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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 1 - Main Report Part A

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

Attachment 2:
Marine Ecology and Fisheries Final Report

DESCRIPTION	PAGE

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

Attachment 3:
Tasi Mane Project Strategic Environmental Management Plan

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Tasi Mane Project – Suai Supply Base

Environmental Impact Assessment

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PROJECT 301012-01504 - TASI MANE PROJECT – SUAI SUPPLY BASE

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CONTENTS

FIGURES

TABLES

PLATES

APPENDICES

ATTACHMENTS

GLOSSARY

Units

µg/m^3	micrograms per cubic metre
cfu	colony-forming units
dB	decibels
DWT	deadweight tonnes
g/m^2/month	grams per square metre per month
ha	hectare
hPa	hectopascals
kL	kilolitres
km	kilometre
kV	kilovolts
L/min	litres per minute
L/s	litres per second
m	metre
mcm	million cubic metres
mg/kg	milligrams per kilogram
MJ/m^2	megajoules per square metre
mm	millimetre
m/s	metres per second
MT	million tonnes
Mtpa	million tonnes per annum
MW	megawatt
ppb	parts per billion
ppm	parts per million
TPD	tonnes per day

Abbreviations

A	
AACTL	Civil Aviation Authority of Timor-Leste
AADT	annual average daily traffic
ADB	Asian Development Bank
AGWR	annual groundwater resource
ANP	National Petroleum Authority
ANZECC	Australian and New Zealand Environment Conservation Council
APORTIL	Port Authority of Timor-Leste
ARCOM	Communications Regulatory Authority
AQIS	Australian Quarantine Inspection Service
AS/NZS	Australian/New Zealand standard
ASS	acid sulfate soils

Abbreviations

AWS	automated weather station
B	
BGL	below ground level
BOD	biological oxygen demand
C	
CBO	community-based organisation
CEDAW	Committee on the Elimination of Discrimination against Women
CEO	chief executive officer
CITES	Convention on International Trade in Endangered Species
CO	carbon monoxide
CSIRO	Commonwealth Scientific and Insudstrial Research Organisation
D	
DCP	dynamic cone penetrometer
DNSAS	National Directorate for Water and Sanitation
DNSMA	National Directorate of Environmental Service
E	
EC	electrical conductivity
EIA	environmental impact assessment
EIS	environmental impact statement
EMP	environmental management plan
ENSO	El Niño Southern Oscillation
F	
FEED	front-end engineering design
G	
GIS	geographic information system
GoTL	Government of Timor-Leste
GTZ	Gesellschaft für technische Zusammenarbeit
H	
HSE	health, safety and environment
I	
IADE	Instituto de Apoio ao Desenvolvimento Empresarial
IAP	interested and affected party
IBA	impacts and benefits agreement
IEMA	Institute of Environmental Management and Assessment
IFC	International Finance Corporation
IHT	Institute of Highway Engineers
ISO	International Standards Organisation
IUCN	International Union for Conservation of Nature
IWRM	Integrated Water Resources Management
J, K	
KSI	Kadalak Sulimutuk Institute

Abbreviations

L	
LCT	landing craft tank
LI	Landscape Institute
LNG	liquefied natural gas
LTA	Land Transport Authority
M	
MAFF	Ministry of Agriculture, Forestry and Fisheries
MPW	Ministry of Public Works
MSDS	material safety data sheet
N	
NATA	National Association of Testing Authorities
NDP	National Development Plan
NEPC	National Environment Protection Council (Australia)
NEPM	National Environment Protection Measures
NGO	non-governmental agency
NPI EETM	National Pollutant Inventory Emission Estimation Technique Manuals (Australia)
NO	nitric oxide
NO_2	nitrogen dioxide
N_2O	nitrous oxide
NO_X	oxides of nitrogen
NTU	nephelometric turbidity units
O	
O_3	Ozone
OCHA	the United Nations Office for the Coordination of Humanitarian Affairs
P	
Pb	Lead (chemical element)
PM	particulate matter
PSC	production sharing contract
Q, R	
RAP	Resettlement Action Plan
RDTL	Democratic Republic of Timor-Leste
RO	reverse osmosis
S	
SDP	Strategic Development Plan
SEFOPE	Secretariat of State for Professional Training and Employment
SERN	Secretaria de Estado dos Recursos Naturais
SIA	Social Impact Assessment
SISCa	Servisu Integradu da Saúde Communitária (English translation 'Integrated Community Health Services')
SO_2	sulphur dioxide
SO_X	oxides of sulphur

Abbreviations

SOI	Southern Oscillation Index
T	
TBT	tributyltin
TDS	total dissolved solids
TEOM	tapered element oscillating microbalance
TKN	total Kjeldahl nitrogen
TPNS	test pit Nova Suai
TPSS	test pit Suai Supply Base
TSS	total suspended solids
U	
UNTAET	United Nations Transitional Administration in East Timor
US EPA	United States Environmental Protection Agency
USAID	United States Agency for International Development
V	
VOC	volatile organic compound
W, X, Y, Z	
WA	Western Australia
WHO	World Health Organization

Report Conventions

Radii	the plural of “radius”, which is the distance from the center of a circle to any point around the circumference (edge) of a circle
the project	the Tasi Mane – Suai Supply Base project. (*NB. the wider Tasi Mane project includes the proposed Betano refinery and Beaco LNG plant, and associated developments, that are not part of this study).*
the proponent	Secretaria de Estado dos Recursos Naturais (SERN)
the study area	the Suai development area plus any buffer areas defined in the individual environmental specialists studies
the Suai development	the five components of the project i.e., the supply base, industrial estate, Nova Suai, Suai Airport upgrade, and the two crocodile reserves.
the Suai development area	the boundaries of the five components of the Suai development
Timor-Leste	The Democratic Republic of Timor-Leste
Waste	Any substance or solid, liquid, gaseous or radioactive matter from the activities of individuals, public or private institutions which causes change when discharged into the environment.

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SECRETARIA DE ESTADO DOS RECURSOS NATURAIS

Tasi Mane Project – Suai Supply Base Environmental Impact Assessment

EXECUTIVE SUMMARY

301012-01504-EN-REP-0003
May 2012

EXECUTIVE SUMMARY

Introduction

The Government of the Democratic Republic of Timor-Leste (GoTL), through the Secretaria de Estado dos Recursos Naturais (SERN) is proposing to build, own and operate a maritime supply base near the town of Suai on the south coast of Timor-Leste to service the offshore petroleum sector.

Located in the Cova Lima District (see Figure ES-1) approximately 138 km south-west of Dili and 22 km east of the Indonesian border, the Suai Supply Base will be a phased development that will provide the following services and facilities:

- A Supply Base (including land-based facilities and harbor infrastructure).
- A new town; Nova Suai.
- An upgraded airstrip.
- Two crocodile reserves.

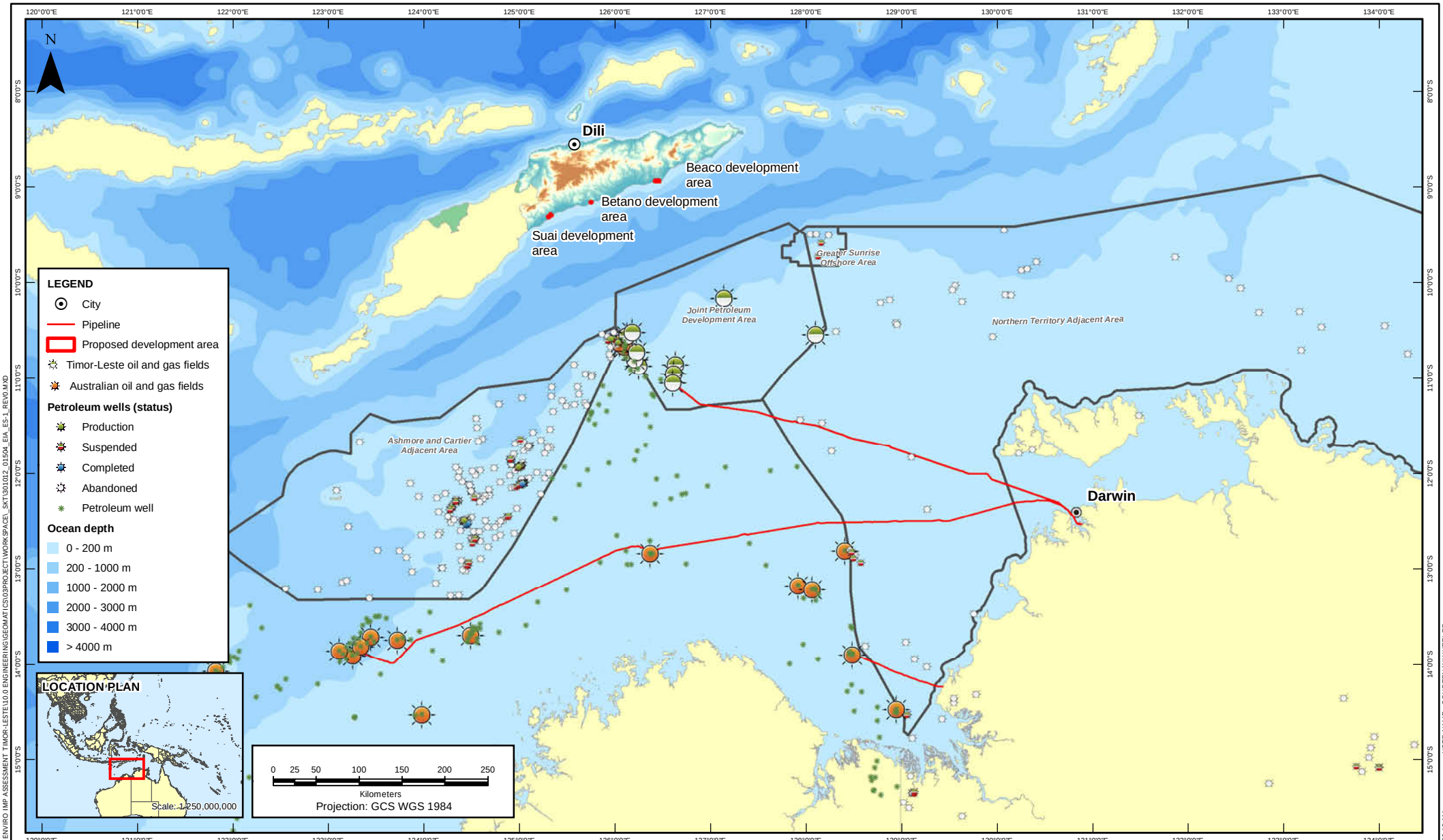
The project originates from the GoTL's vision for the development of the national infrastructure system outlined in the Strategic Development Plan (SDP) 2011-2030. A central component of the SDP is the Tasi Mane Project; comprising three petroleum-related sites on the south coast of Timor-Leste. This project is of critical importance to Timor-Leste as it underpins the nation's projected revenue base (mainly as taxes and royalties), a potentially multi-billion dollar source of capital investment, foreign currency earnings and job creation. The project will, in many respects, be a flagship project for Timor-Leste due to its importance to the economic development of the country. It will also be the first example for both government and community of the benefits and costs associated with large-scale industrial development.

The three sites that comprise the Tasi Mane Project are:

- Suai Supply Base.
- Betano Petroleum Refinery and Petrochemical Complex.
- Beaco LNG Plant.

This document relates to the planned development of the Suai Supply Base. The supply base will service the offshore exploration and development of petroleum in the Timor Sea and is otherwise unrelated to the development at Betano or Beaco although, it may play a role as a port during the construction of those developments.

The indicative layout of the Suai Supply Base facilities is shown in Figure ES-2. The supply base will be built in three phases commencing in 2012 with the third and final phase completed in 2030. SERN has advised that the capital cost during the construction phase is expected to be in the order of US$350 million, depending on local market conditions at the time of procurement. An estimated US$4.5 million will be spent annually from the operating budget (EastLog, 2011).



NOTES:
This map consists of:
1. DEM: SRTM (2011)
2. Petroleum wells: Department of Mines and Petroleum, Western Australia

REV	DATE	REVISION DESCRIPTION	DRN	CHK	DES	ENG	APPD	CUST		
0	9/05/2012	FINAL FOR ISSUE	MW	CW	CS	-	GH	-	A4 SHEET	SCALE 1:6,000,000

PROJECT No: 301012-001504

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TASI MANE PROJECT - SUAI SUPPLY BASE
ENVIRONMENTAL IMPACT ASSESSMENT

Figure ES-1
Petroleum developments in the Timor Sea

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PLOT DATE & TIME: 09 MAY 2012, 8:59:18 AM
USER NAME: COURTENAY.WHEELER

NOTES:
This map consists of:
1. Imagery: DigitalGlobe (2008-2011)
2. Imagery: Google Earth (2010)
3. Rivers: Geographic Information Group TimorLeste (2010)
4. Roads: DivaGIS (2010)

*1 SERN, Dec. 2011
*2 SERN, Jan. 2012
*3 Eastlog SERN, May 2011

REV	DATE	REVISION DESCRIPTION	DRN	CHK	DES	ENG	APPD	CUST	A4 SHEET	SCALE 1:40,000
0	9/05/2012	FINAL FOR ISSUE	MW	CW	-	-	GH	-	PROJECT No: 301012-001504	

TASI MANE PROJECT - SUAI SUPPLY BASE
ENVIRONMENTAL IMPACT ASSESSMENT

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

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Figure ES-2
Suai development area

LOCATION: I:\PROJECTS\301012-01504 ENVIRO IMP ASSESSMENT TIMOR-LESTE\10.0 ENGINEERING\GEOMATICS\03PROJECT\WORKSPACE_SKT\301012_01504_EIA_ES-2_REV0.MXD

USER NAME : COURTENAY.WHEELER

PLOT DATE & TIME : 09 MAY 2012, 8:50:39 AM

The Role of Government

The proponent for the project is the Secretaria de Estados dos Recursos Naturais (Secretary of State for Natural Resources, SERN), a department of the GoTL and the principal law governing the development of the project is Environmental Decree Law No.5/2011. Under Part V, Annex 1, Category A of that law, a series of defined projects require an environmental impact assessment. The trigger for Category A for the Suai Supply Base is that the port and port facilities are of a scale $\geq$ 500 gross tons.

In addition to an environmental licence, a port licence needs to be granted under Decree Law 3/2003 prior to the commencement of construction.

Project Description

The key feature of the proposed Suai Supply Base is the development of a new, all-weather port with a number of related service facilities. Other non-petroleum industries, such as commercial fisheries, expected to be attracted to the area by the port itself, are also anticipated. The port will be developed in three stages through to the year 2030 and, at that time, will occupy approximately 650 ha.

Overall, the new facilities will comprise the following:

- Suai Supply Base

  The Supply Base facilities at Suai will be situated on the coast near the village of Samfuk (in the sub-district of Suai Vila). There will be a new breakwater and jetty with four multi-purpose berths capable of handling ships and barges up to 10,000 DWT with an overall capacity of approximately 2.0 mtpa of dry bulk cargo.

- An industrial estate

  As part of future development at the Suai Supply Base, an industrial estate will be developed adjacent (north-east) of the Suai Supply Base.

- Nova Suai

  A new town, Nova Suai, will be located on 188 ha of land between the existing villages of Holbelis and Dais. The town is expected to house up to 6,500 staff, contractors and their families.

- Suai Airport upgrade

  The existing Suai Airport, located in Holbelis, is classified as a district airport and will be upgraded to cater for expanded passenger and freight services. The main new features will be a 2 km long runway and, a new terminal building and fire station.

- Crocodile reserves

  Two crocodile reserves are proposed within the existing crocodile habitat areas located at We Dare, near the centre of the Suai Supply Base development area, and at We Matan Bua Oan, inside the north-east boundary of the Supply Base development area adjacent to the Rio

Raiketan. Development of the two reserves will focus on the protection of the existing natural environment regarded as sacred by many locals.

Stakeholder Consultation

Stakeholder consultation with the affected communities in the project area has been underway since 2010 and is a crucial component of work on the project to ensure that the proposed works are understood and any concerns addressed. The EIA process has a formal requirement for stakeholder consultation and, separate from this, there is also a need for more focused and direct consultation with those whose farms or residences need to make way for the new project facilities.

The stakeholder consultation for the Suai Supply Base has been led by SERN and has largely been aimed at informing the community about the nature and location of the planned development. The involvement of senior members of the GoTL, including the Prime Minister, in stakeholder consultation undertaken to date provides an indication of the importance placed on the project by the government.

Feedback from the consultation program with potentially affected communities reflects some community support for the project, particularly the potential for jobs for local residents. However, there is predictable concern about the need for appropriate compensation for those displaced and pressures associated with the likely influx of people seeking work. Some have also expressed concern about the lack of information available to the local community.

Stakeholder consultation will continue through the course of the project construction and operation and will underpin the overall success of the project.

Existing Environment

Land Use

The project area comprises a mosaic of rural subsistence farms serviced by a small network of roads and tracks. Where they occur, villages and towns are clustered around the inter-regional roads while scattered housing is prevalent throughout the project area. A variety of animals (chickens, pigs, cattle and goats) and food crops (maize, rice, cassava, coconuts and bananas) are raised. Trees such as teak, rosewood and sandalwood are also farmed and artisanal fishing is common.

Topography, Geology and Soils

The topography of the project area slopes southwards towards the Timor Sea and merges with a wide, flat, coastal plain on which most project-related facilities are located. Nova Suai is the exception and is located on the slopes. The coastal plain is bounded to the north by the Rio Raiketan and to the south by Rio Camanasa. There are swamps, two of which coincide with the proposed crocodile reserves.

Geologically, the project area is situated on unconsolidated sediments ranging from fine silts to conglomerates and, apart from Nova Suai, the project area has very little consolidated rock at surface.

Some potentially unstable or chemically aggressive soil types have been recorded in the project area including expansive clays and, closer to the sea, acid sulfate soil and compressible soils. Erosion and waterlogging are risks during construction. The risk of earthquakes and tsunamis in the region is ever present.

Existing soil contamination from poorly decommissioned oil bores is evident in the area although, it is expected that with the application of appropriate chemical storage and soil management methods, the risk of contamination arising from project activities can be managed without difficulty.

Climate and Meteorology

The project area has a typical tropical monsoonal climate with distinct wet and dry seasons. Seasonal variation in temperature is minimal, with the diurnal temperature variation often greater than the seasonal variation. Daytime temperatures are typically in the low to mid 30's and night-time temperatures are in the mid 20's. Humidity is consistently high, frequently greater than 90% for significant proportions of the day. Long-term, multi-year rainfall trends are generally dictated by El Niño / La Niña effects; however, shorter-term annual rainfall patterns are monsoonal in nature experiencing a 7 to 9 month wet season with two peak months; December and May (CSIRO, 2010).

Tropical cyclones are a feature of weather patterns of Timor-Leste and since 1906, 12 cyclones have passed within 200 km of Suai, with 3 of these travelling within 100 km.

Air Quality

The existing air quality in the project area has been sampled and, in the absence of Timor-Leste standards, has been compared against World Health Organisation, US EPA or Australia's National Environment Protection Council (Ambient Air Quality) standards. The assessment shows that most existing sources of air pollutants (dust particles as $PM_{2.5}$ and PM_{10} and gases such as nitrogen dioxide, sulfur dioxide and carbon monoxide) originate mainly from human activities such as dust from roads, vehicle exhausts, power generation exhausts, smoke from cooking stoves and the burning of vegetation. Current air quality indicators are, with the exception of Freon 12 (a refrigerant gas), all below the limit of reporting or the assessment criteria set in the standards.

During construction, the exposure of large areas of soil accompanied by vehicular traffic will cause localised increases in airborne dust particles. During operations, dust emissions will diminish and the emission of pollutant gases arising from fixed or mobile plant and equipment (power generation and vehicles) will take on a greater significance.

Based on experience with port operations and construction sites in similar environments in Southeast Asia, it is believed that, with the application of appropriate dust mitigation and management measures, continued compliance with these air quality standards should be readily achievable during both construction and operation of the Suai Supply Base.

