

Physicochemical water quality

Results collected during the field investigation between 16 and 18 December 2011 indicated that marine water quality conditions at Suai are generally considered typical of a tropical marine ecosystem at the start of the wet season (Kirono, 2010). Physicochemical water quality parameters varied between nearshore and offshore sites, and are mainly related to differences in depth and their proximity to riverine discharges along the coast.

Temperature was found to generally decrease at a rate of 0.10°C per 5 m across all sites. This is most likely a consequence of the sunlights limitation in penetrating the water column with depth. Generally the offshore temperature was 0.20°C less than nearshore. This can be attributed to an influence of currents offshore and therefore an increased susceptibility to mixing, in comparison to the shallower nearshore waters (Prince et al., 1986).

An increase in salinity was noted in both nearshore and offshore sites with depth. Surface waters from the offshore sites were slightly less saline than surface waters from the nearshore sites but the difference was minor and less than 0.4 ppt. The difference in the inshore sites was in the order of 0.2 ppt. The difference noted may be due to the flow of freshwater runoff from the rivers to the west and east of the site, however no significant pycnocline (density gradient) was evident indicating that coastal waters are well mixed.

No trend in pH was apparent and the dataset too small to draw any conclusions relating to temporal or spatial variation. The pH values in the offshore sites varied between 8.09 and 8.10, while inshore sites varied between 8.11 and 8.14.

Generally turbidity gradually increased with depth at both locations. There was also significant variability noted within the inshore sites, in particular at a Site SBMI3 which had much higher turbidity than other inshore sites. This is most likely attributed to its proximity to a major riverine discharge near the northern boundary of the project site. Of the offshore sites, SBMO3 (and to a lesser extent SBM02) were also elevated compared with other sites but only beyond the 5 m water depth. It is likely that rainfall events mobilise large volumes of sediment from within the catchment discharging them into the ocean causing ambient turbidity levels in the coastal environment to become elevated.

Dissolved oxygen decreased with increasing depth in the offshore sites with a less apparent trend in the inshore sites. Near the surface, water is found to more readily mixed with the atmosphere through

wave action that causes oxygen to become dissolved. With increasing depth, DO is taken up by respiration or biological oxygen demand and there is less turbulence from wave action reducing the level of atmospheric oxygen available for dissolution.

Chemical water quality

Concentrations of nutrients were generally below the laboratories limit of reporting (LOR) for all nearshore and offshore sites, with the exception of ammonia and total nitrogen. Ammonia levels were found to be generally higher in the offshore sites and exceeded the recommended ANZECC/ARMCANZ (2000) trigger level at all sites. Similarly, total nitrogen exceeded recommended trigger levels at five of the ten sites sampled; however, exceedances occurred in both inshore and offshore sites. No spatial trends were apparent in the data.

Low concentrations of total and dissolved metals were observed in offshore and nearshore sites except for total and dissolved copper concentrations which exceeded the ANZECC/ARMCANZ (2000) guidelines at five sites, namely Sites SBM13, SI1, SBMO1, SO1, and SO2. Copper is considered a naturally occurring metal in the marine environment, particularly from rivers and from ocean sediments, therefore high concentrations observed may indicate copper concentrations are likely to be naturally high. Similarly, total concentrations of zinc at SBMO3 and SI1 exceeded the ANZECC/ARMCANZ (2000) trigger for zinc, however all dissolved concentrations were less than the trigger level.

5.2 Sediment Quality

Concentrations of total nitrogen and phosphorus were relatively high in coastal sediments. Concentrations of total nitrogen were generally higher in the offshore sites and highest at Sites S02 and S01. Concentrations of phosphorous were consistent across all sites with no trend apparent.

Total nitrogen concentrations observed at all sampling sites were comprised of 100% organic nitrogen (TKN) which indicates that nitrogen found in sediments within the study area are of organic origin. Organic sources of nitrogen found in the study area are likely derived from agriculture activities along the Karoulin and Raiketan Rivers. Organic nitrogen that form the primary constituent of natural fertilizing techniques are washed into the catchment before discharging from the river mouth into the ocean (Carpenter et al., 1998).

All metal concentrations in marine sediments were less than the ANZECC/ARMCANZ (2000) sediment quality guidelines except for nickel. Elevated concentrations were recorded from sites SBMI1, SBMI 3 as well as sites SBMO1, SBMO2 and SBMO3. Interestingly, concentrations of chromium, copper and zinc were also above the limits of reporting whereas concentrations at remaining sites were consistently less than their respective limit of reporting.

All hydrocarbons were at levels less than the limit of reporting at both nearshore and offshore sites.

Particle size distribution in sediments at Suai followed expectations, with shallower inshore sites dominated by sand, and deeper offshore sites dominated by fines. These fine fractions of sediment are likely sourced from riverine systems, becoming resuspended by currents and wave energy in the shallower areas, eventually settling in deeper areas offshore.

5.3 Benthic Habitat

The southern Timor-Leste coastline consists of a combination of sandy beaches and limestone rock ledges that extend from the shoreline as intertidal reef flat areas that then slope down steeply towards the seabed. In some places along the southern coastline, water depths of 200m can be found less than 1km offshore (Australia – East Timor, Timor Sea, Dillon Shoal to East Timor chart produced by RAN). The sandy beaches consist of medium to fine sand with silt. During heavy rains, sediments are mobilised from the surrounding catchment and enter the ocean causing large sediment plumes. Aerial photographs associated with the Suai area show turbid plumes moving from east to west along the Suai coastline.

The benthic habitat within the study area is dominated by sediment. Given the high elevation and seasonal rainfall in catchments draining to the south coast of East Timor, a natural high flux of fluvial sediments occurs. In addition, deforestation in the region, which is evident to varying extents in aerial photographs, is likely to have enhanced sediment supply. Hard substratum made up approximately 13% of the surveyed transects. The primary hard substrate along the south coast of Timor-Leste is highly erodible coastal limestone, formed by acidification of shell material and ocean movement along the coastline. The only hard substrate found in the Suai footprint area was weathered coastal limestone.