Noise

The main existing sources of anthropogenic (i.e., caused by human activity) noise in the project area are motor vehicles and power tools while animals such as chickens and dogs also contribute to the current noise environment. Project-specific noise limits have been developed based on the Western Australian Environmental Protection (Noise) Regulations 1997. These limits recognise the need to have varying permissible noise levels depending on the time of day (e.g., to protect sleeping patterns) and the sensitivity of the affected premises (residence, commercial premises or industrial site).

The recommended noise limits are based on the existing noise levels in the area and, for noise sensitive premises such as a dwelling, range from 55 to 62 dB(A) during daylight hours to 45 to 52 dB(A) during the night period from 2200 hrs. Commercial premises (75 db(A)) and industrial premises (80 dB(A)) have higher limits at all times due to their lower sensitivity.

Hydrology, Drainage and Water Quality

The mean annual rainfall across Timor-Leste varies between 500 mm to 3,000 mm.

The two largest watercourses in the project area, Rio Raiketan and Rio Camanasa, have catchment areas of approximately 110 km^2 and 75 km^2. Both streams discharge into the Timor Sea and have braided channels, which is characteristic of steep watercourses that have high energy and high sediment loads. Significantly for the Supply Base area, there is evidence of relict channels that indicate that the river path has wandered over time. The flow patterns of these rivers are highly variable between wet and dry seasons and, as a result, water quality varies widely due to the changing sediment loading and the effect of dilution.

The shore base site is within the Mola and Tafara Hydrologic Unit where the dominant consumer of water was crop irrigation which is well below average flows. Mean annual streamflows for the Rio Raiketan and Rio Camanasa are 99,000 ML and 58,410 ML respectively while respective annual irrigation demands are 7,000 ML and 4,760 ML.

Groundwater

In the project area, at a regional scale, groundwater recharge occurs in the Ramelau mountain range to the north and generally flows southwards towards the Timor Sea where it discharges through the unconsolidated sediments of the Suai and Dilor formations.

Groundwater is the principal source of drinking water in Timor-Leste and natural groundwater springs are the dominant sources of water supply in rural areas, supplying potable water to approximately 60% of the population (ADB, 2001). Shallow wells are used extensively in villages and rural areas, especially those such as Suai, near the sea or on river plains.

The World Health Organization (WHO) drinking water guidelines have been used as a benchmark to assess the current state of groundwater quality. Groundwater samples were analyzed for TDS, salinity and turbidity. TDS values ranged from 6 to 7,935 mg/L, with two water samples above the WHO drinking water guideline criteria of 1,000 mg/L. Salinity values ranged from 0.04 to 19%. There is currently no WHO drinking water guideline for salinity. Turbidity values ranged from 0.9 to

384 nephelometric turbidity units (NTU); with a majority of the samples reporting values above the WHO drinking water guideline criteria of 5 NTU.

The potential contamination of groundwater during the disposal of process water could affect residents that consume groundwater for drinking water purposes or as a potable water supply for agricultural purposes and will need to be managed carefully.

Marine Ecology

Water Quality

Currently, sediment plumes arising from the entrainment of soil during heavy rains is the primary source of variations in marine water and sediment quality otherwise, marine water quality conditions at Suai are generally considered typical of a tropical marine ecosystem at the start of the wet season (Kirono, 2010). Turbidity recorded at nearshore and offshore sites displayed large variability; between 0.6 NTU and 47.4 NTU (onshore) and between 3.1 NTU to 20.0 NTU (offshore).

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 to 20 NTU. 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 which are believed to be affected by the use of nitrogenous fertilisers and potentially, the drainage of sewage.

Sediments within the project area are generally uncontaminated, with the levels of cadmium, chromium, copper, lead, zinc and mercury all well below ANZECC trigger values for sediment quality (ANZECC/ARMCANZ (2000).

Benthic Habitat

The benthic habitat within the project area is dominated by sediment and a natural high flux of fluvial sediments occurs. Hard substratum made up approximately 13% of the surveyed transects. The only hard substrate found in the project area was weathered coastal limestone.

Within the project area, the biotic benthic community was dominated by turfing brown algae. The turf algae was primarily associated with areas of hard substrate and generally had <25% coverage. The only coral reef known locally is located out of the project area to the south west.

The proposed development of the breakwater and the introduction of commercial shipping will cause the greatest changes in the local water quality, benthic environment and its use by artisanal fishers.

No impacts from mobilised contaminants or the saline plume from the planned reverse osmosis plant are expected whereas construction of the breakwater and any dredging that may occur will unavoidably disturb and alter habitats within the area of the breakwater. Temporary resuspension of sediments will occur during construction; however, this will diminish once it ends. Antifoulant contamination, the risk of invasive marine species and the need (for safety reasons) to exclude small boats from the shipping channels and harbour remain residual risks that will need to be managed through further environmental management planning.

Land Transport

The current degraded condition of the existing road network in the project area reflects the heavy rainfall, challenging soil conditions and low maintenance budgets. Within the project area, the major means of transport are buses, trucks, motorcycles and horses. Pedestrian traffic on roadsides and informal tracks is also widespread while cars are relatively uncommon.

Traffic counts during the study period show that a large number of vehicle movements are localised, between residential properties and local areas of activity such as the market, schools and other community facilities. Slightly longer distance trips were also recorded between local town centres (e.g., between Suai and Beaco).

When construction commences, there will be a large and rapid increase in the use of local roads notably between Nova Suai and the port area. It is estimated that approximately 50% of the residents of Nova Suai will be workers and 90% of them will travel to the port and industrial areas by bus.

During construction there will also be additional heavy vehicle traffic bringing in construction equipment (cranes, bulldozers, graders, excavators and piling rigs) and materials such as rock for the breakwater. Traffic management of these large vehicles will require care to ensure that the safety of existing road users along the relatively densely populated roadsides is maintained. This will need to include new road diversions with enhanced pavement and drainage controls, public education processes, new signage and, in places, new pedestrian paths.

Assuming that these mitigation measures are implemented, the residual impact of changes to the land transport conditions will range from negligible to minor.

Terrestrial Flora and Fauna

Terrestrial flora and fauna in the project area has been considered from the perspective of both its commercial and conservation significance due to the economic importance of some flora species to the local community and in recognition of Timor-Leste's commitment to protecting the natural environment.

As noted earlier, the project area is a patchwork of farmland and native vegetation. Patches of native vegetation are generally less than 20 ha and commonly used as foraging areas for stock and for gathering firewood.

There are three main types of vegetation communities in the project area:

- Coastal vegetation that includes the *Pes-caprae* formation that 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). The area is dominated by *Borassus flabellifer* and *Corypha utan* palms and introduced timber trees along with some thickets of *Acacia*/*Vachellia* spp. Also present were introduced crop trees such as candlenut and tamarind, teak, and weed tree species such as coffee bush.
- Riparian vegetation includes *Bambusa vulgaris* (bamboo), occasional ai-na, ai-baganasa and infestations of Siam weed (*Chromolaena odorata*). Riparian vegetation is predominantly deciduous during the dry season.

- Mangroves occur on beaches, at brackish inlets and at lagoons. The dominant mangrove present was ai-tano which prefers beaches while the second dominant is Ai-biku is found in sand and mud. Mangroves are of conservation significance.

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*, Ai-na (*Pterocarpus indicus)* and sandalwood *(Santalum album)* (Cowie, 2006, 2007). Two of these were recorded in the Suai development area during the field surveys, Ai-na and sandalwood.

Eleven species of economic importance occur in the project area. They are: coconut, cashew, banana, breadfruit, mango, candlenut, cinnamon, teak, gmelina, cassod, sandalwood, rosewood and mangrove trumpet tree. Nine major weed species were identified, the most widespread is Siam weed (*Chromolaena odorata*), a highly invasive species, estimated to cover more land than any other species in Timor-Leste.

The IUCN Red List has been used as a benchmark to establish the conservation significance of fauna species during the study. Five species on the Red List were recorded in the project area: beach thick-knee (Near Threatened), slaty cuckoo dove (Near Threatened), yellow-crested cockatoo (Critically Endangered), Timor (white-bellied) bushchat (Near Threatened), Canut's horseshoe bat (Vulnerable).

The greatest threat to these and other native plant and animal species arising from this project is the clearance of native vegetation. The avoidance of native vegetation by any project-related activities will help to preserve all species regardless of their conservation significance; however, this will need to be balanced against the need for farmland, particularly to cater for those displaced by the new facilities and those new to the area seeking work.

Socio-economic

Cova Lima is located in the western part of Timor-Leste and borders Indonesia to the west. It has a population of 59,455 inhabitants (Census 2010) and an area of 1,226 km². Camanasa is situated the closest to the development areas and consequently stands to be most directly affected by the Suai Supply Base development. Belecasac, Matai and Labarai are located within 500 m of the Suai development sites. The total number of households across all villages is 2,515 with an average household size of 5.5 people.

According to the 2010 Census, the vast majority of households in the project area are subsistence farmers although this varies from as little as 18% (Labarai) to 85% in Suai Loro and Matai.

Wood is the most commonly used energy source for cooking with an average of 96% of households using wood across the five villages. Fishing is important as a food source and a source of cash income.

Literacy rates in the 15 to 24 year old group ranged between 78 and 92% in the five villages.

Common perceptions of the project expressed in all five villages in the Suai project area include:

- Development is good for Timor-Leste and the project will have a positive impact on the community.

- It is recognised that outsiders will have to be employed to fill some of the skilled positions. However, local people need to receive priority during the recruitment process over people from other districts and foreigners, especially for positions where skills are available locally.
- 'Outside' employees can be housed in, or adjacent to, the villages as long as their numbers remain low. Large number of outside employees should be housed elsewhere.
- It is hoped that the project will provide a brighter future through job creation, in particular for the youth.
- The project will have a positive impact in terms of infrastructure development of the area.
- There is concern about physical and economic displacement. Compensation to be provided needs to be fair, properly negotiated with affected individuals, and payments made over a long period of time (monthly) to avoid 'splurging'.

Economically, the local impacts include financial benefits of a scale unprecedented in the area. An estimated 40% of the engineering, procurement and construction contracts will also be awarded to local contractors for works and services to be performed in the construction of the breakwater and Supply Base facilities as well as for purchase of local supplies and materials (EastLog, 2011).

The key residual socio-economic impacts will be; job creation, economic opportunities, involuntary relocation, loss of farming land and commercial trees, and population influx.

Environmental Management Framework

Integral to the EIA process has been the identification of potentially adverse impacts on the existing environment and community, and specific measures to avoid, manage and mitigate those impacts. An environmental management framework has been developed for the project that will provide guidance to the future management of these issues during the construction and operation of the Supply Base. Nevertheless, preparation of specific management measures, in the form of an environmental and social policy, environmental management plans, work instructions and monitoring programs, can only be completed once the project design has been confirmed and more detailed assessments have been undertaken.

Implementation of the management framework will see a regular program of monitoring against defined standards, auditing to confirm compliance and opportunities for improvement and, reporting to GoTL regulators and community stakeholders.

For the Suai Supply Base, a program of monitoring is planned including: air quality and dust particulates, noise, water quality and biodiversity.

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Tasi Mane Project – Suai Supply Base Environmental Impact Assessment

CHAPTER 1
INTRODUCTION

301012-01504-EN-REP-0003
May 2012

1 INTRODUCTION

1.1 Context

The Government of Timor-Leste (GoTL), through the Secretaria de Estado dos Recursos Naturais (SERN), proposes to facilitate development of oil and gas resources in Timor-Leste. This proposed development forms part of the strategic vision for the nation and is central to securing new commercial and industrial activities that can contribute to sustainable social and economic growth for Timor-Leste (Strategic Development Plan (SDP) 2011-2030).

The implementation of this vision starts with the Tasi Mane project - a collection of three, shore-based petroleum-related facilities on the south coast of Timor-Leste which are of strategic importance to the GoTL. The SDP identifies the careful management of the petroleum sector as a key source of the nation's future development: *'This sector is critical not only to our economic growth and strength, but also to our future progress as a successful, stable nation. While developing the sector, we must ensure that Timor-Leste's natural resource wealth is used to build our nation and support our people.'* (SDP, 2011).

The Tasi Mane project will establish industry 'clusters' at three locations shown in Figure 1-1:

1. A supply base industry at Suai.
2. A refinery and petrochemical complex at Betano.
3. A liquefied natural gas (LNG) plant at Beaco.

The proposals for Betano and Beaco do not form part of the scope for this study and have been assessed separately.

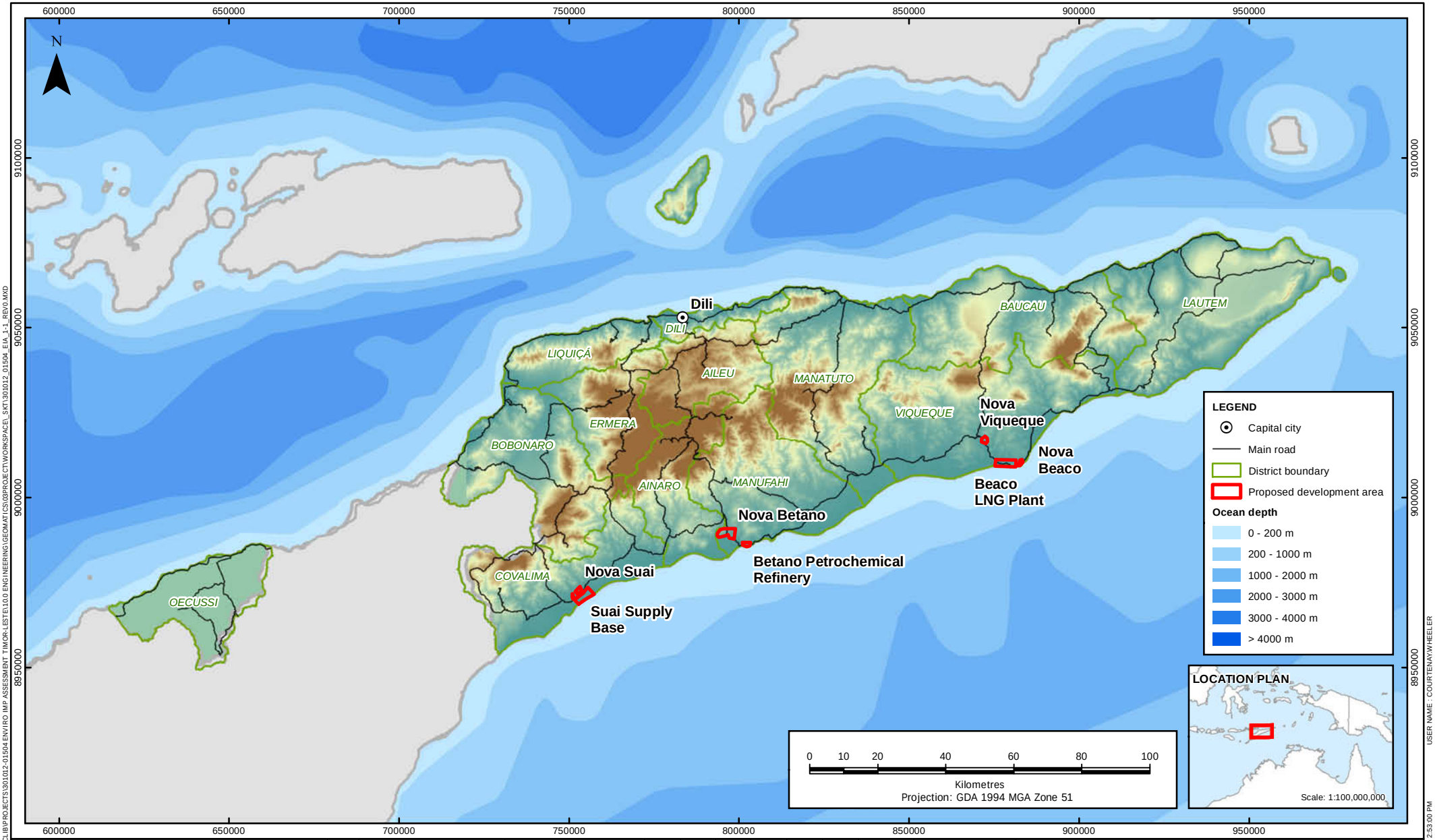
1.2 Project Outline

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 location of the project ('the Suai development area') is shown in Figure 1-2, and will include the following facilities:

- A Supply Base (including land-based facilities and marine-based infrastructure);
- An industrial estate;
- A new town, Nova Suai;
- Suai Airport upgrade; and
- Two crocodile reserves.

Nova Suai, the industrial estate, and upgrade to Suai Airport will directly support the development of the Suai Supply Base. These sites and the crocodile reserves are outlined further in Chapter 4 (Project Description).



NOTES:
This map consists of:
1. DEM: SRTM (2011)
2. District boundaries: Geographic Information Group TimorLeste (2010)
3. Rivers: Geographic Information Group TimorLeste (2010)
4. Roads: DivaGIS (2010)

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TASI MANE PROJECT - SUAI SUPPLY BASE
ENVIRONMENTAL IMPACT ASSESSMENT

Figure 1-1
Tase Mane Project overview

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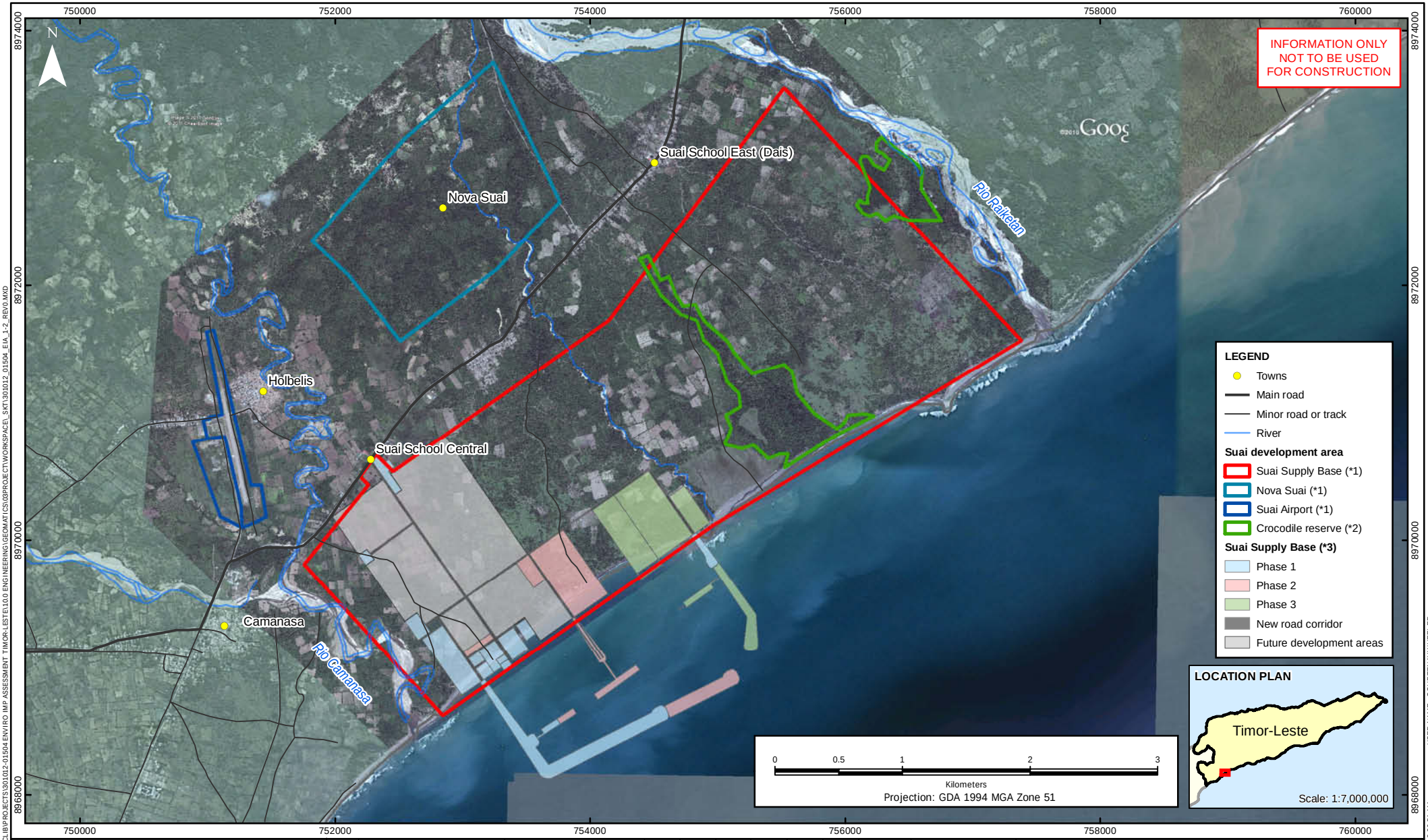

NOTES:
This map consists of:
1. Imagery: DigitalGlobe (2008-2011)
2. Imagery: Google Earth (2010)
3. Rivers: Geographic Information Group TimorLeste (2010)
4. Roads: DivaGIS (2010)

*1 SERN, Dec. 2011
*2 SERN, Jan. 2012
*3 Eastlog SERN, May 2011

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TASI MANE PROJECT - SUAI SUPPLY BASE
ENVIRONMENTAL IMPACT ASSESSMENT

Figure 1-2
Suai development area

1.3 This Document

This EIA has been prepared under the Democratic Republic of Timor-Leste (RDTL) Government Decree Law 5/2011 – the legal framework for regulating the environmental impacts of significant projects in Timor-Leste. Section 2.2.1 sets out the regulatory framework and EIA process.