Within the study area, brown turf algae was the primary biotic benthic community. The turf algae was primarily associated with areas of hard substrate and generally had <25% coverage. There is a coral reef located to the south west of the main Suai footprint region.

The fringing reef identified adjacent to the Suai study area is typical of the fringing reef systems found in South East Asia (Burke et al., 2002). The reef generally consisted of a low diversity reef flat which falls steeply into deep water. The greatest coral diversity was generally found within 5 to 10m of the surface which then gradually declines below 10m as depth increases and light diminishes. A high diversity of coral reefs exist in southern Timor-Leste with 301-500 species identified (Burke et al., 2002). The band of rich coral growth is very narrow, being approximately 50m wide.

Seagrass communities have previously been identified in northern parts of Timor-Leste. Dense seagrass meadows were found along the reef flats adjacent to the Suai footprint region. Meadows identified within the study area were generally limited in extent and are not considered to provide a significant resource for grazing by dugongs and turtles.

5.4 Plankton

Plankton communities identified from samples collected in the study area were dominated by calanoids, pteropods and larvaceans, which also had a 60% combined contribution to the difference between sites. The planktonic communities showed potential groupings in the MDS, however, these were not supported by the ANOSIM. It is most likely that the fish larvae are from the family Blennidae. Similarly a low diversity and abundance of fish larvae and eggs were also collected in the plankton trawls.

The diversity and abundance observed in this survey event are more likely a reflection of sampling being undertaken during the day. Significantly more and larger zooplankton is caught at night and is responsible for a large proportion of zooplankton variability, due to diel (diurnal) vertical migration (Suthers et al., 2009). Migratory patterns can be variable and are known to differ with the sex and age of species, habitat type and season (Van Gool & Ringelberg, 1998). In some seasons or years there may be no difference between day and night zooplankton abundance, in other years there may be a significant difference (Suthers & Rissik, 2009).

5.5 Infauna

The macroinvertebrate communities during the baseline sampling event were species rich in polychaetes and crustaceans, each contributing to 29% of the community fauna. It is common for either polychaetes or crustaceans to be the dominant benthic fauna in sandy sediments from the Australasian region (Long & Poiner, 1994; Currie & Small, 2005). The most abundant family was Tellinidae (bivalves), which also had a 27.2% contribution to the difference between sites. The benthic community showed no significant differences across sites.

6. CONCLUSION

The marine waters on the southern coast of Timor-Leste are generally well mixed with little physical stratification. Some of the variation noted in physical and chemical parameters is most likely due to the effects of freshwater associated with the numerous rivers that discharge along this section of coastline.

Large volumes of sediment are transported into coastal areas by rivers during the rainy season. Runoff from the surrounding catchment is the most likely source of nutrients and contaminants into the inshore marine environment.

Given the importance of rainfall, significant seasonal differences in water quality is likely between the wet and dry seasons.

Infaunal communities were similar across all sites and composition was typical of sand dominated sediments elsewhere in the region. Plankton species richness and abundance was low but largely reflected a day time community composition with few differences noted between the grouped sites. Fish larvae and eggs were also present in low numbers. Overall, the marine communities during the baseline survey showed no significant different in faunal composition across sites.

The benthic habitat within the study area is predominantly sediment. Hard substratum made up 13% of the surveyed transects. Within the study area, brown turf algae was the primary biotic benthic community. The turf algae was primarily associated with areas of hard substrate and generally had <25% coverage. The coral reef located on the western side of the Suai footprint region consisted of a low diversity limestone reef flat which dropped steeply into deep water. A thin band of rich corals occurs from the 5 to 8m depth contour which grades into an algae and invertebrate dominated habitat from 8 to 12m. Beyond the 12m depth, the habitat is sand.

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REPUBLICA DEMOCRATICA DE TIMOR-LESTE
SECRETARIA DE ESTADO DOS RECURSOS NATURAIS

ATTACHMENT 3

Tasi Mane Project - Suai Supply Base EIA

Strategic Environmental Management Plan

301012-01504-EN-REP-0004

May 2012

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GOVERNMENT OF TIMOR-LESTE, THROUGH THE SECRETARIA DE ESTADO DOS RECURSOS NATURAIS
TASI MANE PROJECT – SUAI SUPPLY BASE EIA
STRATEGIC ENVIRONMENTAL MANAGEMENT PLAN

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PROJECT 301012-01504 – TASI MANE PROJECT – SUAI SUPPLY BASE EIA: STRATEGIC EMP

REV	DESCRIPTION	ORIG	REVIEW	WORLEY-PARSONS APPROVAL	DATE	CLIENT APPROVAL	DATE
A	Issued for Internal Review				22 Nov 2011		
B	Issued for client review				23 Mar 12		
0	Issued for client use	M. Hendricks	M. Hendricks	G. Hamilton	9 May 12		

CONTENTS

1. INTRODUCTION

1.1 Project Proponent

The proponent for the Tasi Mane project ('the project') is the Secretaria De Estado Dos Recursos Naturais (SERN) or Secretary of State for Natural Resources, a division of the Government of Timor-Leste (GoTL).

1.2 Project Overview

The Tasi Mane project (project) comprises three petroleum infrastructure clusters along the southern coast of Timor-Leste. The GoTL, through SERN, proposes to establish a supply base industry at Suai, a refinery and petrochemical industries at Betano (Manufahi District), and an LNG plant at Beaco (Viqueque District) along the southern coast.

The project forms part of the government's strategic vision for the economy to secure new commercial and industrial activities, and will provide modern infrastructure and facilities.

This document only relates to the development of the supply base at Suai.

The area of Suai, in the Cova Lima district, is intended to become an industry base for Timor-Leste and provide a focal point for services, logistics, fabrications and human resources. The primary purpose of the supply base is to support the offshore exploration and development of petroleum, although, it will provide (generally) indirect support to the proposed oil and gas industry developments at Betano and Beaco.

The components of the development at Suai are:

- Supply base, including sea port, warehouse logistics area, offices and fuel storage facilities.
- Industrial estate.
- New town development: Nova Suai.
- Suai Airport upgrade.
- Crocodile reserves.

1.3 Purpose of the Environmental Management Plan

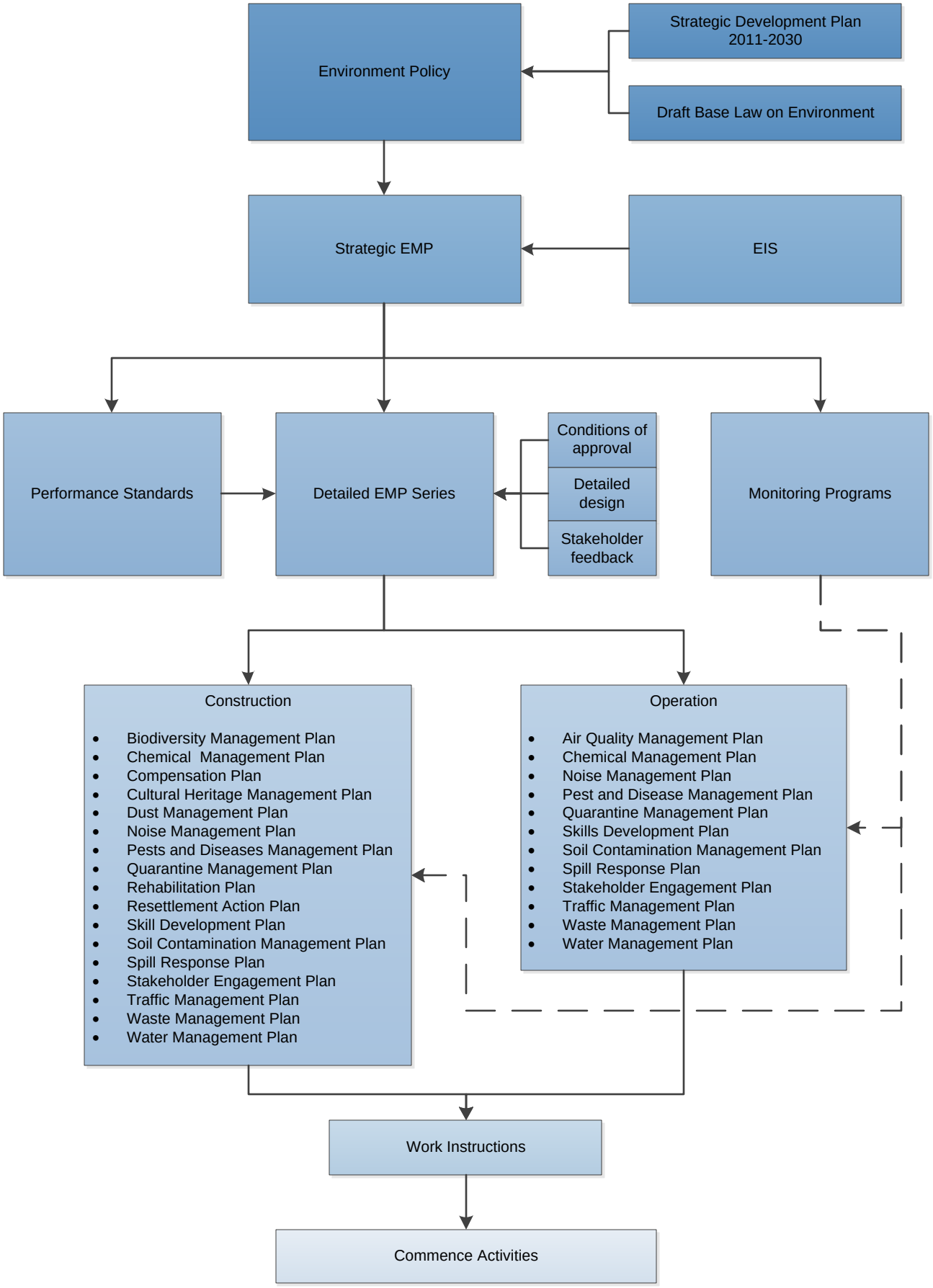
An environmental management plan (EMP) is required to be submitted with the environmental impact statement (EIS) to support an environmental licence application in accordance with the Decree Law 5/2011 on environmental licensing.

The purpose of the EIS is to determine the baseline conditions for the physical, biological and social environment at the Suai development area, identify the likely environmental and social impacts

associated with the project and prescribe the measures to avoid, manage and mitigate potential adverse impacts. This EIS also identifies further work required for each environmental aspect. This further work, and more detailed assessment, will influence the number and type of sub-plans required for the project.

An environmental management plan typically flows from the EIS and continues through the life of the project. An EMP consolidates all the management and mitigation measures which can be given statutory effect through formal approval. Figure 1-1 shows the EMP development process and its interaction with the EIS.

In the absence of a detailed project description, a strategic EMP (this document) has been prepared which outlines the overarching environmental and social management impacts, describes the objectives for the project, collates the mitigation measures resulting from the impact assessment process described in the EIS and identifies the monitoring, responsibility and reporting requirements. The strategic EMP will then form the basis for detailed EMP's required prior to construction and operation of the project. The detailed EMP's will be site and activity specific and will set out the specific tasks to be implemented by the project staff and contractors.