The purpose of this document is to identify the likely environmental and social impacts associated with the construction and operation of the project (as defined in Section 1.2), to inform the detailed design stage and determine the baseline conditions for the physical, biological and social environment at the Suai development area.

This study identifies the social, economic and major environmental impacts that are likely to arise from the construction and operation of the Suai development (as far as possible), assesses qualitative environmental impacts of the project on sensitive receptors including communities, and prescribes measures for management and mitigation to minimise likely adverse impacts. Where relevant, further work has been identified by each environmental specialist for studies required at the detailed design stage.

1.4 Scope

The original commission from SERN was for the preparation of an environmental impact assessment (EIA) to describe the likely environmental and social impacts associated with the Tasi Mane project as a whole. Upon commencement of the study, a detailed review of the available project information revealed that more project information was available for the Suai development than for the Betano and Beaco components and it was agreed that differing levels of assessment were necessary.

SERN elected to continue with an EIA for the Suai Supply Base development; however, it decided to assess the Betano and Beaco components separately as a Strategic EIA to reflect the lower level of certainty surrounding the project design and the level of stakeholder consultation undertaken to date. The Strategic EIA for the Betano and Beaco components will be submitted to SERN under a separate cover.

Therefore, this document relates to the Suai Supply Base aspect of the Tasi Mane project, as outlined in Section 1.2 above. A copy of the original terms of reference for tender ID ICB/016/MNR-2011 is presented as Appendix A.

1.5 Document Structure

This document has been structured to describe the new, project-related facilities and their likely impacts - positive, neutral or negative - on the existing environment (including the community, the natural environment and local cultural heritage) in the context of prevailing government policies and law.

Chapters 2 to 4 provide the context and a description of the proposed facilities while Chapters 5 to 19 describe the various specialist studies that have informed preparation of this EIA, the environmental management framework and overall recommendations for further work. Recommendations for further work are also included within each of the Chapters from 6 to 17.

The remainder of this document is divided into the following chapters:

Chapter 2: Regulatory Context - describes the relevant environmental policies, legislation and international conventions to regulate the project, and acknowledges that these policies represent the aspirations of the GoTL and what it aims to achieve for the people of Timor-Leste should the project proceed.

Chapter 3: Project Setting - summarises the existing environment of the Suai development area, which is presented in detail in Chapters 6 to 17.

Chapter 4: Project Description - provides a description of the project including infrastructure, the various phases of development, their location and an outline of likely construction activities.

Chapter 5: Stakeholder Consultation – addresses the requirements for undertaking public consultation under the of Timor-Leste Decree Law No. 5/2011, and sets out the stakeholders and consultation activities that were undertaken for this stage of the project.

Chapter 6: Climate and Meteorology – provides a baseline (i.e., prior to disturbance by any project-related activity) description of the general climate and meteorological profile of the region in which the project will be located, and determines the general climate and meteorological trends relevant to the project.

Chapter 7: Land Use and Visual Amenity – provides a preliminary land use and visual amenity assessment of the project, including a discussion of the local topography and landscape, and a description of the likely land use impact.

Chapter 8: Topography, Geology and Soils - provides a preliminary geological assessment including a description of the prevailing topography and geological and soil conditions within the Suai development area.

Chapter 9: Air Quality – provides a baseline description of the general air quality in the study area, based on the ambient concentrations of particulates and gas pollutants against the assessment criteria, and determines the maximum allowable increase in ground-level concentration for pollutants likely to be emitted by the project.

Chapter 10: Noise – provides a baseline description of the noise profile for the project, by identifying noise sensitive receptor locations in proximity to the project and conducting baseline monitoring of ambient levels, and developing sound power level predictions for construction and operations accounting for meteorological conditions.

Chapter 11: Hydrology, Drainage and Water Quality – outlines the hydrological impact assessment undertaken for the project, including an assessment of the available water resources information, an estimation of the design flows for the streams adjacent to the site, and overview comments on potential water quality impacts and mitigation measures.

Chapter 12: Hydrogeology – describes the regional hydrogeology, assesses potential impacts of the project, and possible avoidance, management and mitigation measures.

Chapter 13: Terrestrial Biodiversity – outlines the findings of the flora and vegetation assessment, and a vertebrate fauna assessment prepared as part of this study. The full report is presented as Attachment 1.

Chapter 14: Marine Ecology and Fisheries – outlines the findings of the marine ecology and fisheries assessment, including water and sediment quality, prepared as part of this study. The full report is presented as Attachment 2.

Chapter 15: Social and Economic Values – identifies the social and economic impacts that are likely to result from the project, and considers the residual impacts following recommended management and mitigation measures.

Chapter 16: Land Transport – outlines the assessment undertaken to determine the potential impacts on existing land transport links arising from the project including the establishment of the baseline conditions and understanding the way in which anticipated traffic from the development will distribute and affect road transport in the study area.

Chapter 17: Waste Management – describes the typical waste management strategies that could be employed for the project, which will generally rely on the development of new facilities and waste management areas.

Chapter 18: Environmental Management Framework – outlines the environmental and social management framework for the project that will be applied throughout construction, commissioning and operation of the project.

Chapter 19: Conclusions and Recommendations – provides the overarching conclusions, and recommendations for further environmental studies upon completion of the detailed design stage.

1.6 Study Limitations

The RDTL is one of the world's newest countries, officially gaining independence from Indonesia in May 2002. A significant amount of the country's infrastructure was damaged or destroyed during the 1999 conflict that preceded this independence. Redevelopment of key infrastructure (including health, education, drinking water supply, electricity and highways) has commenced under the government's guidance; however, much of this is in the early stages of development. Similarly, the passage of

government policies, legislation, regulations and regulatory standards is still at an early stage and social, economic and environmental data for Timor-Leste which is typically readily available in most western democracies was fragmented, in development, or unavailable. As a result, many of the criteria used to assess the significance of project-related impacts in this assessment have been adopted from other jurisdictions.

As a result of these many factors, a number of assumptions have been required in undertaking this study to overcome the limitations presented. The key limitations are the:

- Short timeframe commissioned for the study period.
- Absence of key baseline environmental information and infrastructure details.
- Early stage of engineering design for the proposed facilities.

Chapter 19 sets out the recommendations for further environmental studies upon completion of the detailed design stage of the project.

1.7 Alternatives

The 'Alternatives' section of an EIA would typically describe the sequential process that was followed to develop, appraise, and eliminate reasonable alternative options for siting and design, and how each compares to meeting environmental standards and minimising harm.

SERN has confirmed that no other suitable alternative locations were identified for siting the proposed Supply Base, industrial estate, Nova Suai or the crocodile reserves.

1.8 Page Numbering

The page numbers of this document are located at the bottom right of each page.

The page numbering format is: chapter–page number. For example, "2-32" refers to the thirty-second page of the document within Chapter 2.

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Tasi Mane Project – Suai Supply Base Environmental Impact Assessment

CHAPTER 2
REGULATORY CONTEXT

301012-01504-EN-REP-0003
May 2012

2 REGULATORY CONTEXT

This chapter describes the government policies, laws and international conventions that are applicable to the Tasi Mane project – Suai Supply Base (the project) and includes an outline of the country's national guiding principle contained in its constitution, the laws and regulations of the RDTL and the relevant international conventions and agreements to which RDTL is a signatory. These policies are important as they represent the aspirations of the GoTL and what it aims to achieve for the people of Timor-Leste should this development proceed, while the laws represent legal constraints for the assessment, operation and administration of the project.

The RDTL is one of the world's newest countries, gaining independence from Indonesia in 2002 and as a result, development of a comprehensive environmental management framework in terms of legislation, regulation and adequately resourced institutions (World Bank, 2009) is in its early stages and continuing.

2.1 Constitution of the Republic of Timor-Leste

Timor-Leste's environment and its valuable natural resources (i.e., gas and petroleum), represent a potential source of wealth that may support economic growth and community development (RDTL, 2011). However, the GoTL recognises the need to develop these resources in a sustainable way and still provide a better quality of life for its citizens. The GoTL and the constitution recognise the importance of environmental protection as a fundamental task of the country and as a fundamental right of its citizens. The constitution of Timor-Leste provides the guiding principle for environmental protection in the country. Article 61 of the constitution states:

- Everyone has the right to a humane, healthy and ecologically balanced environment and the duty to protect it and improve it for the benefit of the future generations.
- The State shall recognise the need to preserve and rationalise natural resources.
- The State should promote actions aimed at protecting the environment and safeguarding the sustainable development of the economy.

Furthermore, the constitution states 'the exploitation of the natural resources shall preserve the ecological balance and prevent destruction of ecosystems'.

2.2 National Legislation

There is a collection of legislation promulgated by the Indonesian Government, United Nations Transitional Administration in East Timor (UNTAET) and RDTL that applies in Timor-Leste. Of the enacted legislation, there are a number of approvals required before construction and operation of the project can commence. These approvals are outlined below.

2.2.1 Environmental Licensing Law

The legal framework for regulating the environmental impacts of significant projects is the RDTL Government Decree Law 5/2011 on environmental licensing (environmental licensing law). The EIA study has been conducted based on this decree (unofficial translation) which is administered by the Direcção Nacional dos Serviços do Meio Ambiente or National Directorate of Environmental Service (DNSMA). Annex I of the Decree specifies triggers for Category A projects – projects that may potentially cause significant environmental impacts. Category A projects require an EIA, and the grant of an environmental licence. This project is considered a Category A project.

EIA Process

In accordance with international standards, an EIA is defined as the process of identifying, predicting, evaluating and mitigating the biophysical, social, and other relevant effects of development proposals prior to major decisions being taken and commitments made (IAIA, 1999). The EIA will determine the positive and negative changes produced in the environmental and social parameters resulting from the project, and analysing this against the existing conditions or if the project was not implemented. DNSMA, as the decision maker, will consider the predicted environmental impacts when deciding whether to allow the project to proceed. If the net impact of the project is deemed to be acceptable, the grant of the environmental licence as the legal instrument and written decision gives the proponent the right to proceed with the project.

Figure 2-1 shows the EIA process stipulated by the environmental licensing law. This EIA serves as the environmental impact statement (EIS) and has been prepared based on the terms of reference prepared by SERN.

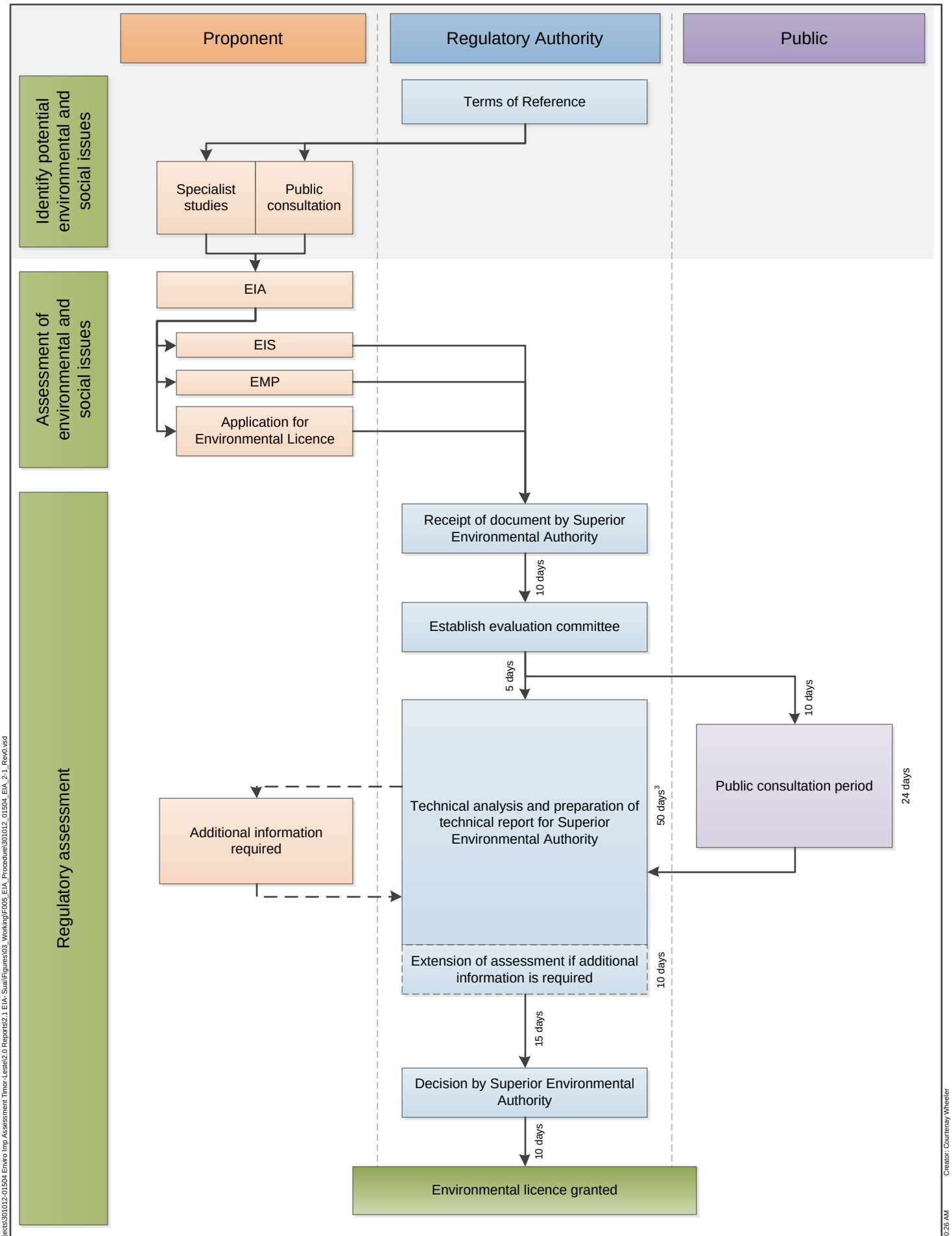
In summary, there are four key procedural steps in the grant of an environmental licence:

1. Presentation of the project for evaluation and application for environmental licence.
2. Public consultation.
3. Technical analysis and opinion by the evaluation committee.
4. Decision on the procedure of EIA and allocation of the environmental licence.

The EIA and the environmental management plan (EMP) will form the documentation to be presented for evaluation to the environmental authority.

Within ten days of receipt of the project information, the superior environment authority must establish an evaluation committee whose role will be to manage the public consultation process – a period of 24 days – and subsequently provide technical analysis of the EIS and EMPs. The evaluation committee will formulate their recommendation in a final technical report, for final consideration and decision by the superior environmental authority.

The superior environmental authority will either approve or not approve the project and the decision must be published in an official gazette, Jornal da República. If the project is approved, the environment licence can then be granted, following submission of a fee. The duration of a licence is 2 years and can potentially be renewed for another 2 years.



NOTES:
1 Figure based on an unofficial English translation of Timor-Leste decree law 5/2011 on environmental licencing.
2 All time measured in working days.
3 A pause will occur in the technical analysis if the proponent is required to provide additional information.

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PROJECT: 301012-001504

TASI MANE PROJECT – SUAI SUPPLY BASE ENVIRONMENTAL IMPACT ASSESSMENT

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Figure 2-1
Timor-Leste environmental impact assessment process for Category A projects

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Creator: Courtenay Wheeler

In addition, the environmental licensing law requires an Impacts and Benefits Agreement (IBA) be developed with the communities located around or near the proposed development whose traditional land use, customs or traditional rights are potentially affected. The IBA is to be negotiated following the approval of the environmental licence.

2.2.2 Port Law

The Decree Law 3/2003 on the establishment of the Port Authority and on the approval of the bylaws thereof details the structure, nature and responsibilities of the Administração dos Portos de Timor-Leste or Port Authority of Timor-Leste (APORTIL). The annex to this law requires APORTIL to grant licences for works carried out within their jurisdiction. The marine facilities associated with the project will require the issuing of a port licence from APORTIL prior to commencement of construction.

2.2.3 Civil Aviation Law

The Decree Law 1/2003 on the basic law on civil aviation governs the activities associated with airfields. The law requires permission to be sought from the Autoridade da Aviação Civil de Timor-Leste or Civil Aviation Authority of Timor-Leste (AACTL) prior to the construction of an airfield or associated facilities. This is applicable to the air facilities associated with the project.

2.2.4 Road Transport Law

The Decree Law 2/2003 on the basic law on the road transport system establishes the technical standards for regulating passenger and cargo transport by road in Timor-Leste. The Ministry of Infrastructure is responsible for the Autoridade Reguladora dos Transportes e Comunicações or Regulatory Authority for Transports and Communications and this Decree law.

The development of road infrastructure is governed by the law on the national road plan. The national road plan will define the rules that shall govern the technical specifications of national, district and local roads, taking into consideration traffic nature and volume.

The Decree law specifies the construction, maintenance and operation of district and local road networks, as is the case for this project, is the responsibility of the local authority. Depending on how the project workforce are transported to the construction sites, the Decree law outlines the requirements for operation of urban and local regular passenger transport services, interurban regular passenger transport and occasional passenger transport.

2.2.5 Water Supply Law

The Decree law 4/2004 on water supply for public consumption creates conditions for water distribution for domestic use for urban and non-urban areas. In accordance with the Decree law, the Direcção Nacional Serviço de Agua e Saneamento or National Directorate for Water and Sanitation (DNSAS) facilitates, at the national level, the appropriate, secure and sustainable water supply for public consumption, outside of urban areas, by community run water supply systems. The water supply system, outside of urban areas, is managed by water management groups, which are appointed by the community. The role of the water management group is to establish a number of

procedures, including who, how and how much water is distributed to members of the water management group.

2.2.6 Telecommunications Law

The Decree Law 11/2003 on establishing the bases for the telecommunications sector describes the requirement for establishing, managing and operating telecommunications infrastructure and services. The law requires urbanisation schemes and the construction of buildings and urban roads to pre-install telecommunications infrastructure. The installation of telecommunications infrastructure must be in accordance with the requirements of the regulator, the Autoridade Reguladora Das Comunicações or Communications Regulatory Authority (ARCOM) and approved by the Cabinet members responsible for urbanism, telecommunications and internal administration.

2.2.7 National Electricity Law

The Decree Law 13/2003 on establishing the bases for the national electricity system outlines the bases for organising the national electricity system and the principles for governing electricity production, transmission and distribution. The law requires pre-installation of electrical infrastructure for urbanisation activities and the construction of buildings and urban roads, consistent with the requirements of the regulatory authority.

In accordance with this law, electricity producers must obtain a licence from the regulator. There are two types: a binding or non-binding production licence. A non-binding commercial production licence is required for businesses producing electricity for its own or third party needs, or supplying electricity in an autonomous network.

The Ministry of Infrastructure is responsible for the Autoridade Reguladora dos Transportes e Comunicações or Regulatory Authority for Transports and Communications and this Decree law.

2.3 Other Legislation and Regulations

The following legislation and regulations are also relevant to the project.