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0	4/05/2012	FOR FINAL ISSUE	CW	MH	-	-	GH		A4 SHEET

TASI MANE PROJECT – SUAI SUPPLY BASE ENVIRONMENTAL IMPACT ASSESSMENT

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Figure 1-1
Environmental management flowchart

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PLOT DATE AND TIME: 4 May 2012, 5:22 PM

Creator: Courtenay Wheeler

2. IMPLEMENTATION OF ENVIRONMENTAL MANAGEMENT

2.1 Land Use and Visual Amenity

Impact	The development of the project will cause a visual change to the landscape as a result of the introduction of an industrial development into a rural setting. However, the undulating topography of the site combined with the existing dense vegetation would be expected to mitigate this impact to some extent. The clearing of vegetation, construction earthworks and permanent infrastructure is likely to generate the greatest visual impact.
Objectives	• Locate and design facilities to minimize visual impact. • Avoid or minimize the loss of agricultural land. • Avoid areas of steep terrain.
Avoidance, management and mitigation measures	• Retain existing vegetation as much as possible. • Reduce, as far as is practicable, the cleared areas needed to construct and operate the project. • Restore existing vegetation to its previous or an improved condition, prior to removal. • Undertake tree screening along the borders of the cleared areas of the project using fast growing dense vegetation. • Adopt a sensitive lighting approach to reduce light spill. Measures may include providing directional or shielded lighting, minimizing light pole elevations, purchasing lower lux rating lights, motion sensors and timers.
Monitoring	• Monitor the number of complaints regarding visual amenity and investigate accordingly. • Compliance audits to be undertaken during construction and operation.
Responsibilities	• The Construction Contractor Environmental Manager will be responsible for ensuring the monitoring and auditing of the EMP is carried out. • The Construction Contractor Supervisor will be responsible for ensuring the implementation of the avoidance, management and mitigation measures in the EMP.
Reporting	• Construction Contractor Environmental Manager will provide monthly updates to the Construction Contractor Supervisor on routine monitoring and auditing results. • Construction Contractor Supervisor to provide SERN with periodic updates on routine monitoring and audit results.

2.2 Geology and Soils

Impact	Impacts can be minimised and the need for rehabilitation reduced, by implementing management measures that prevent the: • Loss of soil quality. • Soil erosion. • Land instability and slope failure. • Disturbance of acid sulfate soils. • Soil contamination.
Objectives	• Minimize soil loss and erosion. • Avoid or minimize use of sites with sodic or acid sulfate soils. • Maintain the integrity and environmental values of the geology and soils.
Avoidance, management and mitigation measures	• Ensure erosion control structures are used during construction and designed for storm events. • Install appropriate sediment controls, such as erosion berms, drains and sediment traps, to collect runoff and sediment from the work sites and prevent sediment entering watercourses. • Where practicable, ensure construction traffic uses formed access tracks to minimize soil disturbance. • Ensure formed access tracks are covered with a compacted trafficable base (e.g., road base). • Install temporary culvert or pipes where access roads cross drainage lines and continuity of flow is required. • Store construction material away from watercourses, with suitable control structures, to avoid being washed away. • Appropriate slope stability structures must be installed on slopes during construction. • Protect slopes that are susceptible to slope failure from mass movement or landslides by preventing excess loading and by preparing and stabilizing soils prior to construction in the area. • Carry out soil surveys to identify areas of potential slope failure. • Direct drainage around work sites to natural drainage lines. • Ensure stormwater runoff is treated prior to discharge from the work site, which may include use of sediment and litter traps, sedimentation ponds, wetlands, grassed swales and oil separators (for target areas such as car parks.

	• Ensure chemical and fuel storage areas are purpose built, above ground on hardstand areas and within containment bunds. • Ensure spill prevention and response plans are in place. • As far as practicable, refuel vehicles and equipment at dedicated refueling areas. • Ensure spill response kits are onsite and maintained. • Implement inductions to ensure the workforce has knowledge of correct use of refueling systems and chemicals. • Implement appropriate construction methods in order to avoid acid sulfate soil formation. • If acid sulfate soils are exposed, treat or dispose of appropriately. If acid sulfate soils are to remain in situ, then cap the soil with a clean source material. • Lightly scarify or shallow rip compacted construction soil surfaces to aid water infiltration. • Treat exposed soil areas, which are exposed for prolonged periods or have been identified as problem soils, (e.g., erosive, dispersive) with chemical surface stabilisers or physical alternatives (crushed rock). • Stockpile topsoil in designated areas for later reuse. Topsoil stockpiles must be separated from subsoil stockpiles and located close to where the topsoil originated. • Stabilize topsoil stockpiles to prevent erosion and maintain integrity when stored for long periods of time. • Rehabilitate disturbed bare soils by respreading topsoil and revegetating soon as practicable after construction is completed.
Monitoring	• Monitor watercourses upstream and downstream of construction work sites to ensure water quality is maintained. • Regularly inspect erosion and sediment control measures during construction and immediately after a potentially damaging weather event to ensure its effectiveness. • Inspect drainage lines and areas of concentrated water flow to assess whether erosion is occurring and whether remedial action is required. • Regularly inspect soil stabilization techniques during construction and immediately after a potentially damaging weather event to ensure its effectiveness. • Undertake monthly visual integrity inspections of fuel and chemical storage facilities for breaches of containment or spills. • Compliance audits to be undertaken during construction and operation.

Responsibilities	• The Construction Contractor Environmental Manager will be responsible for ensuring the monitoring and auditing of the EMP is carried out. • The Construction Contractor Supervisor will be responsible for ensuring the implementation of the avoidance, management and mitigation measures in the EMP.
Reporting	• Construction Contractor Environmental Manager will provide monthly updates to the Construction Contractor Supervisor on routine monitoring and auditing results. • Construction Contractor Supervisor to provide SERN with periodic updates on routine monitoring and audit results.

2.3 Air Quality

Impact	Construction of the project will generate emissions to air primarily in the form of fugitive dust. Dust emissions not only affect the environment, but can also affect human health due to the inhalation of fine particulate matter. • Operation of the project is likely to affect air quality due to fuel combustion in electricity generation and, vehicle and equipment use.
Objectives	• Minimize the impacts of air quality to the environment and on the health, welfare and amenity of people and land uses.
Avoidance, management and mitigation measures	• Establish appropriate environmental buffer zones between dust sources and sensitive receptors. • Control dust generation using suitable dust suppression techniques such as watering. • Ensure adequate water is stored onsite or is available for dust suppression. • Minimise areas of cleared land exposed at any one time. • Treat exposed soil areas, which are exposed for prolonged periods or have been identified as problem soils (e.g., erosive, dispersive), with chemical surface stabilisers (wetting agents) or physical alternatives (crushed rock). • Reinstate cleared areas as soon as practicable after construction. • Where practicable, ensure construction traffic uses formed access tracks to minimize soil disturbance. • Ensure formed access tracks are covered with a compacted trafficable base (e.g., road base). • Restrict hours in which construction is permitted. • Limit vehicle speeds onsite to minimize dust generation. • Maintain fit for purpose vehicles and equipment with appropriate emission control devices (e.g., vehicle exhaust system, filters). • Regularly service vehicles and equipment to maintain optimum vehicle emission levels. • Communicate plans and status of construction activities to stakeholders. • Appoint a principal contact person for community queries. • Ensure third party complaints are recorded and actioned.
Monitoring	• Undertake visual monitoring of the construction site during potential dust generating activities.

	• Undertake monthly visual monitoring of dust deposition on vegetation upwind and downwind (of the prevailing wind) surrounding the construction site. • Continuously monitor ambient pollutants, particulate matter and deposited dust to assess compliance levels. • Monitor meteorological conditions. • Undertake monthly inspections on emission control devices to ensure they are fitted and working correctly. • Monitor the number and nature of complaints regarding dust and air quality and investigate accordingly. • Compliance audits will be undertaken during construction and operation.
Responsibilities	• The Construction Contractor Environmental Manager will be responsible for ensuring the monitoring and auditing of the EMP is carried out. • The Construction Contractor Supervisor will be responsible for ensuring the implementation of the avoidance, management and mitigation measures in the EMP.
Reporting	• Construction Contractor Environmental Manager will provide monthly updates to the Construction Contractor Supervisor on routine monitoring and auditing results. • Construction Contractor Supervisor to provide SERN with periodic updates on routine monitoring and audit results.

2.4 Noise

Impact	Excessive noise emissions are expected from the construction and operational activities of the project, reducing the amenity of the surrounding community. Construction noise impacts are expected to have tonal, modulated and/or impulsive characteristics from piling and excavation activities. Operational noise is expected to have tonality and vibration characteristics resulting from ongoing activities at the supply base, industrial estate and airport.
Objectives	• Minimize adverse impacts of noise emanating from the project on the health, welfare and amenity of people. • Avoid adverse noise impacts to farm animals and native fauna.
Avoidance, management and mitigation measures	• Establish appropriate environmental buffer zones between noise sources and sensitive receptors. • Restrict hours in which construction is permitted. • Schedule noisy activities to less sensitive times allowing for periods of respite. • Provide noise barriers where required. • The equipment used for construction must be the quietest reasonably available. • Fit noise suppression devices to equipment where required. • Service equipment in accordance with manufacturer's specification to ensure they are maintained in a good working order. • Install alternative noise movement/reversing warning systems for equipment and vehicles that will operate for extended periods, during sensitive times or in close proximity to sensitive sites. • Communicate plans and status of construction activities to stakeholders. • Appoint a principal contact person for community queries. • Ensure third party complaints are recorded and actioned.
Monitoring	• Undertake compliance noise monitoring at each identified sensitive receptor. • Undertake quantitative noise monitoring at the source of a noise complaint. • Compliance audits will be undertaken during construction and operation.
Responsibilities	• The Construction Contractor Environmental Manager will be responsible for ensuring the monitoring and auditing of the EMP is carried out.

	• The Construction Contractor Supervisor will be responsible for ensuring the implementation of the avoidance, management and mitigation measures in the EMP.
Reporting	• Construction Contractor Environmental Manager will provide monthly updates to the Construction Contractor Supervisor on routine monitoring and auditing results. • Construction Contractor Supervisor to provide SERN with periodic updates on routine monitoring and audit results.

2.5 Surface Water

Impact	Reduction in water quality and alteration to water flow is likely during construction and operational activities as a result of erosion, potential flooding, impediment to existing channel migration and stormwater runoff. The Suai site is located at the downstream end of the catchment between two sizeable watercourses Rio Raiketan (to the east) and Rio Camanasa (to the west).
Objectives	Protect the quality and quantity of surrounding surface water from the impacts of the project.
Avoidance, management and mitigation measures	• Flood protection measures, such as flood levees and diversion channels, may be required to prevent inundation of the project site by flood waters. • Ensure diversion structures and storage dams, if required, are sited away from environmentally sensitive areas. • Establish appropriate environmental buffer zones between infrastructure and nearby channels to minimize the risk of erosion. • Ensure erosion control structures are used during construction and designed for storm events. • Install appropriate sediment controls, such as erosion berms, drains and sediment traps, to collect runoff and sediment from the work sites and prevent sediment entering watercourses. • Store construction material away from watercourses, with suitable control structures, to avoid being washed away. • Direct drainage around the work sites to natural drainage lines. • Ensure stormwater runoff is treated prior to discharge from the work site, which may include use of sediment and litter traps, sedimentation ponds, wetlands, grassed swales and oil separators (for target areas such as car parks. • Rehabilitate disturbed bare soils as soon as practicable after construction is completed. Avoid riparian vegetation clearance where practicable. Where clearance cannot be avoided, reinstate and revegetate bed and banks of watercourses as quickly as practicable after construction. • Do not store chemicals near watercourses. • Ensure refueling areas for construction equipment are well away from watercourses. • Ensure wastewater streams are directed to the wastewater treatment plant to ensure discharges offsite meet the applicable water quality standards for either aquatic or marine environments.