2.3.1 Protected Areas Regulation

During the period of the UNTAET, regulation on protected areas became law. The objective of the Regulation 19/2000 on Protected Places is to protect specific areas or sites. Wild Protected Areas are the only areas that have been declared for protection. The nearest Wild Protected Area to the project is the Tilomar Reserve in the administrative region of Cova Lima, located approximately less than 10 km from the nearest project area. The protected area is 12,800 ha and consists of forest habitat that supports the threatened species *Cacatua sulphurea*, the yellow-crested cockatoo. The hunting, trade and keeping of all native Timor-Leste birds is banned in the reserve. While the project area is not physically located in the Tilomar Reserve, the yellow-crested cockatoos have been observed in the project area.

We Dare is an untouched area of thick tropical rainforest located near the centre of the Suai development area. Approximately 45 ha in area, locals believe the area to be a sacred place. The GoTL is committed to preserving and protecting the area to provide an important habitat for any endangered species in the area and support the crocodile reserves.

The regulation also protects the following endangered species:

- Sea tortoises.
- Sea turtles.
- Marine mammals, including bottlenose dolphins, whales and dugongs.
- Wallabies.
- Crocodiles.

The killing, injuring, harming, taking or disturbing endangered species and the destruction of their habitat is prohibited, unless an exemption is obtained from DNSMA.

In addition to wild protected areas and endangered species, the protected places regulation also protects wetlands and mangrove areas in Timor-Leste; historic, cultural and artistic sites in Timor-Leste; and coral reefs in waters of Timor-Leste.

The importance of protected areas will be communicated to all project personnel and appropriate avoidance, management and mitigation measures will be implemented in the project area to avoid and protect these environmental sensitivities.

2.3.2 Logging Regulation

The UNTAET Regulation 2000/17 on the prohibition of logging operations and the export of wood from East Timor came into effect in 2000. This regulation prohibits the cutting, removal and logging of wood from East Timor. However, exemptions to this regulation can be sought from a UNTAET Directive. Prior to the removal of wood for the project, SERN may have to seek an exemption from the Direcção Nacional de Florestas or Forestry Department (NDF).

2.3.3 Quarantine Decree

The Government Decree-Law 21/2003 on Quarantine and Sanitary Control on Goods Imported and Exported establishes the processes for sanitation control of the import and export of plants and animal and their derived products. The objective of the law decree is to:

- Prevent and control the introduction, establishment and propagation of exotic plagues and diseases and other harmful organisms in the national territory.
- Protect the environment, agricultural production and livestock as well as aquaculture production originating from the country.
- Control the already existing plagues and diseases in the country.
- Protect human beings and the public health from diseases transmitted by animals, plants or their derivatives, or by other organisms.

If exotic plagues, diseases and harmful organisms are identified as part of the EIA, appropriate avoidance, management and mitigation measures will be adopted in accordance with this decree.

2.4 Traditional Practices

There are also traditional regulations and customs which in some areas have been successful in conserving natural resources such as forests and crops. This system of communal protection is known as *tara bandu*. Villagers designated as *cab-leha/tobe* are responsible for seeing that village laws are followed (Sandlund *et al*., 2001). *Tara bandu* includes temporary prohibitions on resource extraction, such as tree cutting including mangroves and the designation of specific areas as sacred *Tara bandu* prescribes fines for violations and also provides for mediation of land disputes.

Timor-Leste's constitution recognises and values customary laws, including *tara bandu*.

2.5 Summary of Project Approvals

Table 2-1 details the licensing required under Timor-Leste law for the full implementation of the project. SERN will be responsible for the grant and administration of the various regulatory approvals.

Table 2-1 Government licensing approvals for the project

Project Activities		Statutory Requirement	Relevant Legislation
Suai Supply Base Cluster			
Suai Supply Base	Marine facilities	Environment licence from DNSMA	Decree law 5/2011 on environment licensing law
		Port licence from APORTIL	Decree law 3/2003 on the establishment of the Port Authority and on the approval of the bylaws thereof
	Land facilities	Environment licence from DNSMA	Decree law 5/2011 on environment licensing law
Suai industrial estate		Environment licence from DNSMA	Decree law 5/2011 on environment licensing law
Nova Suai	New residential town for oil and gas workforce and families	Environment licence from DNSMA	Decree law 5/2011 on environment licensing law
Suai air facilities	Upgrade	Environment licence from DNSMA	Decree law 5/2011 on environment licensing law
		Authorisation from AACTL	Decree law 1/2003 on civil aviation
Crocodile reserves		Environment licence from DNSMA	Decree law 5/2011 on environment licensing law
Additional infrastructure			
Internal roads			Decree law 2/2003 basic law on the road transport system
Water			Decree law 4/2004 on water supply for public consumption
Telecommunications			Decree law 11/2003 establishing the bases for the telecommunications sector
Electricity			Decree law 13/2003 establishing the bases for the national electricity system

2.6 International Conventions

Timor-Leste has ratified a number of international treaties, conventions and protocols. Table 2-2 summarises these international agreements and identifies its relevance to the project.

Table 2-2 Relevant international agreements to which RDTL is a signatory

Title	Objective	Relevance to the Project
United Nations Framework to Combat Climate Change (1992) and the Kyoto Protocol	To stabilize greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Requires industrialised countries to reduce emissions by setting a mandatory emission limit. RDTL is currently exempt from the emission reduction target.	Greenhouse gas emissions.
United Nations Convention for Biodiversity (1992)	To develop national strategies for the conservation and sustainable use of biological diversity.	Terrestrial biodiversity and marine biodiversity assessment.
International Finance Corporation (IFC) (2006, 2011) Policy and Performance Standards on Social and Environmental Sustainability	To minimise adverse impacts socially, culturally, economically or environment arising from the development of a new project through a process of thorough assessment, avoidance, management and mitigation.	The standards apply to projects that are seeking project funding from the IFC and/or choose to apply 'best practice' performance standards. Although requirements to comply with these standards were considered early in the project's development, they are now considered non applicable as the GoTL will be funding construction of the Suai Supply Base.
United Nations Convention to Combat Desertification	To combat desertification and mitigate drought in affected countries through international cooperation and partnerships.	Geology and soils, terrestrial biodiversity, marine biodiversity, surface water and groundwater assessment.
Vienna Convention for the Protection of the Ozone Layer (1993) and the Montreal Protocol	To protect the ozone layer by controlling the production and consumption of specific chemicals and phasing out the production of numerous substances believed to be responsible for ozone depletion.	Compliance with the standards and protocols for chemical use.

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Tasi Mane Project – Suai Supply Base Environmental Impact Assessment

CHAPTER 3
PROJECT SETTING

301012-01504-EN-REP-0003
May 2012

3 PROJECT SETTING

The information presented within this section provides regional context to the project area, with more detailed information on the existing conditions at the Suai provided in each of the technical chapters (6 to 17) of this EIA report.

3.1 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.

Rainfall is generally dictated by El Niño/La Niña effects; however, short term annual rainfall patterns reflect a seven to nine month wet season. The wettest months are December and May.

Maximum daily temperatures range from 28.5°C to 36.9°C, while minimum daily temperatures range from 22.4°C to 27.3°C. The average difference between maximum and minimum daily temperature over the monitoring period was 10.2°C.

The maximum daily relative humidity is frequently above 90%. The minimum daily relative humidity ranges between 40% and 75%. On average, humidity falls to approximately 60% at 11:00 am and then steadily climbs to above 85%.

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 100 km/h occur, on average, once every 2.6 years (Heyward *et al*., 1997).

3.2 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. 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.

The Suai development area is located on the southern coast, between two sizable watercourses, Rio Raiketan (to the east) and Rio Camanasa (to the west), which have catchment areas of approximately 110 km^2 and 75 km^2.

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 indicates that the river is

likely to discharge sediment directly to the coastal slope and deeper offshore waters (Milliman *et al*., 1999).

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. 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.

3.3 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 (20 to 30 m) reefs.
- The mangrove and seagrass areas located along the Timor and northern Australian coast and islands (Sandlund *et al*. 2001; SKM 2001).

Timor-Leste is located in the Central Melesia (Wallacea) region and its terrestrial 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 Tengarra and Maluku, of which only eight species are shared between each location (Monk *et al.* 1997). Nusa Tengarra 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%.

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).

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. Similarly, the knowledge on the habitat requirements of Timor-Leste vertebrate fauna is lacking and most studies conducted have largely been focused on bird species.

Through the recent ecological assessment, sheoak trees (*Casuarina* sp. aff. *junghuhniana)* recorded as occurring within the Suai development area, are thought to be an important habitat for the yellow-crested cockatoo (*Cacatua sulphurea*), listed as critically endangered on the IUCN Red List of Threatened Species.

3.4 Land and Water Resources

The Suai development area is located on a flat coastal plain with gentle undulations formed by shallow drainage and swampy depressions. The land rises gradually northwards to the central and upper parts of the coastal plain on which the Suai Airport and the proposed Nova Suai development site are located, respectively.

Timor-Leste can be broadly divided into six key land types; the mountainous areas, highland plains, moist lowland areas, arid lowland areas, coastal areas and urban areas (Metzner, 1977).

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.

Natural groundwater springs are considered the primary source of water for domestic and agricultural uses for most villages in Timor-Leste (AusAID, 2009). Estimates of groundwater withdrawals per capita within the Mola and Tafara area were 59 m^3 per year, less than 1% of the total water resources per capita (8, 822 m^3; ADB, 2004) in an average year. However, during a dry (1 in 5 low flow) year, groundwater withdrawals can account for up to 1.5% of total water resources due to limited water availability (3,853 m^3 per year; ADB, 2004).

3.5 Socio-economic Environment

The Cova Lima district is located in the western part of Timor-Leste and borders Indonesia to the west. It has a population of 59,455 inhabitants (Census, 2010) and an area of 1,226 km². The capital of Cova Lima is Suai, which lies approximately 135 km south-west of Dili. The Cova Lima district comprises the sub-districts of Fatululik, Fatumean, Fohorem, Zumulai, Maucatar, Suai Vila and Tilomar.

According to the 2010 Census, the total population of the five villages surveyed in the socio-economic assessment (Suai Loro, Labarai, Belecasac, Matai, Camanasa) is 13,737 with a relatively even gender distribution (51% male, 49% female). The total number of households across all villages is 2,515 with an average household size of 5.5 people. The most populated of the five villages is Suai Loro with a population of 3,730. The least populated village is Belecasac with 855 people.

There is a natural population growth in the villages (i.e., slightly higher birth rate than mortality rate). Anecdotal evidence suggests that the mortality rate has decreased in recent years; however, no specific reason for this decrease was provided. The population age distribution across the five villages is generally young, consistent for both genders.

According to the 2010 Census, there are two main languages spoken in the five villages, namely Tetum Terik and Bunak. Tetun Terik is the mother tongue for the vast majority of people in Suai Loro and Camanasa villages while Bunak was dominant in Labarai and Belecasac villages. Interestingly, in Matai village the distribution of mother tongue language is almost equal. Across the five villages, only a small minority (2%) consider the national language, namely Tetum Prasa, to be their mother tongue.

In 2007, the core road network of Timor-Leste comprised 1400 km of national roads and 800 km of district roads which 'is a small national network when compared to those of many countries in the region'. Since 2007, there has been little expansion in the core network.

Other roads in the Suai area and surrounds are primarily urban roads within townships and rural roads leading from either urban roads or the core network to individual properties or locations. There are no known cycle paths and limited pedestrian facilities. The majority of roads in the area are not surfaced, in poor condition and affected by seasonal weather patterns.

Farming is a very important livelihood in these communities. All families in the area farm (even if they have another job) and it is the main source of food for the population. If the fields are some distance from the village, farmers tend to have a small dwelling close to the plot.

Fishing takes place all along the coast, although no specific fishing areas were mentioned by fieldwork participants. Villagers tend to favour fishing in the ocean rather than in rivers due to the prevalence of crocodiles in the rivers.

3.6 Cultural Heritage

Sacred sites are commonplace in Suai. They may be a stream, rock, tree, house or bush. Some of the sites are outside villages. Churches are also present in the area. Reportedly, there are four sacred sites within the Supply Base area, namely a sacred forest, a large tree and two water streams inside a forest.

Sacred houses are of particular importance to the people of Timor-Leste. Uma-Lulik (the sacred house) is a 'tall, thatched, conical shaped building' and every family in Timor-Leste has a sacred house. Sacred houses are associated with spirituality, tradition, ancestors, self-assurance, strength and honour for the local people. They are the home of animist culture in Timor-Leste.

According to local legend, the island of Timor was formed from the fossilized body of a huge crocodile (Durand, 2006). Since these times, the crocodile has become a sacred animal that the Timorese call

'Grandfather'. Crocodile habitat occurs within the project area, and is intended to be reserved as part of project development.

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Tasi Mane Project – Suai Supply Base Environmental Impact Assessment

CHAPTER 4
PROJECT DESCRIPTION

301012-01504-EN-REP-0003
May 2012

4 PROJECT DESCRIPTION

4.1 Overview

The GoTL proposes to develop a supply base and the related infrastructure to serve oil and gas industry developments in Timor-Leste. It is understood that current logistics support for off-shore oil and gas activities are largely undertaken from Darwin (Australia) and Singapore.

The Suai Supply Base development that is the subject of this EIA spans three phases of development, over a 50 year timescale.

This chapter describes the construction and operational phases of the Supply Base and other components of the project.

4.2 Location

The GoTL has determined Suai as the most appropriate location to develop a Supply Base and the supporting infrastructure.

The settlement of Suai is located approximately 135 km south-west of Dili, 22 km from the Indonesian border, and 5 km inland from the Timor Sea (southern coastline). The main township of Suai is serviced by the national road network connecting to Uemassa (west), Zumalai (east), and Fatululic to the north.

Figure 1-2 shows the location of the Suai development area, which comprises the following:

- Suai Supply Base

  The Supply Base facilities at Suai will be situated on the coast near the village of Sanfuc (in the sub-district of Suai Vila), between the Rio Camanasa and Rio Raiketan.
- An industrial estate

  As part of future development at the Supply Base, an industrial estate will be developed adjacent (north-east) to the land-based facilities.
- Nova Suai

  A new town, Nova Suai, will be located on land between the existing villages of Holbelis and Dais.
- Suai Airport upgrade

  Suai Airport is located at Holbelis, on the northern side of the Suai to Beaco South Coast Road approximately 2 km inland of the coast. The existing airport is classified as a district airport and will be upgraded to cater for expanded passenger and freight services, and to meet oil and gas industry standards.
- Crocodile reserves

Two crocodile reserves are proposed within the existing habitat areas located at We Dare, near the centre of the Supply Base development area, and at We Matan Bua Oan, inside the north-east boundary of the Suai Supply Base development area adjacent to the Rio Raiketan.

4.3 Strategic Vision for the Supply Base

The Supply Base will have modern infrastructure and facilities to provide the logistics services required to serve the existing petroleum exploration in the Timor Sea that will facilitate development of hydrocarbons processing facilities ('downstream' activities), such as LNG and petroleum refining. It will serve multiple users, both off-shore and potentially onshore.

The first phase of construction will commence in 2012 with the third and final phase to be completed in 2030. The indicative layout of the proposed facilities for the Suai Supply Base is shown in Figure 4-1. SERN has advised that the capital cost during the construction phase is expected to be in the order of US$350 million, depending on local market conditions at the time of procurement. The final cost will be subject to commercial negotiations and potentially, a local content purchasing policy.

The Supply Base project will spend an estimated US$4.5 million annually from the operating budget (EastLog, 2011). An estimated 40% of the engineering, procurement and construction contracts will be awarded to local contractors for works and services to be performed in the construction of the breakwater and Supply Base facilities as well as for purchase of local supplies and materials (EastLog, 2011).

It is expected that operational services at the Supply Base will be provided by a combination of government and private organisations that will be resolved through normal tendering processes as the project progresses. These services would include marine engineering, stevedoring, security, catering, drilling, oil spill response and waste management.

The strategic vision for Suai is also to become a national industry base, providing a focal point for services, logistics, fabrications and human resources to promote new local industries and government infrastructure projects.

A feasibility study undertaken by EastLog Holding Pte Ltd [Suai Supply Base Feasibility Study and Front End Engineering Design (FEED), 2011] identifies the key built aspects likely to be required for the Supply Base, which are summarised in Table 4-1. SERN has advised that the feasibility study was undertaken concurrently with the front-end engineering design (FEED) for the Supply Base. Detailed design of the Supply Base is in progress.

4.4 Project-related Infrastructure

4.4.1 Supply Base

The Supply Base will provide dedicated shore-based berths and a focal point to receive, store and administer materials and equipment required for the construction and operation of oil and gas exploration, and production infrastructure. This is likely to include the supply of, for example, fuel, drilling equipment and provisions to drilling rigs in the Timor Sea. The establishment of land-based

facilities (offices and warehousing) and upgrade to the local Suai Airport is also proposed, as broadly described in Section 4.4.4.

Phase 1 of the proposed Supply Base development is focussed on the construction of infrastructure to support the oil and gas industry, with subsequent phases (2 and 3) to cater for the projected increase in demand of bulk commodities, general cargo and container trade.

The lifespan of the Supply Base will be a minimum of 50 years. The indicative layout of the Supply Base is shown in Figure 4-1 and Figure 4-2. This shows the proposed three-phase approach for development, which is discussed below.

Phases 1 to 3 of the proposed Supply Base development, including both onshore and offshore infrastructure, will be located within an area of approximately 135 ha, including the construction of new roads required to access the development areas. However, as shown in Figure 4-1, an additional area of approximately 150 ha has been designated for future development (phase unknown), with another 140 ha of unallocated land included within the Suai Supply Base development footprint, although the nature of the development activities proposed within these areas is yet to be determined.

Phase 1

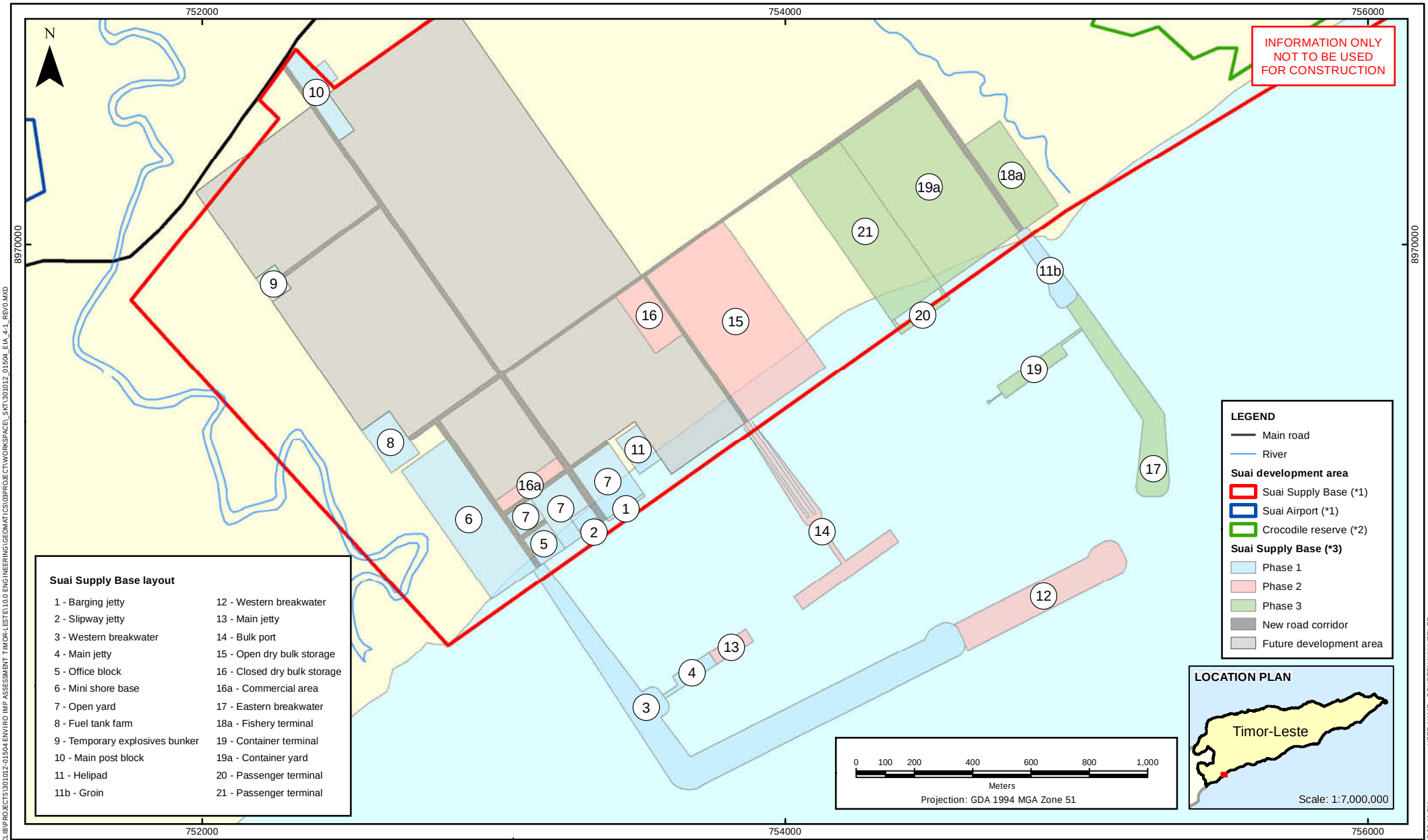
Phase 1 will be designed to provide full capability to support the oil and gas industry at Suai and the southern regions for 10 years, and capacity to export/import commercial dry bulk cargoes (less than 200,000 MT per month) as well as general cargo (EastLog, 2011).

It will include the construction of a western breakwater required for 365/24 capability, a jetty with 4 shore-based berths, 2 LCT ramps and 1 barge berth. The extent of dredging required is subject to further investigation by SERN. It is understood that a dredging study has not yet been undertaken.

Land-based facilities (including offices) will be established to host up to four production sharing contracts (PSCs). The construction activities will also require significant quantities of diesel and construction materials to be stored on site. The fuel tank farm will be comprised of 2 x 500 kl and 2 x 3,000 kl tanks, contained within a 3 m-high earth, containment bund, and enclosed by security fencing. The 3,000 kl tanks will be utilised to store diesel fuel, with the two 500 kl tanks to provide storage capacity for gasoline and aviation fuel to support the helicopter operations (EastLog, 2011).

Phase 1 of the proposed development, including the seabed area designated for construction of the western breakwater, will be located within an area of approximately 50 ha.

The construction period for the Phase 1 work will be approximately 12 to 18 months, and is anticipated to be operational by the end of 2013 or early 2014, provided that construction commences in mid-2012.



NOTES:
This map consists of:
1. Rivers: Geographic Information Group TimorLeste (2010)
2. Roads: DivaGIS (2010)

Layouts have been sourced from:
*1 SERN, Dec. 2011
*2 SERN, Jan. 2012
*3 Eastlog Holding Pty Ltd., May 2011

REV	DATE	REVISION DESCRIPTION	DRN	CHK	DES	ENG	APPD	CUST	PROJECT No: 301012-001504
0	8/05/2012	FINAL FOR ISSUE	MW	CW	-	-	GH	-	A4 SHEET SCALE 1:17,500

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TASI MANE PROJECT - SUAI SUPPLY BASE ENVIRONMENTAL IMPACT ASSESSMENT

Figure 4-1
Suai Supply Base layout

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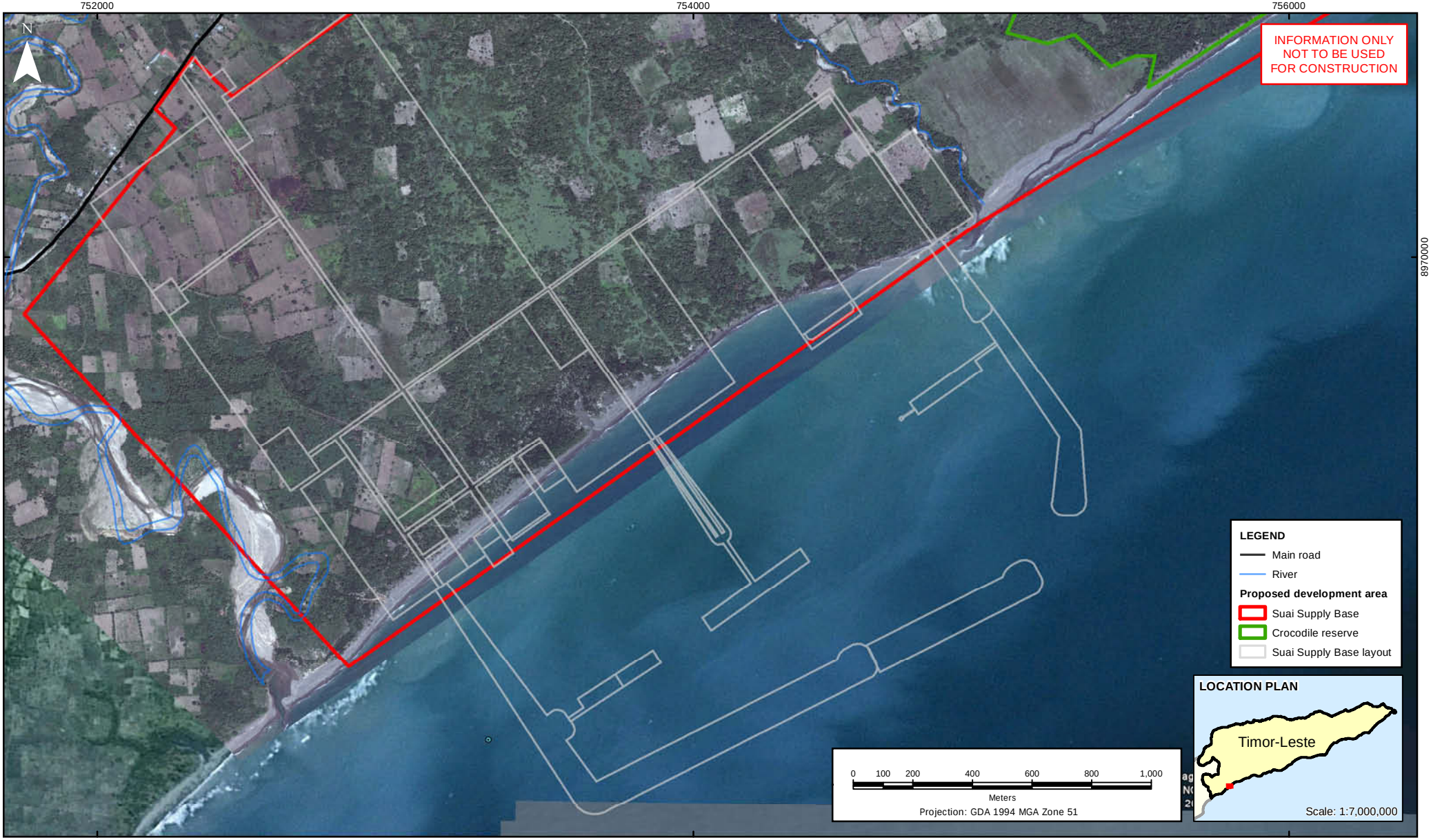

NOTES:
This map consists of:
1. Imagery: DigitalGlobe (2008-2011)
2. Roads: DivaGIS (2010)
3. Rivers: Geographic Information Group TimorLeste (2010)

REV	DATE	REVISION DESCRIPTION	DRN	CHK	DES	ENG	APPD	CUST
0	8/05/2012	FINAL FOR ISSUE	MW	CW	CS	-	GH	-

A4 SHEET | SCALE 1:17,500
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TASI MANE PROJECT - SUAI SUPPLY BASE
ENVIRONMENTAL IMPACT ASSESSMENT

Figure 4-2
Suai Supply Base outline

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Phase 2

In Phase 2, the breakwater and jetties constructed in Phase 1 will be extended to facilitate the development of a dry bulk terminal and associated land-based facilities (including bulk storage and commercial area) subject to demand. The proposed extension to the main jetty is 50 m wide and 150 m long, designed to allow for a number of berthing configurations; up to three cargo vessels at any one time. The land-based services (dry bulk storage) will be developed on a lot (~25 ha) adjacent (north-east) to Phase 1. The area designated for the Phase 2 development, including the offshore components (jetty and breakwater extensions and bulk port berths), totals approximately 40 ha.

The SDP estimates Phase 2 will be completed by 2016; however, programming for this phase may have been updated since the time of writing the SDP.

Phase 3

Phase 3 will occupy an area of approximately 45 ha and will include the construction of a new eastern breakwater to accommodate development of a container terminal, passenger jetty and a fishery terminal complex, and associated land-based facilities, including a container yard. The land-based services will be located on the lot adjacent (north-east) to Phase 1.

The SDP indicates that construction of Phase 3 will occur between 2024 and 2030.

Table 4-1 Suai Supply Base: likely components and phasing (Part 1)

Component	Phase	Figure 4-1 ref	Facilities	Capacity	Approximate Area
Marine facilities					
Jetties	**1, 2**		**Phase 1 -**		
		1	**Barging jetty**: for unloading construction materials and support operations using heavy lifts, and may provide an alternative jetty during operation for fuel unloading or commercial dry bulk.	Barging jetty: concrete piles, 50 t bollards.	Barging jetty: Unknown
		4	**Main jetty**: comprising four berths, with all-weather (365 day) capabilities with lighting for 24 hour working.	Main jetty: 4 x 75 m and 1 x 50 m multi-purpose berth capacity. Trestle: 2 tug boat berths	Main jetty: 50 m x 150 m Trestle: 15 m x 100 m
			Phase 2 -		
		13	**Main jetty**: extension to provide four additional land-based berth facilities of either 2 x 5,000 DWT supply boat and 1 x 10,000 DWT drill ship, or, 2 x 10,000 DWT dry bulk barge and 1 x 10,000 DWT general cargo ship.	Unknown	50 m x 150 m
		14	**Bulk port jetty**: new jetty and terminal for 2 x 400 m berths.	Loading 2 x 20,000 tpd of mineral ore	Unknown
Breakwaters	**1, 2, 3**	3, 11b 12 17	**Phase 1 –** new western breakwater and eastern groin. **Phase 2 –** extension to western breakwater. **Phase 3 –** new eastern breakwater (extension from groyne).		Phase 1 - 1,850 m length Phase 2 - unknown Phase 3 - unknown

Table4-1 Suai Supply Base: likely components and phasing (Part 2)

Component	Phase	Figure 4-1 ref	Facilities	Capacity	Approximate Area
LCT Ramps (2)	**1**	2	For loading/unloading of over-sized and overweight materials or equipment using transporters. Includes a slipway (ramp) initially for unloading construction materials for the main jetty, and to be used for launching the oil spill boom.	Accommodate 5,000 DWT barges	
Land-based facilities					
Office block, utilities and service infrastructure	**1**	5	Office block area, including: • Main building accommodating for the port operations office (with radio room). • Office parking. • Central kitchen and refrigerated container area (to cater for the food supply requirements for off-shore facilities). • Operations canteen (to cater three meals a day for base personnel and visitors) 12 m x 12 m building. • Crew change building. • Medical clinic, for minor conditions and initial treatment / stabilisation in the event of more serious injuries, including ambulance standby for hospital transfer. • Telecommunications facilities, including tower. • Substation for electricity supply: 8 m x 25 m concrete building to accommodate a step-down transformer, low voltage panels and cabinets, 3 x 500 kVA generators (for back-up power supply), and 3 kL fuel storage tank. • Reverse osmosis (RO) plant and water storage tanks: plant, storage tanks (2 x 400 kL) and pumping station to pump the processed water from the storage tanks. Plant capacity of 15 kL/hr, and discharge capacity of 120 kL/hr.		

Table4-1 Suai Supply Base: likely components and phasing (Part 3)

Component	Phase	Figure 4-1 ref	Facilities	Capacity	Approximate Area
Mini shorebases (4)	**1**	6	Four mini shorebase facilities for PSC to use, including: • Open yard. • Office. • Closed warehouse. • Mini staging and parking area.		• 20,000 m^2 open yard • 500 m^2 office • 1,000 m^2 closed warehouse
Open yard	**1**	7	Storage area; pipes, drilling rods, other construction material.	15 t/m^2 load bearing capacity	10 ha
Fuel tank farm	**1**	8	Fenced-off area for liquid tanks to store diesel (for drilling operation), gasoline, and aviation fuel.	Tank capacity: • 2 x 3,000 kL diesel • 1 x 500 kL gasoline • 1 x 500 kL aviation fuel	
Temporary explosive storage	**1**	9	Temporary structure to store explosive materials, likely to include additional zinc roofing, and earthing and lightning protection.		6 x 20 foot containers

Table4-1 Suai Supply Base: likely components and phasing (Part 4)

Component	Phase	Figure 4-1 ref	Facilities	Capacity	Approximate Area
Main post block area	**1**	10	Including: • Transit and staging area to accommodate equipment, cargo, and passenger vehicles while waiting for security checks or jetty berth. • Badminton court and football field for base personnel as well as the general community. • Accommodation building for senior executives. • Training and conference facilities.		46 m x 14 m accommodation building
Helipad	**1**	11a	Temporary helipad fur use during the construction period for visual landings only (e.g., for inspections, guests etc.)		
Common warehouse buildings (2)	**1**	22	Two warehouse buildings will be divided in two, forming four warehouses for each separate use as follows: • General cargo (with cool room). • Chemical and dangerous goods. • Maintenance workshop (with 5 MT overhead crane). • Fabrication workshop and inspection area (with 10 MT overhead crane).		2 x 3,600 m^2 (1,800 m^2 for each part)
Power building	**1**	Not indicated	Concrete building to terminate incoming high voltage cabling from the power grid and house equipment		5 m x 8 m building
Security system	**1**	Not indicated	Security system features could include a main and secondary guard post, control room and closed circuit television (CCTV), guard towers, guard quarters and ready room, and security vehicles		Unknown

Table4-1 Suai Supply Base: likely components and phasing (Part 5)

Component	Phase	Figure 4-1 ref	Facilities	Capacity	Approximate Area
Firefighting system	**1**	Not indicated	Including hydrants, fire pumps, seawater backup pump, foam systems, firewater pond, deep well and water tank		
Oil spill response equipment	**1**	Not indicated	Services and equipment for lease when required for handling oil spills; including spill booms, dispersants, clothing stores, etc.		
Waste management	**1**	Not indicated	Waste management facilities for domestic (segregation area) and industrial (handled by a specialist waste management company) waste materials. Refer to Chapter 17 for consideration of likely waste streams		
Open dry bulk storage	**2**	15	Steel framed warehouse with conveyor system		20 ha
Closed dry bulk storage	**2**	16	To support the dry bulk operation		
Commercial area	**2**	16a	Commercial space to cater for oil and gas service companies, vehicle parking and associated roads		1,400 m^2 open yard 250 m^2 commercial space
Fishery terminal complex	**3**	Not indicated			
Container terminal	**3**	19			
Container yard	**3**	19a			
Passenger jetty	**3**	20			
Passenger terminal	**3**	21			

Source: EastLog, 2011
Note: Figure 4-1 presents the indicative layout prepared by EastLog Holding Pte Ltd. The locations of some components have not yet been finalised.

Temporary activities

The types of temporary activities during the construction phases are likely to include the establishment of a construction compound, laydown areas and temporary accommodation for construction personnel. SERN has advised that information on temporary activities is not currently available in order to be able to assess potential impacts.

Associated infrastructure requirements

Timor-Leste is deficient in the core infrastructure, support industries and human resources to fully operate and manage the country's developing petroleum sector (SDP, 2011) and, as a result, a range of infrastructure and services will be upgraded to facilitate the local petroleum industry. These works do not form part of the scope of this EIA but are considered logical and necessary developments, for example, the proposed upgrade of the Suai Hospital.

Road Network

The Suai to Beaco South Coast Road will be developed to support the growth of the petroleum industry and to open up this area of coastline to allow economic development and the delivery of social services (SDP, 2011). The upgrade of the road will be a staged development serving the new towns associated with the growth of the petroleum industry.

The SDP also sets out that by 2020, all national and regional roads will have been fully upgraded to international standards. This is discussed further in Chapter 16 (Land Transport).

Power Infrastructure

SERN has advised that details on the upgrade of power generation and utility networks and connections are not currently available.

However, it is understood that the Southern Power Plant proposed for Betano will provide for a 10 MW substation in Suai, to supply the Suai area (EastLog, 2011).

4.4.2 Industrial Estate

Approximately 250 ha of land has been allocated for the future development of an industrial estate adjacent to the Supply Base. The estate is intended to provide facilities for small and medium-sized local businesses to benefit from the new infrastructure and transportation networks associated with the Supply Base development. SERN has confirmed that no additional details are available for this assessment.

4.4.3 Nova Suai

Nova Suai is intended to support the Supply Base development. The area allocated for the new settlement is approximately 188 ha including internal roads.

The new town will provide for up to 6,500 residents, primarily intended for staff and their families involved in the oil and gas industry development including primary contractors, support companies and visitors.

The GoTL publication *Book 6 Master Plan and Urban Design Package of Nova Suai* sets out the preliminary physical framework for a new settlement at Suai and forms part of the government's *Spatial Design Planning for Southern Coast of Timor-Leste (2011)*, which have been prepared to align with the *Timor-Leste Strategic Development Plan 2011 – 2030*).

Book 6 has been prepared as an initial concept document, setting out an approach to master plan and urban design guidelines for Nova Suai. It forms the basis for a detailed master plan and urban design package and detailed engineering to be prepared at subsequent stages, and provides an early indication of infrastructure requirements.

Figure 4-3 shows the indicative layout for Nova Suai and the total general land use areas which will comprise:

- Multi-family residential houses (two areas): approximately 42.3 ha.
  - Apartment buildings, c.96 sqm living space per apartment.
  - Employee dormitory buildings.
  - Recreational facilities.
- Single family residential houses ('Hillside Residential'): approximately 78.1 ha.
  - Common areas.
  - 350 sqm single storey houses on 450 sqm lots.
- International school: approximately 6.7 ha.
  - Elementary school and associated facilities.
  - Junior high school and associated facilities.
- Commercial area: approximately 7.4 ha.
  - Supermarket and grocery store.
  - Shopping mall.
  - Petrol station.
  - Business hotel.
- Community center: approximately 6.5 ha.
  - Multi-purpose hall.
  - Sporting facilities.
  - Training and conference facilities.
  - Library.