	• Ensure the potential extraction of water from nearby surface waters protects the flow regime, particularly during low flow periods. • Determine baseline water qualities of watercourses potentially affected by the project.
Monitoring	• Monitor watercourses upstream and downstream of construction work sites to ensure water quality is maintained. • Monitor the effectiveness of flood protection measures regularly during construction and immediately after a significant rainfall event. • Inspect erosion and sediment control structures for their integrity and effectiveness regularly during construction and immediately after a significant rainfall event. • Monitor stormwater discharge from work sites to ensure impacts to water quality are prevented. • Inspect drainage lines and areas of concentrated water flow to assess whether erosion is occurring and whether remedial action is required. • Compliance audits to be undertaken during construction and operation.
Responsibilities	• The Construction Contractor Environmental Manager will be responsible for ensuring the monitoring and auditing of the EMP is carried out. • The Construction Contractor Supervisor will be responsible for ensuring the implementation of the avoidance, management and mitigation measures in the EMP.
Reporting	• Construction Contractor Environmental Manager will provide monthly updates to the Construction Contractor Supervisor on routine monitoring and auditing results. • Construction Contractor Supervisor to provide SERN with periodic updates on routine monitoring and audits results.

2.6 Hydrogeology

Impact	Construction and operation of the Suai development has the potential to adversely affect groundwater and could potentially result in changes to groundwater quality. Groundwater flow patterns, groundwater recharge and discharge areas and site dependent changes to surficial hydrology and water quality. Likely sources of the groundwater impacts include: • Construction and operation of surface facilities. • Disposal of process water. • Leachate from solid waste disposal (e.g., containment of wastes). • Accidental spills or releases of chemicals and fuels.
Objectives	• Protect existing beneficial users of groundwater. • Maintain groundwater quality. • Minimise disruption to groundwater discharge and recharge areas and groundwater flow paths during construction.
Avoidance, management and mitigation measures	• Ensure groundwater is not extracted for use during construction. • If groundwater is intercepted, direct to sedimentation ponds. • Ensure chemical and fuel storage areas are purpose built, above ground on hardstand and within containment bunds. • Ensure spill prevention and response plans are in place. • As far as practicable, refuel vehicles and equipment at dedicated refueling areas. • Ensure spill response kits are onsite and maintained. • Implement inductions to ensure the workforce has knowledge of correct use of refueling systems and chemicals. • Install groundwater monitoring bore(s) to establish a baseline of groundwater levels and quality prior to construction.
Monitoring	• Quarterly groundwater monitoring to assess quality against baseline levels. • Undertake monthly visual integrity inspections of fuel, chemical and waste storage facilities for breaches of containment or spills. • Compliance audits to be undertaken during construction and operation.
Responsibilities	• The Construction Contractor Environmental Manager will be responsible for ensuring the monitoring and auditing of the EMP is carried out. • The Construction Contractor Supervisor will be responsible for ensuring the implementation of the avoidance, management and mitigation measures in the EMP.

Reporting	• Construction Contractor Environmental Manager will provide monthly updates to the Construction Contractor Supervisor on routine monitoring and auditing results. • Construction Contractor Supervisor to provide SERN with periodic updates on routine monitoring and audit results.

2.7 Terrestrial Biodiversity

Impact	Potential environmental impacts to terrestrial flora and fauna, and habitat values as a result of construction and operations include: • Loss of individuals of IUCN listed species; *Santalum album* (Sandalwood) *Pterocarpus indicus* (Rosewood), both valuable timber trees; • Loss of floristic biodiversity that has not been documented; • Secondary weed invasion after clearing, particularly Siam Weed and Cogon Grass; • Loss of forest and tree cover; • Loss of important mangrove habitat; • Loss of agricultural land and subsistence gardens; • Loss of food crops and estates e.g. coconuts, bananas; • Loss of timber for fuel source; • Loss of cash crops e.g. Teak, Rosewood and Sandalwood; and • Loss of fauna habitat, specifically important habitat for species of conservation significance. • Increased noise disturbance to fauna species. • Changes to fauna habitat and assemblages. • Changes to conservation significant fauna. • Increased potential of vehicle strike due to construction and operational vehicles. • Increased erosion potential and sedimentation due to soil disturbance.
Objectives	• Protect IUCN Red Listed species (both flora and fauna) from adverse impacts. • Avoid disturbance to the habitat that supports IUCN Red Listed fauna species. • Ensure impacts on other terrestrial flora and fauna, and habitat values are minimised and/or mitigated. • Increase awareness about the importance of the terrestrial flora and fauna in the vicinity of the project.
Avoidance, management and mitigation measures	• Site project infrastructure to avoid key habitat areas. • Retain native vegetation wherever possible, specifically mangrove communities and Sheoak trees thought to be important habitat for the Yellow-crested Cockatoo (IUCN Red List species).

	• Clearly identify the project footprint area of the project, including access roads and buffer areas prior to the commencement of works. • Use temporary fencing, flagging, signage or other delineation to clearly identify vegetation to be retained. • Clear vegetation in a sequential manner to encourage fauna to move out of the project area and into adjacent vegetation. • Avoid vegetation clearing activities in periods of high rainfall to reduce soil erosion and sediment runoff. • Fell trees in the direction of the work site or into existing cleared areas. • Collect and relocate tree logs to existing vegetation areas to enhance habitat quality. • Mulch cleared vegetation and stockpile in existing cleared areas. • Spread mulched material on erosion prone areas or rehabilitated areas. • Ensure all vehicles, machinery, plant equipment and materials which have entered a known weed infested areas are washed down at a dedicated onsite washdown location to remove all soil and vegetative material from cabins, trays and under carriages. • All equipment, machinery and materials entering Timor-Leste from overseas will be inspected to ensure quarantine standards are met. • Use appropriate techniques to remove weed infestations where possible. Avoid use of herbicides in and adjacent to areas with surface water. • If practicable, appoint environment specialists to ensure construction does not adversely impact on the terrestrial biodiversity.
Monitoring	• Undertake daily monitoring of vegetation clearing activities to ensure buffer areas are not compromised. • Ongoing monitoring and control of disturbed areas to minimize the emergence of weeds. • Compliance audits will be undertaken during construction and operation.
Responsibilities	• The Construction Contractor Environmental Manager will be responsible for ensuring the monitoring and auditing of the EMP is carried out. • The Construction Contractor Supervisor will be responsible for ensuring the implementation of the avoidance, management and mitigation measures in the EMP.
Reporting	• Construction Contractor Environmental Manager will provide monthly updates to the Construction Contractor Supervisor on routine monitoring and auditing results. • Construction Contractor Supervisor to provide SERN with periodic updates on routine monitoring and audit results.

2.8 Marine Biodiversity

Impact	The construction and operation of the Suai Supply Base has the potential to adversely affect the marine environment and could potentially result in one or more of the following: • Changes in local hydrodynamics and coastal processes (sediment transport). • Changes in water quality. • Changes in sediment quality. • Direct and indirect changes in benthic habitats and infaunal communities. • Changes in fisheries resources Likely sources of marine environmental impacts include: • The construction and physical presence of new marine structures. • Sediment disturbance by construction and port operation activities. • Spills, discharges and runoff associated with construction and port operation activities. • Operation of the desalination plant. • Operation of the wastewater treatment plant. • The introduction of marine invasive species.
Objectives	• Protect IUCN Red Listed marine biodiversity from adverse impacts. • Ensure impacts on other marine flora and fauna are minimised and/or mitigated. • Ensure impacts on coastal landscape values are minimised, and mitigated, including the prevention of coastal erosion.
Avoidance, management and mitigation measures	• Vessels will be fitted with differential GPS to ensure there is no direct impact outside the work site. • All vessels will be required to have in place a Shipboard Oil Pollution Emergency Plan. • Mooring and anchoring activities will only occur at designated sites. • Navigation aids will be used to identify the designated mooring and anchoring sites. • Maintain fauna (marine mammals) exclusion zones where required. • Vessels will not approach marine mammals. • Time dredging and disposal operations to avoid key lifecycle stages for local biota.

	• Select appropriate dredge plant and dredging methods, including utilization of suspension reduction technologies where practicable. • Implement a 'No Overflow' policy during dredge loading. • Minimise dredging volume through careful planning and avoidance of excessive deepening. • Carefully select disposal sites to maintain the natural dynamics of the marine system and minimise material transport costs. • Ensure adequate reception facilities are provided to receive ship wastes. • Ensure site runoff from the tank farm is controlled within a containment bund. • Ensure all jetties are fully bunded with drainage to a sump which can be pumped to the wastewater treatment plant where required. No oily residues will be washed from ships into port waters. • Any onshore maintenance work will avoid pollution of waters from chemical and biological residues. • Ensure port operator(s) have first response capabilities. • Ensure spill prevention and response plans are in place. • Ensure spill response kits are on site and maintained. • Ensure the location of desalinisation plant outlet is situated in an area of high turbulence and water movement to optimise dilution and dispersal of the discharge.All wastewater will be treated via the wastewater treatment plant. • Ensure human contact is excluded within 100 m of the wastewater treatment plant outlet and shellfish collection excluded within 500 m. • Prohibit or control certain antifoulant coatings <(tributyl tin)>. • Contain and control the disposal of all antifoulant residues and waste. • Remove vessels and movable structures from the water for cleaning and maintenance wherever practicable.
Monitoring	• Monitor water quality monitoring within the harbour area. Measurements should include the levels of dissolved oxygen and nutrients (particularly organic nitrogen and phosphorus compounds). Monitoring may also include phytoplankton sampling. • Monitor water quality and benthic communities in the vicinity of the wastewater treatment and desalination plant outlets. • Weekly checks of jetty sump to maintain adequate capacity. • Monitor de-chlorination and toxicity of the wastewater treatment plant discharge if a chlorination disinfection process is used.

Responsibilities	• The Construction Contractor Environmental Manager will be responsible for ensuring the monitoring and auditing of the EMP is carried out. • The Construction Contractor Supervisor will be responsible for ensuring the implementation of the avoidance, management and mitigation measures in the EMP.
Reporting	• Construction Contractor Environmental Manager will provide monthly updates to the Construction Contractor Supervisor on routine monitoring and auditing results. • Construction Contractor Supervisor to provide SERN with periodic updates on routine monitoring and audit results.

2.9 Social and Economic Values

Impact	The potential socio-economic impacts (both positive and negative) from the Suai supply base include: • Employment creation. • Skills development. • Creation of economic opportunities. • Physical displacement. • Loss of land crops and natural resources including fishing and potable water. • Loss of commercial trees. • Disturbance and/or loss of access to sacred sites and scattered graves. • Reduced mobility due to loss of road network interlinking grazing area and water sources. • Population influx. • Increased pressure on government to deliver on infrastructure service and administrative demands set by the project. • Community health and safety. • Improvement of basic services and infrastructure. • Conflict affecting construction and operation of the supply base. • The supply base development exacerbating gender equality issues in the study area.
Objectives	• Project specific goals and objectives are to be determined subsequent to the stakeholder consultation program.
Avoidance, management and mitigation measures	• Undertake a skills audit and identify relevant training programs to optimize local employment. • Develop and implement a Skills Development Plan to deliver trained people, education programs for local children and advice on long term sustainable farming practices. • Ensure the demobilisation of construction personnel is coordinated with the mobilisation of the operations team as much as possible. • Ensure employment opportunities are open, transparent, non-discriminatory and aligned with community needs. • Ensure local vocational institutes offer curriculum appropriate for a skilled labour workforce.

	• Ensure royalties and taxes from the project are used efficiently and transparently.
	• Ensure local businesses providing goods and services are used as much as possible.
	• Develop a Resettlement Action Plan (RAP) to address
	  ○ Involuntary relocation of all affected households and associated assets.
	  ○ Loss of crops and natural resources for all affected households.
	  ○ Compensation for loss of natural resources, agricultural fields and commercial trees.
	• Consult regularly with local fishermen to minimise impacts on their existing fishing activities and to optimise local opportunities generated by these facilities.
	• Enclose sacred sites and graves to avoid disturbance where possible.
	If disturbance is unavoidable, the project will consult with affected parties to find culturally appropriate solutions.
	• Ensure alternate roads and paths are established for the local community prior to project commencement.
	• Ensure safety buffer zones from activities posing unacceptable risks to villages and the local community.
	• Ensure consultation with the local community encourages free speech for all.