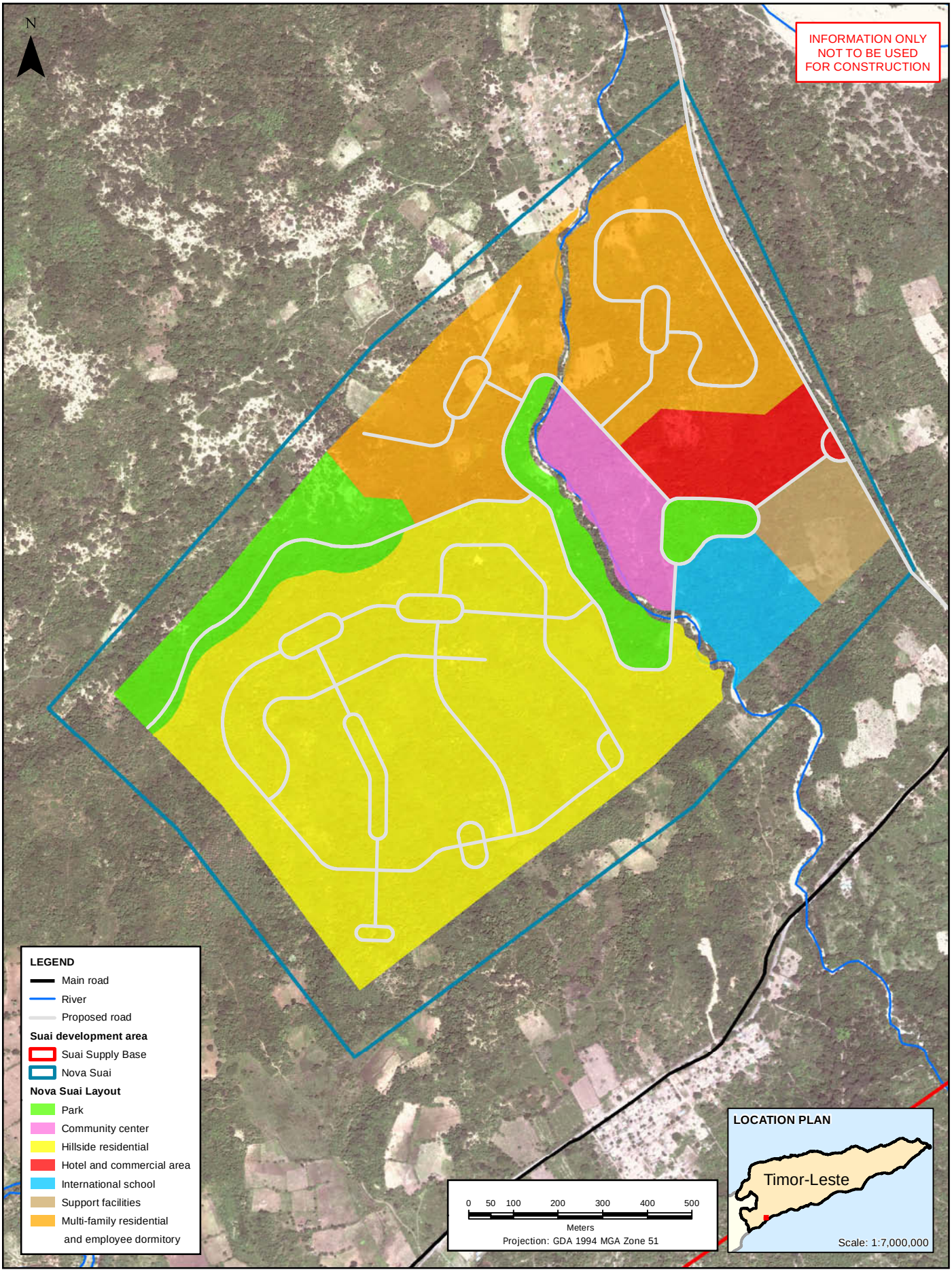
- Park and recreation: approximately 13.3 ha.
  - Riverside park.
  - Mountain walk park.
- Gate landmark entrance and security building: approximately 0.4 ha.
- Public facilities: approximately 5.5 ha.
  - Security office.
  - Estate management office.
  - Fire department.
  - Maintenance and workshop.
- Internal road infrastructure and utility network: approximately 27.9 ha.
- Support facilities:
  - Stormwater pond.
  - Water supply and facilities.
  - Sanitation (sewerage and waste water treatment).
  - Power plant.

Nova Suai will be the first of the four new settlements to be developed under the GoTL's Tasi Mane Project. Nova Betano, Nova Beaco and Nova Viqueque will be developed as part of their respective industrial developments, and are considered under a separate cover.

The current plan for developing Nova Suai is to build part of the multi-family residential and single family residential areas, the community center and support facilities first. Stage 2 will include the development of the remaining areas of the multi-family residential, the single family residential area and the commercial area.

It is understood that access to the new settlement would be facilitated by the upgraded Suai to Beaco South Coast Road. As outlined in Section 4.4.1 above, the road upgrade does not form part of the scope for this EIA.

Figure 4-4 presents recent aerial imagery, indicating the current land use and extent of vegetation at the proposed Nova Suai development site.



NOTES:
This map consists of:
1. Rivers: Geographic Information Group TimorLeste (2010)
2. Roads: DivaGIS (2010)
3. Nova Suai Concept Layout SERN (2010)
4. Imagery: DigitalGlobe (2008-2011)

REV	DATE	REVISION DESCRIPTION	DRN	CHK	DES	ENG	APPD	CUST
0	8/05/2012	FINAL FOR ISSUE	MW	CW	-	-	GH	-

A4 SHEET SCALE 1:11,500
PROJECT No: 301012-001504

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TASI MANE PROJECT - SUAI SUPPLY BASE
ENVIRONMENTAL IMPACT ASSESSMENT

Figure 4-3
Nova Suai layout

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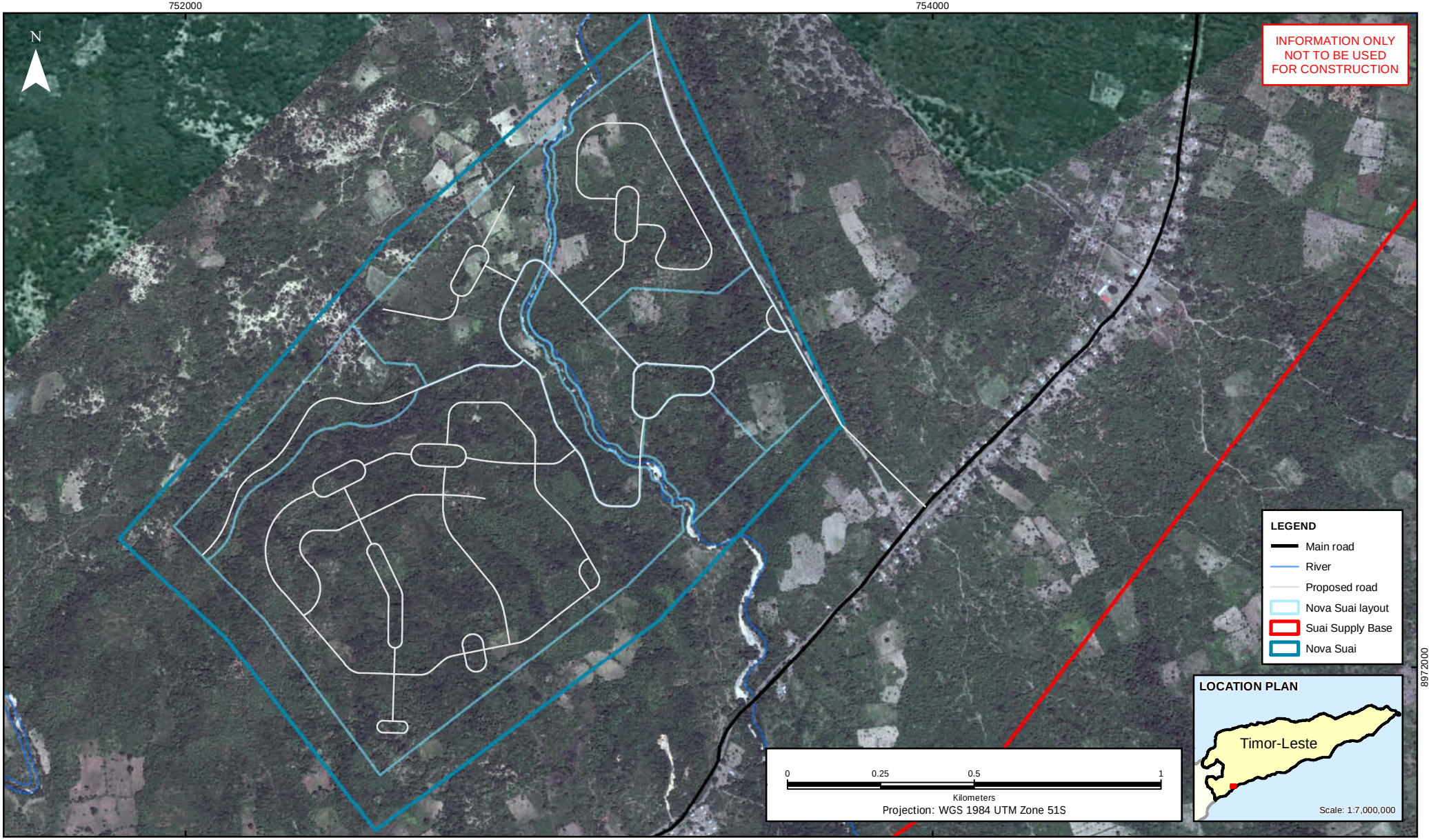

NOTES:
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1. Imagery: DigitalGlobe (2008-2011)
2. Imagery: Google Earth (2010)
3. Rivers: Geographic Information GroupTimorLeste (2010)
4. Roads: DivaGIS (2010)
5. Nova Suai Concept Layout: SERN (2010)

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PROJECT No: 301012-001504

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TASI MANE PROJECT - SUAI SUPPLY BASE
STRATEGIC ENVIRONMENTAL IMPACT ASSESSMENT

Figure 4-4
Nova Suai outline

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4.4.4 Suai Airport Upgrade

The existing airport at Suai (Figure 4-5) will be upgraded to a fully operational district airport. Improved civil aviation facilities at Suai also forms part of the sustainable growth strategy set out in the National Planning Document (2002) and the SDP.

It is understood that Suai Airport is currently an abandoned airstrip, approximately 1,050 m in length and 30 m in width. The upgrade works will include an extension to the existing runway of up to 2 km in length, and new facilities for customs and immigration, arrival and departure, fire-fighting, and site fencing, a helipad with Medevac air ambulance facilities.

4.4.5 Crocodile Reserves

Crocodiles hold sacred status with the Timorese. As part of the project, SERN proposes to establish two crocodile reserves within existing areas of natural crocodile habitat shown in Figure 1-2.

One of the habitat areas at We Dare is located near the centre of the proposed Suai Supply Base development area, extending inland from the coastline and covering approximately 45 ha of densely vegetated land. The other area, We Matan Bua Oan, is located inside the north-east boundary of the Suai development area (adjacent to the Rio Raiketan) and covers approximately 10 ha of densely vegetated land.

The specific location and design of the crocodile reserves have not been finalised by SERN; however, similar principles to other crocodile reserves in Indonesia are likely to be followed by providing protected habitats for saltwater crocodiles.

SERN intends for the proposed crocodile reserves to become a tourist attraction where visitors can view crocodiles of a range of sizes and ages. In addition, these reserves will host natural rainforest and cultural heritage areas for traditional ritual ceremonies.

NOTES:
This map consists of:
1. Imagery: DigitalGlobe (2008-2011)
2. Rivers: Geographic Information Group TimorLeste (2010)

REV	DATE	REVISION DESCRIPTION	DRN	CHK	DES	ENG	APPD	CUST
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A4 SHEET | SCALE 1:6,500

PROJECT No: 301012-001504

TASI MANE PROJECT - SUAI SUPPLY BASE
ENVIRONMENTAL IMPACT ASSESSMENT

Figure 4-5
Suai Airport

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LOCATION: \\PERWORFIL1\INFRSTRUCL\IBV\PROJECTS\301012-01504 ENVIRO IMP ASSESSMENT TIMOR-LESTE\10.0 ENGINEERING\GEOMATICS\03PROJECT\WORKSPACES_SKT\301012_01504_EIA_4-5_REV0.MXD

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4.5 Construction Activities

The proposed construction phasing for the project was not available at the time of preparing this report. In considering the typical sequence of activities for developments of a similar scale and nature, the construction of the Supply Base, Nova Suai and the industrial estate are likely to include the following activities:

- Site surveying

  Surveying the site to mark the boundaries, access ways, and locations of structures and features in accordance with the co-ordinates on the detailed design drawings.

- Access and administration

  Establishment of temporary access ways (to and within the sites) and the construction management office on site.

- Perimeter fencing

  Installation of perimeter fencing around each site to restrict unauthorised entry, for the safety and security of staff, the community, equipment and property.

- Vegetation clearance

  Clearing of vegetation necessary to facilitate the built and sealed aspects, and temporary construction laydown areas.

- Site levelling

  Carry out earthworks activities using heavy machinery to move and compact soil for leveling.

- Construction laydown area and temporary buildings

  Establishment of construction laydown areas and temporary buildings and structures, including administration buildings, staff facilities, and waste management areas.

- Power supply

  It is understood that generators will be used to provide power during the construction of the Supply Base, and will again be used during start-up and operation until a grid connection is available. Generators will be retained during operation for back-up power supply (EastLog, 2011).

- Key equipment

  The type of heavy machinery (including specifications), hand tool equipment and vehicles to be used during construction (including their frequency of use and duration on site) will be determined by the awarded construction contractor upon appointment.

- Facilities construction

  The construction methodology for the project is not currently available. It is assumed that the awarded contractor will prepare a construction EMP upon appointment which will include details of construction activities, methodology and phasing.

4.6 Commissioning

All facilities for the project will go through a period of testing and commissioning prior to handing over to the operators.

4.7 Rehabilitation and Decommissioning

Given the lifespan of the project (~50 years), the decommissioning phase has not been assessed at this stage. It is recommended that a decommissioning and closure plan be developed approximately 10 years prior to commencement of decommissioning, and the associated environmental impacts are assessed as part of the development of this plan.

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Tasi Mane Project – Suai Supply Base Environmental Impact Assessment

CHAPTER 5
STAKEHOLDER CONSULTATION

301012-01504-EN-REP-0003
May 2012

5 STAKEHOLDER CONSULTATION

This section addresses requirements of Timor-Leste Decree Law No. 5/2011 (Article 11 of Chapter IV) which outlines specific requirements for public consultation in the environmental impact of those projects designated as Category A by the law. The law states that public consultation should have the following objectives:

- Providing access to the EIA findings.
- Inform and enlighten the public about the project, including potential environmental impacts and their way of mitigation.
- Promote discussion about the EIA and EMP.

Any member of the public may provide recommendations or proposals based on the EIA and EMP to the Evaluation Committee, during the public exhibition of the EIA. Public consultation is required to define the project scope and to discuss the project terms of reference (ToR) and the opinions of interested parties must be reflected in the ToR.

The DNSMA, who is responsible for assessment and approval of the EIA, also developed various guidelines; the most important of those from social perspective being DNSA Guideline No. 5 on Public Consultation.

5.1 Objectives

Stakeholder consultation aims to create an environment of informed and constructive participation of all parties interested in, or affected by, a proposed development. On its own, consultation cannot prevent conflict; rather it facilitates a process in which people feel heard and included in decision-making and project design, and where potentially satisfactory outcomes are identified.

On-going consultation with stakeholders will continue following the submission of the EIA. The objectives of further consultation are twofold in nature. It will:

- Ensure full disclosure of project information at local, district and national level.
- Provide feedback on the key findings of the EIA.

5.2 Stakeholders

The stakeholder consultation process includes the identification of stakeholders that are directly or indirectly affected by the project, also referred to as interested and affected parties (IAPs).

As part of its investigation for the socio-economic study, an initial stakeholder identification process was undertaken using data received from secondary sources including:

- GIS data, to identify villages in the project area.
- Reference books and internet sites.

A diverse range of stakeholders were identified and divided into two groups – primary stakeholders and secondary stakeholders, as shown in Table 5-1. Primary stakeholders are defined as those who are directly affected or can influence the development, while secondary stakeholders are those who are not directly affected; however, have a strong interest in the development.

Table 5-1 Identified stakeholders (Part 1)

Primary Stakeholders	Secondary Stakeholders
Directly affected residents (landowners and land users). More specifically, the following villages should be consulted during forthcoming stakeholder consultation: • Suai Loro • Labarai • Belecasac • Matai • Camanasa	NGOs and community-based organisations (CBOs) active at a national and local level, as well as those having international representation in the country. More specifically, the following NGOs were reported to be active in villages in the project area: • Children's Fund, • CARE, • Triangle GH, • Gesellschaft für technische Zusammenarbeit (GTZ), • Tuba Rai Metin, • Oxfam, • La'o Hamutuk, • Haburas, • Fitun Naroman, • Grace.
Regulatory authorities, councillors and tribal authorities covering national, district and sub-district levels with authority in the directly affected project area. More specifically: • DNSMA – main regulatory body for assessment and approval of ESIA. • Ministry of Agriculture, Forestry and Fisheries (MAFF). • Ministry of Public Works (MPW). • Minister of Justice (in case a business license is required).	Ministry representatives in political positions. More specifically: • Ministry of Health • Ministry of Justice • Ministry of Internal Administration

Table 5-1 Identified stakeholders (Part 2)

Primary Stakeholders	Secondary Stakeholders
Ministry representatives in political positions More specifically: • Ministry of Environment • MAFF • Ministry of Transport and Communication • Ministry of Development • Ministry of Education and Culture (Secretary for Culture) • Secretariat of State for Employment and Professional Training (SEFOPE) • Ministry of Planning and Finance	

5.3 Consultation Activities

The project disclosure consultation for the Suai Supply Base has been undertaken by the SERN. The first meeting comprised of SERN representatives, the Prime Minister, a Member of Parliament, the Minister of Justice and Village Chief representatives. Another three meetings were held at a district level (Cova Lima) and two public village meetings. Separate to this, additional stakeholder consultation has been undertaken to identify the socio-economic baseline characteristics for the Suai study area and to describe community perceptions about the project. The Suai study area includes the villages interviewed by WorleyParsons namely Camenaca, Matai, Belecasac, Suai Loro and Labarai. The results of this consultation are discussed in detail in Chapter 15 of this report

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Tasi Mane Project – Suai Supply Base Environmental Impact Assessment

CHAPTER 6
CLIMATE AND METEOROLOGY

301012-01504-EN-REP-0003
May 2012

6 CLIMATE AND METEOROLOGY

6.1 Study Method

This study was designed to provide a baseline description of the general climate and meteorological profile of the region in which the Suai development will be located.

The study method adopted for the climate and meteorological assessment of the Suai study area is summarised as follows:

- A literature review to identify:
  - Relevant documentation describing climatic trends.
  - Relevant sources of the regional meteorological data.
- Establishment of a temporary meteorological station in close proximity to the Suai development area in general accordance with Australian Standard AS 3580.14-2011 *Methods for sampling and analysis of ambient air Part 14: Meteorological monitoring for ambient air quality monitoring applications* (AS 3580.14-2011).
- Determination of general climate and meteorological trends.
- Development of recommendations for any future or ongoing meteorological monitoring for the Suai study area.

6.1.1 Study Scope

Meteorological trends are more adequately described on a scale of tens of kilometres or greater. Therefore the study scope includes the Suai development areas the wider coastal lowland region extending approximately 10 km along the coast in either direction and approximately 5 km inland to the foothills.

6.1.2 Literature Review

Several sources of information are available describing the general climate for Timor-Leste on a country-wide scale. However, fewer sources describe the particular meteorological trends for the south-western region of the country around Suai. The following documents were reviewed as part of this assessment:

- *Report on restoration of meteorological network – Timor Loro'Sae* (Keefer G.D., 2000).
- *Vulnerability to climate variability and change in East Timor* (Barnett J. et.al, 2007).
- *Climate change in Timor-Leste – a brief overview on future climate projections* (CSIRO, 2010).
- *Climate Risk and Agriculture in Timor Loro'Sae* (Dolcemascolo G., 2003).

Meteorological information was provided for an automated weather station (AWS) owned by the Ministry of Agriculture (MoA, 2012) within the Suai study area. The reported information is provided in Appendix B, and location coordinates of the AWS are provided in Table 6-1. The information spans the 2008 to 2011 calendar years and reports daily averaged information for the following parameters:

- Maximum, minimum and mean temperature (degrees Celsius).
- Maximum, minimum and mean relative humidity (%).
- Rainfall (mm).
- Mean wind speed (m/s).
- Solar radiation (MJ/m^2).
- Evapotranspiration (mm).

The supplied data are daily averages and does not include wind directions. Typically meteorological automated weather stations make observations at a minimum of an hourly basis. In addition, there are significant data gaps over the reported period. As such, this information does not provide sufficient time-dependent resolution to adequately determine prevailing climate trends.

6.1.3 Baseline Measurement Method

A temporary, semi-automated meteorological station was established in Samfuk from 15 December 2011 to 7 February 2012, between the Suai Supply Base and Nova Suai development areas. Location coordinates of the meteorological station are shown in Table 6-1. The meteorological station was sited in general accordance with AS 3580-14-2011 – *A guide to sampling and analysis of air emissions and air quality*. The meteorological station comprised of two parts: the weather vane and instrumentation; and the hand-held data storage device. The data storage device also incorporated an internal electronic thermometer for indoor temperature measurements and an internal electronic hygrometer for indoor humidity measurements. Meteorological parameters were recorded automatically and downloaded periodically over the monitoring period to a computer for statistical analysis.

Table 6-1 AWS and temporary meteorological station coordinates

Source	Location Coordinates		Elevation Above Ground Level	Total Elevation Above Sea Level
	Latitude	Longitude		
AWS (Ministry of Agriculture)	9° 19’ 07.42” S	125° 15’ 36.14” E	2 m	24 m
Suai Weather Station (WorleyParsons)	9° 17’ 45.1” S	125° 18’ 23.4” E	3 m	28 m

Parameters measured by the meteorological station are listed below:

- Date and time.
- Measurement interval (minutes).
- Indoor and outdoor humidity (relative %).
- Indoor and outdoor temperature (degrees Celsius).
- Absolute and relative pressure (hPa).
- Wind speed and gust speed (m/s).
- Wind direction (16 directions).
- Dewpoint temperature and wind-chill (degrees Celsius).
- Hourly, 24 hourly, weekly, monthly and total rainfall (mm).
- Wind and gust speed (Beaufort wind force scale 0-12). Whilst this data was recorded, data relating to wind speeds has been presented in m/s for this assessment.

Measurements were made automatically at 30 minute intervals from the time the device was reset. Measurements that are analysed on an hourly average (wind speed/direction and rainfall) were averaged or summed over each hour period.

6.1.4 Data Assumptions and Limitations

There have been several limitations to this study as outlined below:

- The monitoring period for the baseline measurements spanned 55 days and is not representative of seasonal or long-term trends.
- The meteorological station installed on site was oriented as close as reasonably practicable to true north; however, it cannot be guaranteed that the orientation angle was exact.
- Site personnel were not present for the entire duration of the monitoring period, therefore it is possible that the meteorological station may have been interfered with, altering the results.
- The required long term (50+ years), national (10 to 20 locations) that would allow a more scientific assessment of climate conditions was not available.

6.2 Existing Environment

6.2.1 General Description

The Suai study area displays a typical tropical monsoonal climate with distinct wet and dry seasons. Seasonal variation in temperature is minimal, with the diurnal temperature variation often greater than the seasonal variation. Daytime temperatures are typically in the low to mid 30's and night-time temperatures are in the mid 20's. Humidity is consistently high, frequently greater than 90% for

significant proportions of the day. Long-term, multi-year rainfall trends are generally dictated by El Niño / La Niña effects; however, shorter-term annual rainfall patterns are monsoonal in nature experiencing a 7 to 9 month wet season with two peak months; December and May (CSIRO, 2010). The coastal region in which the Suai study area resides generally receives less annual rainfall than the midland and highland regions further inland. Rainfall events are often torrential in nature and short in duration.

During the monitoring period, low to moderate wind speeds were recorded from most directions ranging from north to south-east across the western arc. The majority of the recorded wind speeds were below 0.5 m/s. Three cyclone events have been reported within 100 km of the Suai study area since 1983.

6.2.2 Major Processes Influencing Climate

The primary climate process that influences the rainfall across Timor-Leste is the El Niño Southern Oscillation (ENSO). The ENSO is an air-sea interaction in the Pacific Ocean that affects climate variability in the Indo-Pacific region with a cycle of three to seven years. An El Niño / La Niña event occurs when the eastern tropical Pacific is much warmer / cooler than normal (CSIRO, 2010).

CSIRO (2010) reports that a strong association exists between the Southern Oscillation Index (SOI) and both the dry season total rainfall and the onset date of the wet season. Some reported effects of El Niño events in (Barnett J. et.al, 2007) are:

- Annual rainfall in Dili during the 1997/1998 and 1982/1983 El Niño events are the lowest and second lowest in 48 years of records (1950 to 1999); and
- Districts such as Ainaro and Lautém have experienced annual rainfall as low as 50% of average while districts such as Baucau and Oecussi experienced greater than average rainfall.

El Niño events are commonly associated with prolonged drought and it is reported that Timor-Leste experiences agricultural and hydrological drought approximately once every four years (Dolcemascolo G., 2003).

During the monitoring period, the SOI ranged from 23.0 to 9.4. Prolonged periods with the SOI greater than 8.0 are indicative of La Niña conditions. This indicates that Timor-Leste experienced weak La Niña conditions during the monitoring period.

Solar radiation is always a driving force for climatic processes. In the case of the Suai study area, cloud cover is often minimal during the morning and midday hours, with large cloud banks covering the sky later in the afternoon. These cloud banks are an indirect result of the evaporation of the ocean due to solar radiation.

The mountainous region spanning the length of the Timor Island acts as a barrier to trade winds emanating from the north-west. Moisture-laden air from the surrounding oceans encounters the mountains and is pushed higher into the atmosphere. The moisture then precipitates out of the atmosphere due to the cooler conditions and results in torrential downpours throughout the highlands.

These downpours affect the lowlands on the southern coast of the island by the frequent flushing of the river systems in the area, as well as deposition of sediment eroded from the highlands.

6.2.3 Temperature

Timor-Leste has a tropical climate in which the temperature varies little throughout the year (CSIRO, 2010). However, the diurnal (daily) variation can be larger than the monthly variation throughout the year. It is also estimated that the annual mean temperature decreases with increasing altitude at a rate of 5.5°C per 1000 metres above sea level (CSIRO, 2010). As the Suai study area is in the coastal low-lying region with an approximate elevation of 25 metres above sea level, and the monitoring period was during the southern hemisphere summer, it is expected that the measured temperatures are representative of the hottest period of the calendar year.

The time series for indoor and outdoor temperatures and a daily temperature profile for the monitoring period are presented in Figure 6-1 and Figure 6-2. The time series data appears consistent with (CSIRO, 2010) during the monitoring period as there was very little temperature variation day to day. The maximum daily temperature varied between 28.5°C and 36.9°C and the minimum daily temperature varied between 22.4°C and 27.3°C. The average daily temperature difference between maximum and minimum over the monitoring period is 10.2°C. The maximum and minimum temperatures, and the temperature variations are consistent with the values reported in (MoA, 2012) for the corresponding days between 2008 and 2011.

The daily profile plot shows the average minimum temperature occurs between 4:00 a.m. and 5:00 a. m. with an increase in temperature occurring between 6:00 a.m. and 9:00 a.m. after the sun rises. The maximum temperature is reasonably consistent between 9:00 a.m. and 3:00 p.m. and there is a consistent gradual decline in temperature between 3:00 p.m. and the following 5:00 a.m.

Table 6-2 presents the maximum and minimum daily temperatures recorded for Suai throughout the monitoring period.

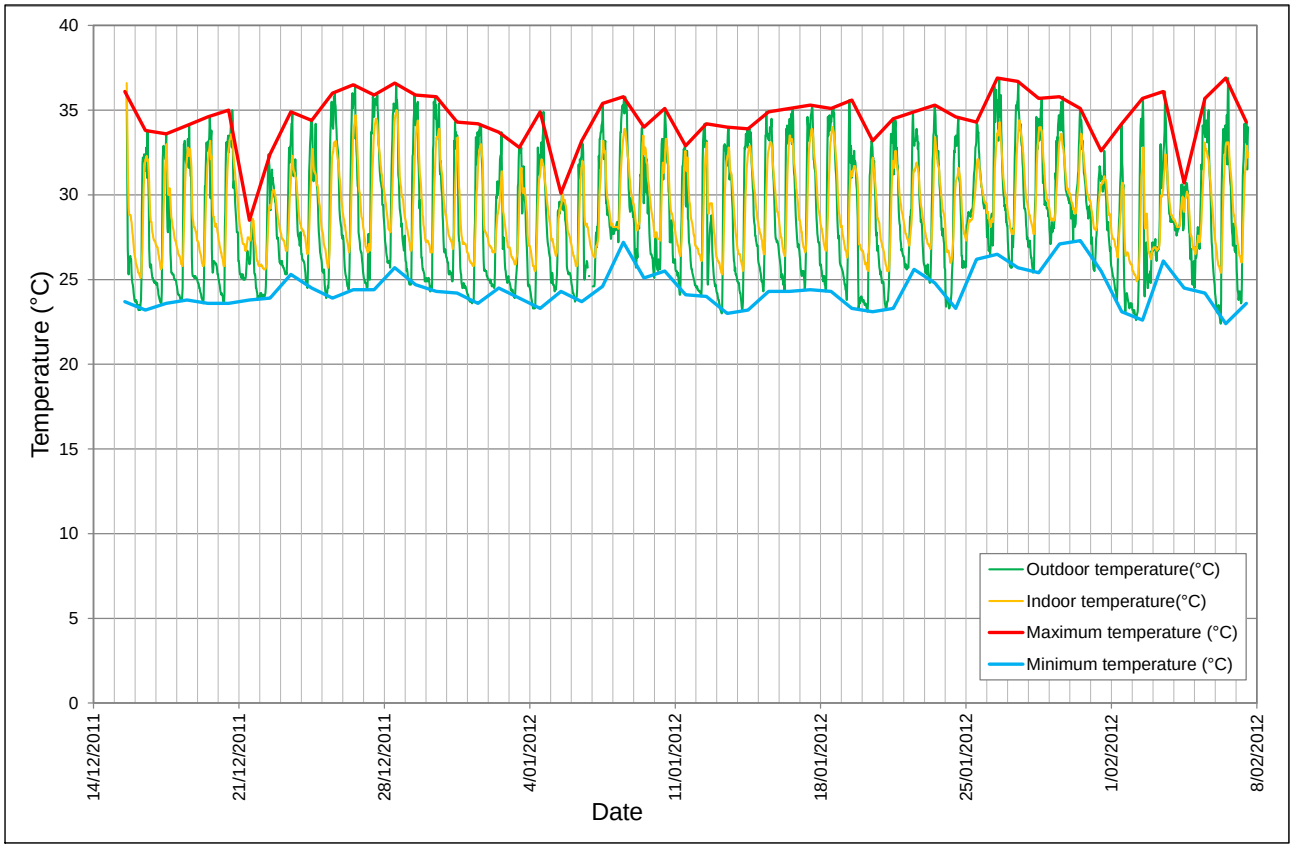

Figure 6-1 Temperature Plot 1: Time series of recorded data

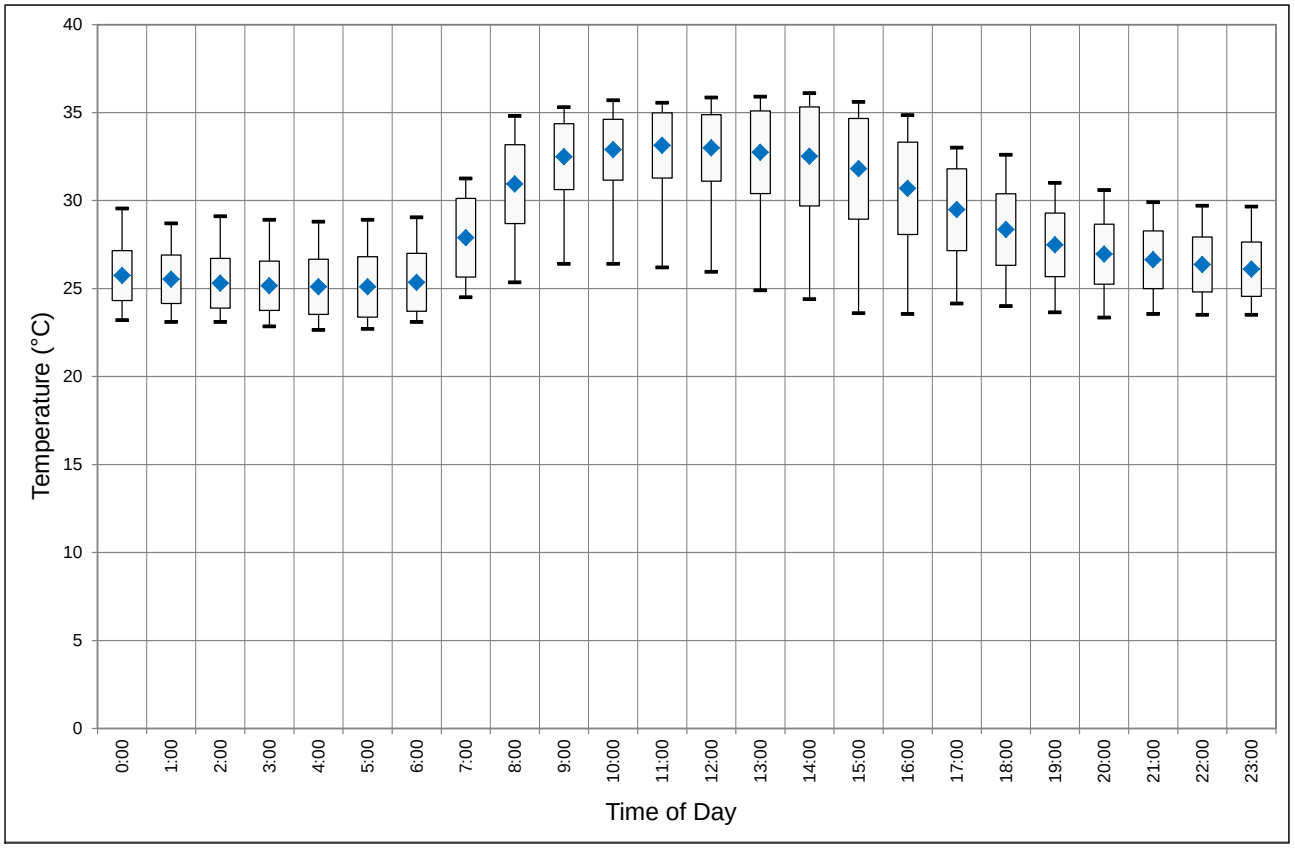

Figure 6-2 Temperature Plot 2: Daily temperature profile

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TASI MANE PROJECT – SUAI SUPPLY BASE ENVIRONMENTAL IMPACT ASSESSMENT

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Figure 6-1
Figure 6-2

LOCATION: \\perworfil1\infstructb\Projects\301012-01504 Enviro Imp Assessment Timor-Leste\2.0 Reports\2.1 EIA- Suai\Figures\03_Working\F060_F062\

PLOT DATE AND TIME: 8 May 2012, 2:01 PM

Creator: Courtenay Wheeler

Table 6-2 Maximum and minimum recorded daily temperatures

Date	Temperature (°C)		Date	Temperature (°C)		Date	Temperature (°C)	
	Maximum	Minimum		Maximum	Maximum		Maximum	Maximum
15/12/11	36.1	23.7	03/01/12	32.8	23.9	22/01/12	34.9	25.6
16/12/11	33.8	23.2	04/01/12	34.9	23.3	23/01/12	35.3	24.8
17/12/11	33.6	23.6	05/01/12	30.1	24.3	24/01/12	34.6	23.3
18/12/11	34.1	23.8	06/01/12	33.2	23.7	25/01/12	34.3	26.2
19/12/11	34.6	23.6	07/01/12	35.4	24.6	26/01/12	36.9	26.5
20/12/11	35.0	23.6	08/01/12	35.8	27.2	27/01/12	36.7	25.7
21/12/11	28.5	23.8	09/01/12	34.0	25.1	28/01/12	35.7	25.4
22/12/11	32.4	23.9	10/01/12	35.1	25.5	29/01/12	35.8	27.1
23/12/11	34.9	25.3	11/01/12	32.9	24.1	30/01/12	35.1	27.3
24/12/11	34.4	24.5	12/01/12	34.2	24.0	31/01/12	32.6	25.5
25/12/11	36.0	23.9	13/01/12	34.0	23.0	01/02/12	34.2	23.1
26/12/11	36.5	24.4	14/01/12	33.9	23.2	02/02/12	35.7	22.6
27/12/11	35.9	24.4	15/01/12	34.9	24.3	03/02/12	36.1	26.1
28/12/11	36.6	25.7	16/01/12	35.1	24.3	04/02/12	30.7	24.5
29/12/11	35.9	24.7	17/01/12	35.3	24.4	05/02/12	35.7	24.2
30/12/11	35.8	24.3	18/01/12	35.1	24.3	06/02/12	36.9	22.4
31/12/11	34.3	24.2	19/01/12	35.6	23.3	07/02/12	34.3	23.6
01/01/12	34.2	23.6	20/01/12	33.2	23.1			
02/01/12	33.7	24.5	21/01/12	34.5	23.3			

6.2.4 Relative Humidity

Relative humidity is one of several measures used to describe the amount of moisture in the atmosphere, and is the ratio of the actual amount of moisture in the atmosphere to the maximum amount that could be held, at a given temperature. Both (CSIRO, 2010) and (Keefer G.D., 2000) report that the south coast of Timor-Leste is marginally more humid than the north coast and that with increasing altitude, humidity decreases. As the Suai study area is on the south-western coastline, it is expected that the humidity measurements represent some of the highest in the country.

Very little seasonal variation is evident from analysis of the Ministry of Agriculture data (2012). The maximum daily relative humidity is frequently above 90% throughout the year. The minimum daily relative humidity varies considerably more than the maximum and is in the range of 40% to 75%.

The time series for indoor and outdoor relative humidity and a daily humidity profile for the monitoring period are presented in Figure 6-3 and Figure 6-4. The time series data and the daily profile show that the measured outdoor relative humidity is consistent the Ministry of Agriculture data (2012), not falling below 45% over the entire monitoring period and frequently ranging above 90% for a significant proportion of the day. On average, the humidity would fall to a minimum slightly below 60% at 11:00 a.m. and then steadily climb to above 85% by midnight.