Monitoring	• Undertake internal and external monitoring of the social management measures at regular intervals. • Compliance audits will be undertaken during construction and operation.
Responsibilities	• The Construction Contractor Environmental Manager will be responsible for ensuring the monitoring and auditing of the EMP is carried out. • The Construction Contractor Supervisor will be responsible for ensuring the implementation of the avoidance, management and mitigation measures in the EMP.
Reporting	• Construction Contractor Environmental Manager will provide monthly updates to the Construction Contractor Supervisor on routine monitoring, waste records and auditing results. • Construction Contractor Supervisor to provide SERN with periodic updates on routine monitoring and audit results.

2.10 Land Transport

Impact	A number of impacts on the land transport network are expected for both the construction and operational phases of the project: • Deterioration of road condition due to significant increase in daily movements of heavy vehicles. • Deterioration of roads from significant increase in daily movements of light vehicles. • Reduction in safety for other road users around the Suai Market location. • Change in road safety for pedestrians in the study area. • Impact on existing intersections. • Introduction of new intersections. • Local road network management in Nova Suai. • Associated air and noise quality impacts.
Objectives	• To manage construction and operational traffic and transport issues such that potential impacts on the community and the operation of the road network are minimized. • Ensure community traffic needs are met during all phases of project implementation.
Avoidance, management and mitigation measures	• Upgrade key roads used for construction and operation traffic. The surfaces should be adequate to withstand the multiple construction phases and should reflect accepted design standards. • Pedestrian crossing points and controls will be provided for the most visible and obvious pedestrian routes at key locations where there is significant heavy vehicle traffic, including Suai market, school areas, commercial locations and community facilities. • Roads will be designed to include the requisite level of drainage that does not otherwise impact negatively on existing drainage features or properties. • Appropriate lighting should be provided on key links where there is likely to be significant traffic flow at night. • Clear bilingual signage should be provided on appropriate routes noting the presence of heavy vehicles. • Heavy vehicles movement will be restricted to key routes only and will avoid travel on local roads, where possible. • Traffic management controls will be provided or upgraded to ensure road and pedestrian safety and improve traffic flow.

	• Regular maintenance of pavement and drainage features should be undertaken during construction and repaired as required. • Strict speed limits should be introduced for construction and operation vehicles. • Dedicated areas for motorcycle parking should be provided away from the proposed heavy vehicle routes through Suai market.
Monitoring	• Regularly inspect pavement and drainage features to ensure adequacy. • Conduct a road safety audit on the design of the road network improvements to highlight whether improvements could be made. • Compliance audits will be undertaken during construction and operation.
Responsibilities	• The Construction Contractor Environmental Manager will be responsible for ensuring the monitoring and auditing of the EMP is carried out. • The Construction Contractor Supervisor will be responsible for ensuring the implementation of the avoidance, management and mitigation measures in the EMP.
Reporting	• Construction Contractor Environmental Manager will provide monthly updates to the Construction Contractor Supervisor on routine monitoring, waste records and auditing results. • Construction Contractor Supervisor to provide SERN with periodic updates on routine monitoring and audit results.

2.11 Waste Management

Impact	• Throughout the Project's life, including site preparation, construction, operation and decommissioning, a variety of waste streams and products are likely to be generated.
Objectives	• Use resources efficiently, reducing the intensity of materials used and implementing programs for the reduction and re-use of waste • Ensure wastes do not adversely affect water resources or lead to land contamination. • To manage waste in accordance with the principles of reuse, reduce and recycle.
Avoidance, management and mitigation measures	• Consider alternative products, i.e., substituting raw materials with less hazardous or toxic materials, and substituting materials for more environmentally friendly options. • Use good housekeeping and operating practices, including inventory control. • Use strict segregation processes to prevent the co-mingling of water and waste streams. • Use low-sulfur diesel-powered equipment, where practicable. • Ensure equipment is maintained in accordance with manufacturer's specifications. • Clear the smallest construction footprint possible, therefore reducing the generation of greenwaste, topsoil, spoil, overburden, ASS and greenhouse gases. • Identify reuse opportunities and assess which materials could potentially be recycled. • Where possible, identify market demands for waste streams in the vicinity of Suai (i.e., reuse of concrete to build roads). • Install dedicated skip bins for designated wastes around the construction site. • Establish a waste management area in close proximity to the Suai development area. • Ensure the waste management area is located in an area free of geotechnical, hydrogeological and topographical risks. The waste management area should also not be within a conservation area or in close proximity to the airport.

	• Ensure the waste management area includes a designated area for sorting and segregating wastes, a high-temperature incinerator, an engineered landfill, a wastewater treatment plant and an industrial shredder. • Undertake incineration to reduce disposal volumes. • Design the engineered landfill to take all non-hazardous and hazardous waste generated at the Suai development area. • Use the industrial shredder to shred and debead tyres and crush drums so that there is available landfill capacity during construction and operations. • Store wastes in a manner that prevents co-mingling or contact between incompatible wastes (e.g., acids and alkalis). • Store wastes that allows for the inspection of containers, i.e., to monitor any potential leaks or spills. • Store chemicals, fuel, paint and adhesives in appropriately sized drums and on hard standing surfaces. • All chemicals will be stored with MSDS's. • Locate spill kits near liquid waste storage areas. • Cover domestic waste storage bins. • Train all employees in spill response.
Monitoring	• Conduct periodic inspections of waste storage areas to ensure compliance with safety standards. • Record and report all wastes generated from the project. • Regularly conduct visual inspections of the waste management area. • Compliance audits will be undertaken during construction and operation..
Responsibilities	• The Construction Contractor Environmental Manager will be responsible for ensuring the monitoring and auditing of the EMP is carried out. • The Construction Contractor Supervisor will be responsible for ensuring the implementation of the avoidance, management and mitigation measures in the EMP.
Reporting	• Construction Contractor Environmental Manager will provide monthly updates to the Construction Contractor Supervisor on routine monitoring, waste records and auditing results. • Construction Contractor Supervisor to provide SERN with periodic updates on routine monitoring and audits result.