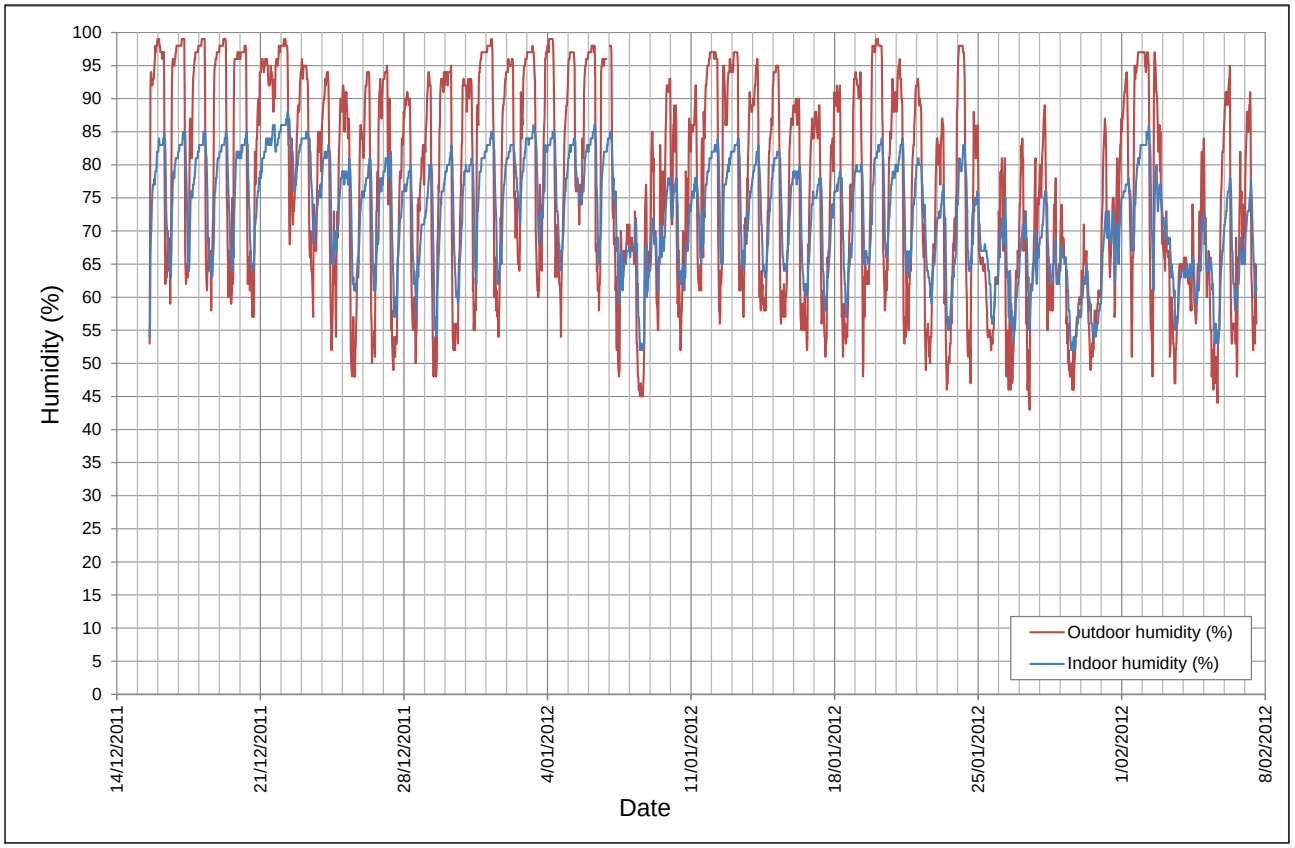

Figure 6-3 Humidity Plot 1: Time series of recorded data

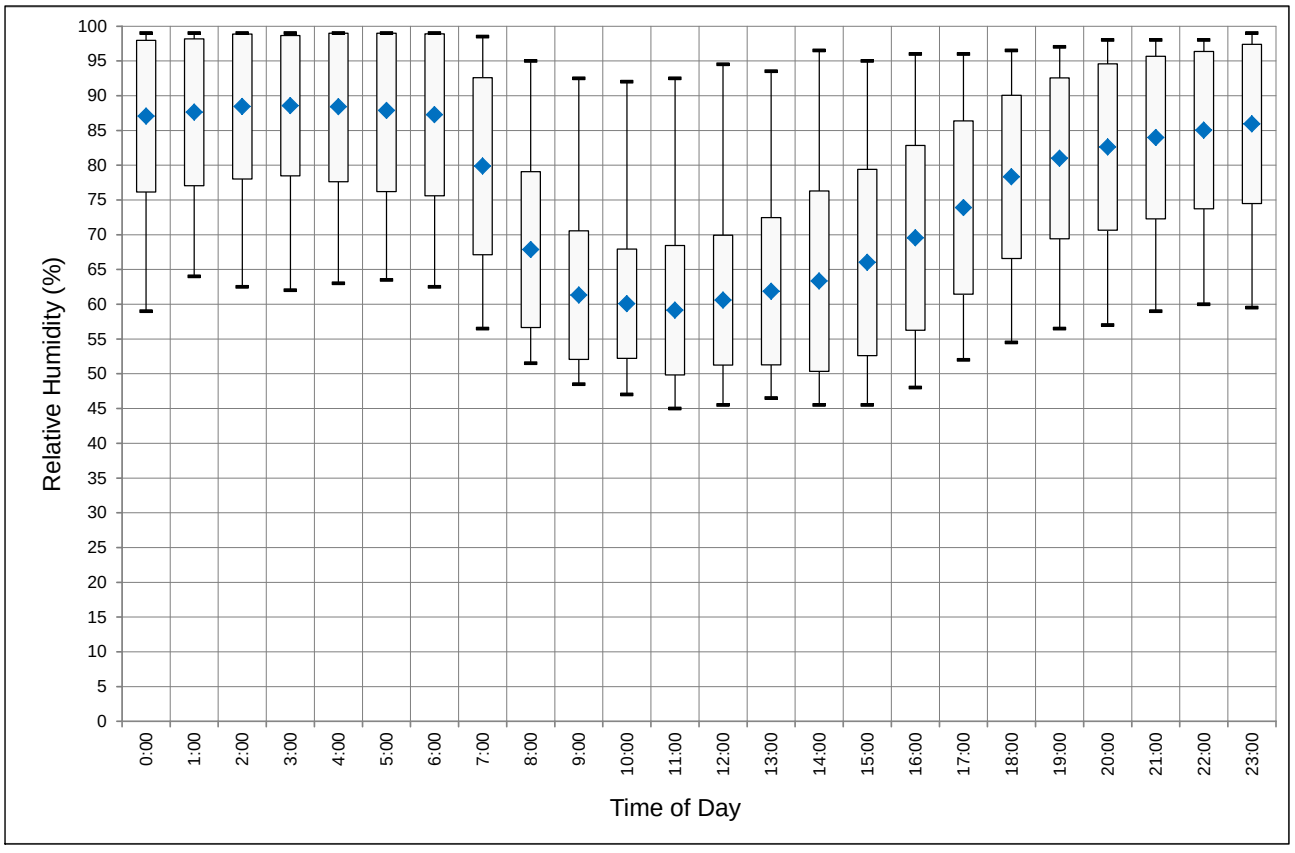

Figure 6-4 Humidity Plot 2: Daily humidity profile

REV	DATE	REVISION DESCRIPTION	DRN	CHK	DES	ENG	APPD	CUST	PROJECT: 301012-001504
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Figure 6-3
Figure 6-4

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PLOT DATE AND TIME: 4 May 2012, 5:26 PM

Creator: Courtenay Wheeler

6.2.5 Rainfall and Evaporation

The rainfall patterns for Timor-Leste are primarily influenced by Asian monsoon patterns. The southern part of the country experiences the Southern Bimodal Rainfall Pattern which provides seven to nine wet months with two peaks, one from December and the other from May (CSIRO, 2010). The variability of rainfall is considerable. Typically, lower-lying areas experience lower total rainfall compared to the higher altitude areas. There are several exceptions to this general trend across the country but, the Suai study area is not considered one of them. It was observed during the field work that a large proportion of the rainfall events occur as torrential downpours. As the field work was conducted during December, recognised as a peak rainfall period, the observations made for the rainfall events are considered to be representative of monsoonal downpours.

The daily total rainfall over the monitoring period spanning 15 December 2011 to 7 February 2012 is presented in Figure 6-5. Several rainfall events greater than 20 mm in one day were recorded during the monitoring period. By far the heaviest rainfall occurred during the first day of recording. As the rainfall event started prior to the commencement of the monitoring period, it is likely that the total rainfall for 15 December 2011 is actually greater than the measured 57 mm. Table 6-3 shows the rainfall measured over the monitoring period.

Table 6-3 Daily rainfall measurements

Date	Rainfall (mm)	Date	Rainfall (mm)	Date	Rainfall (mm)
15/12/2011	57	03/01/2012	20.32	22/01/2012	0
16/12/2011	12	04/01/2012	6.54	23/01/2012	0.6
17/12/2011	5.1	05/01/2012	11.16	24/01/2012	18
18/12/2011	10.2	06/01/2012	19.2	25/01/2012	0.3
19/12/2011	12	07/01/2012	0	26/01/2012	0
20/12/2011	3.9	08/01/2012	0	27/01/2012	0
21/12/2011	13.2	09/01/2012	3.6	28/01/2012	0
22/12/2011	0	10/01/2012	0	29/01/2012	0
23/12/2011	0	11/01/2012	15	30/01/2012	0
24/12/2011	0	12/01/2012	21.3	31/01/2012	0
25/12/2011	0	13/01/2012	0	01/02/2012	9
26/12/2011	1.5	14/01/2012	0.22	02/02/2012	0.9
27/12/2011	0	15/01/2012	0.38	03/02/2012	0
28/12/2011	0	16/01/2012	0	04/02/2012	0.9
29/12/2011	1.8	17/01/2012	0	05/02/2012	0
30/12/2011	0.3	18/01/2012	0.6	06/02/2012	0.3
31/12/2011	24.9	19/01/2012	24.3	07/02/2012	0
01/01/2012	0.9	20/01/2012	0		
02/01/2012	6.3	21/01/2012	0		

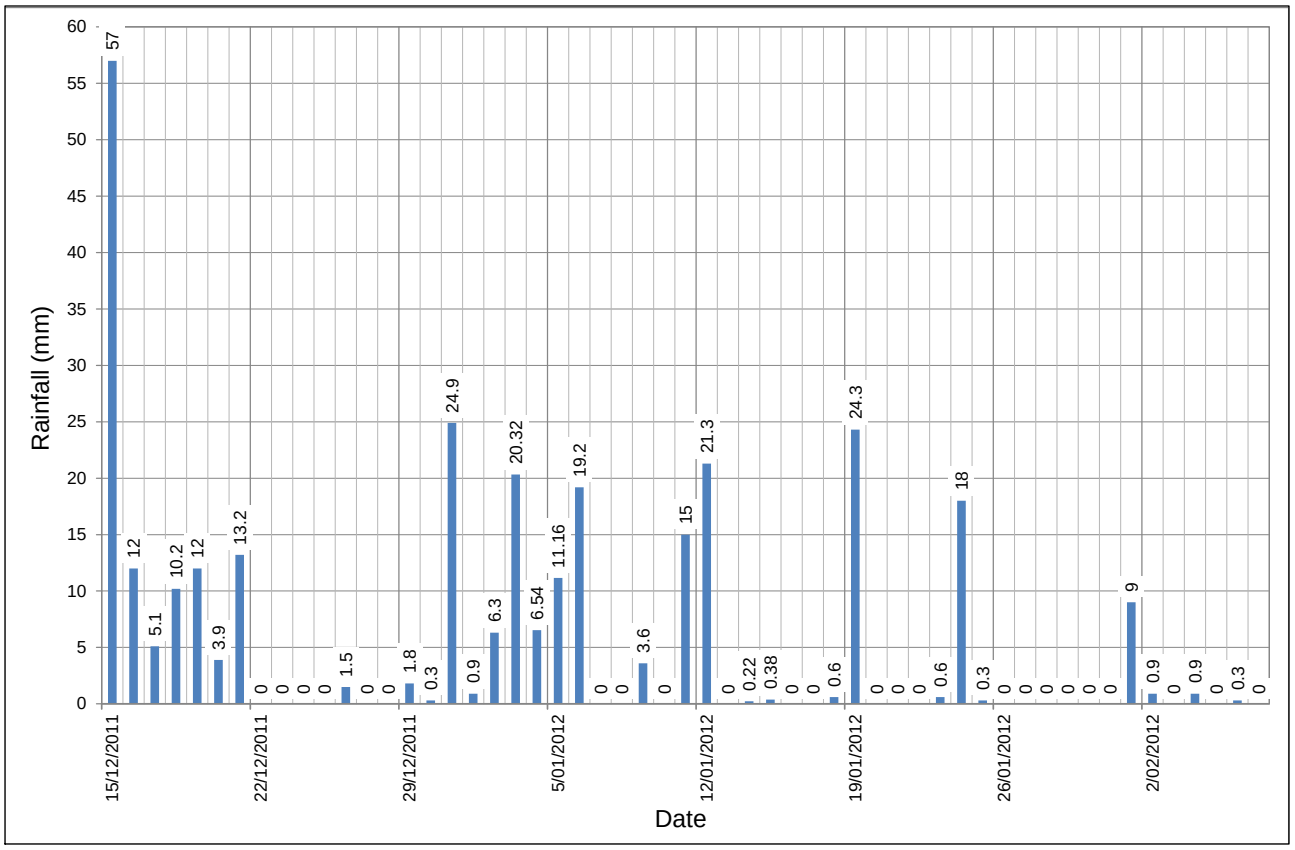

Figure 6-5 Rainfall Plot: Total daily rainfall recorded

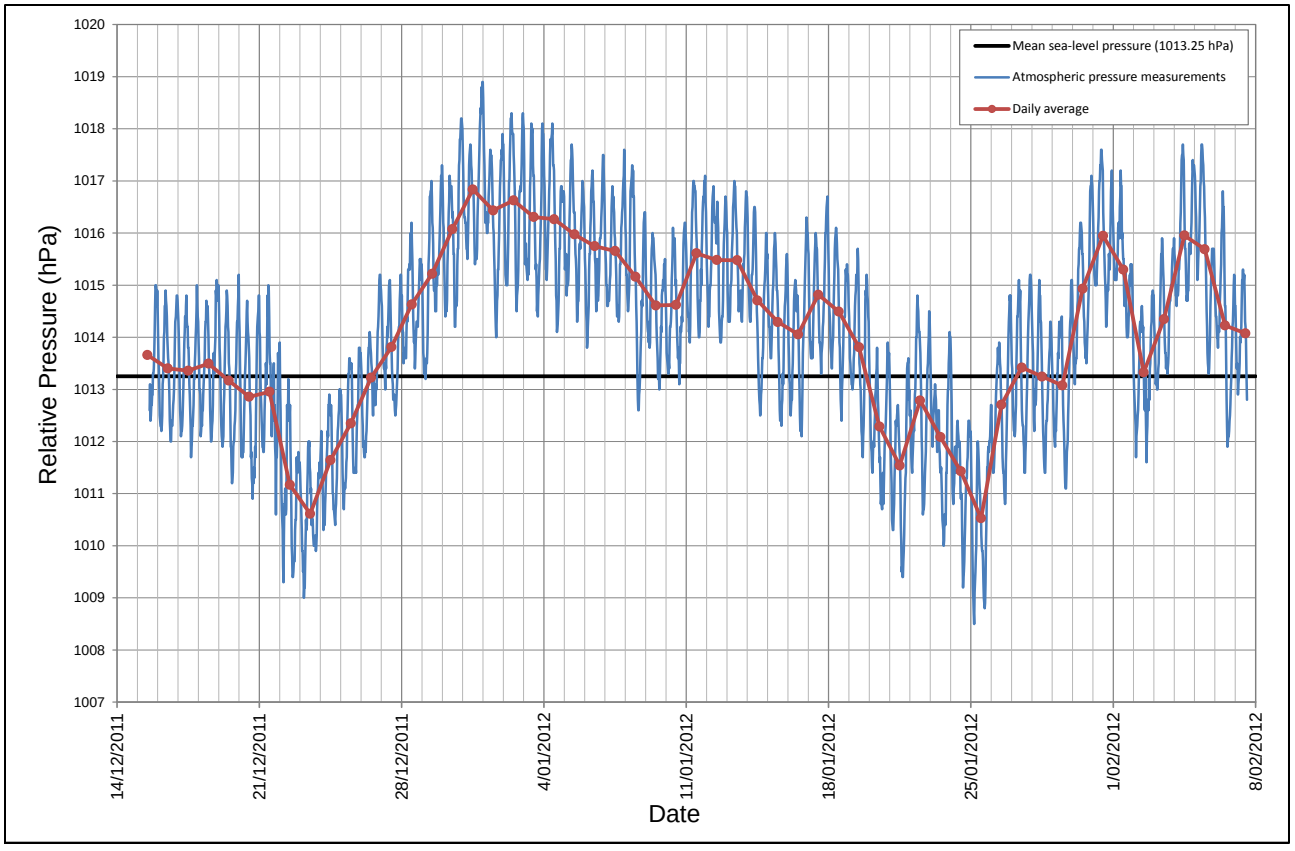

Figure 6-6 Pressure Plot: Time series of recorded data

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Figure 6-5
Figure 6-6

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PLOT DATE AND TIME: 4 May 2012, 5:29 PM

Creator: Courtenay Wheeler

Evaporation rates were not measured over the monitoring period as this was beyond the capability of the installed meteorological stations. However, the following results are reported in CSIRO (2010):

- *In the lowlands, the monthly evaporation ranges from 60 to 230 mm while in the highlands it is 100 to 190 mm per month.*
- *The average daily potential evaporation was in the range of 5.2 to 6.5 mm in the lowlands and 2.6 to 4.9 mm in the midlands.*

6.2.6 Relative Pressure

Relative atmospheric pressure is the measure of the force exerted by the weight of the air above an area on the surface of the Earth adjusted to sea-level altitude. Relative pressure is fundamental in describing climatic patterns for a region. The measured relative pressure in Figure 6-6 shows two separate trends: the synoptic behaviour related to the migration of high- and low-pressure cells across the wider Australasian region; and the diurnal (daily) variation about the mean.

The synoptic-level trends are presented by examining the daily average relative pressures presented in Table 6-4. A general decline in pressure occurred between the 15 December and 23 December 2011. After this period, a rapid increase in pressure occurred until the 31 December 2011. The pressure generally declined again over most of January until 25 January 2012. From this point until the end of the monitoring period on the 7 February 2012, the pressure increased again and then experienced an oscillation over a five-day period.

The diurnal pressure oscillates in a sinusoidal pattern between local maxima and minima on a 12 hour cycle. Daily minima occur at approximately 3:00 a.m. and 3:00 p.m. and daily maxima occur at approximately 10:00 a.m. and 10:00 p.m. The daily variation in pressure is on average 3.6 hPa, this oscillation is representative of ‘atmospheric thermal tidal patterns’ based on the 24 hour solar heating/cooling cycle. In general, the measured relative pressure over the Suai study area is representative of the tropical Australasian region.

Table 6-4 Daily average relative pressure measurements

Date	Average Relative Pressure (hPa)	Date	Average Relative Pressure (hPa)	Date	Average Relative Pressure (hPa)
15/12/2011	1013.7	03/01/2012	1016.3	22/01/2012	1012.8
16/12/2011	1013.4	04/01/2012	1016.3	23/01/2012	1012.1
17/12/2011	1013.4	05/01/2012	1016.0	24/01/2012	1011.4
18/12/2011	1013.5	06/01/2012	1015.7	25/01/2012	1010.5
19/12/2011	1013.2	07/01/2012	1015.7	26/01/2012	1012.7
20/12/2011	1012.9	08/01/2012	1015.2	27/01/2012	1013.4
21/12/2011	1013.0	09/01/2012	1014.6	28/01/2012	1013.2
22/12/2011	1011.2	10/01/2012	1014.6	29/01/2012	1013.1
23/12/2011	1010.6	11/01/2012	1015.6	30/01/2012	1014.9
24/12/2011	1011.6	12/01/2012	1015.5	31/01/2012	1015.9
25/12/2011	1012.3	13/01/2012	1015.5	01/02/2012	1015.3
26/12/2011	1013.2	14/01/2012	1014.7	02/02/2012	1013.3
27/12/2011	1013.8	15/01/2012	1014.3	03/02/2012	1014.3
28/12/2011	1014.6	16/01/2012	1014.1	04/02/2012	1016.0
29/12/2011	1015.2	17/01/2012	1014.8	05/02/2012	1015.7
30/12/2011	1016.1	18/01/2012	1014.5	06/02/2012	1014.2
31/12/2011	1016.8	19/01/2012	1013.8	07/02/2012	1014.1
01/01/2012	1016.4	20/01/2012	1012.3		
02/01/2012	1016.6	21/01/2012	1011.5		

6.2.7 Wind Speed and Direction

A major factor that influences local wind speed and direction trends is the topography and land use of the region. The Suai development area and the surrounding coastal region are low-lying and have reasonably flat terrain, with elevations at approximately 50 m and local peaks around Nova Suai up to 100 metres above sea level. Inland, at distances of approximately 5 km, the terrain becomes mountainous with elevations rapidly increasing to greater than 1,000 m above sea-level. Predominant use of the low-lying land in the region is agricultural with large regions of jungle vegetation. The height of the jungle canopy can result in increased turbulence and therefore decreased wind speed near ground-level where the meteorological station was established.

Historic wind speed or direction data for the Suai study area was not available in the literature review. Therefore, the wind rose presented in Figure 6-7 represents data collected from the monitoring period only (December 2011 – February 2012). The wind rose shows that wind direction varied significantly during the monitoring period. The relatively even distribution of wind direction between north and south-east across the western arc indicates that a prevailing wind direction cannot be determined for this period. The average wind speed was less than 0.5 m/s for most of the recorded hours (62.35%) and a significant proportion of the winds greater than 0.5 m/s were less than 2 m/s. This indicates that

a very high proportion of the recorded winds are low speed. It is possible that the local vegetation in the region shielded the meteorological station from the higher wind speed events.

During the field work, it was observed that regions directly on the coast experienced typical diurnal onshore/offshore wind oscillations with low wind speeds.

Figure 6-8 presents wind roses for the Dili airport, Baucau and the three study areas: Suai, Betano and Beaco. For Dili, available data spans the period for July 2008 to October 2011. For Baucau, available data spans the period for January to October 2011. For the three study areas the data spans each monitoring period:

- Suai study area: 15 December 2011 to 7 February 2012.
- Betano study area: 12 December 2011 to 13 February 2012.
- Beaco study area: 12 December 2011 to 14 February 2012.

For the Dili region, the annual wind rose shows that for all winds measured, approximately 20% are blowing from the south-east and another 20% are blowing from the south-southeast. The predominant south-easterly winds have typically lower speeds ranging up to 5 m/s whereas; winds from the northern arc have been recorded to range up to 10 m/s.

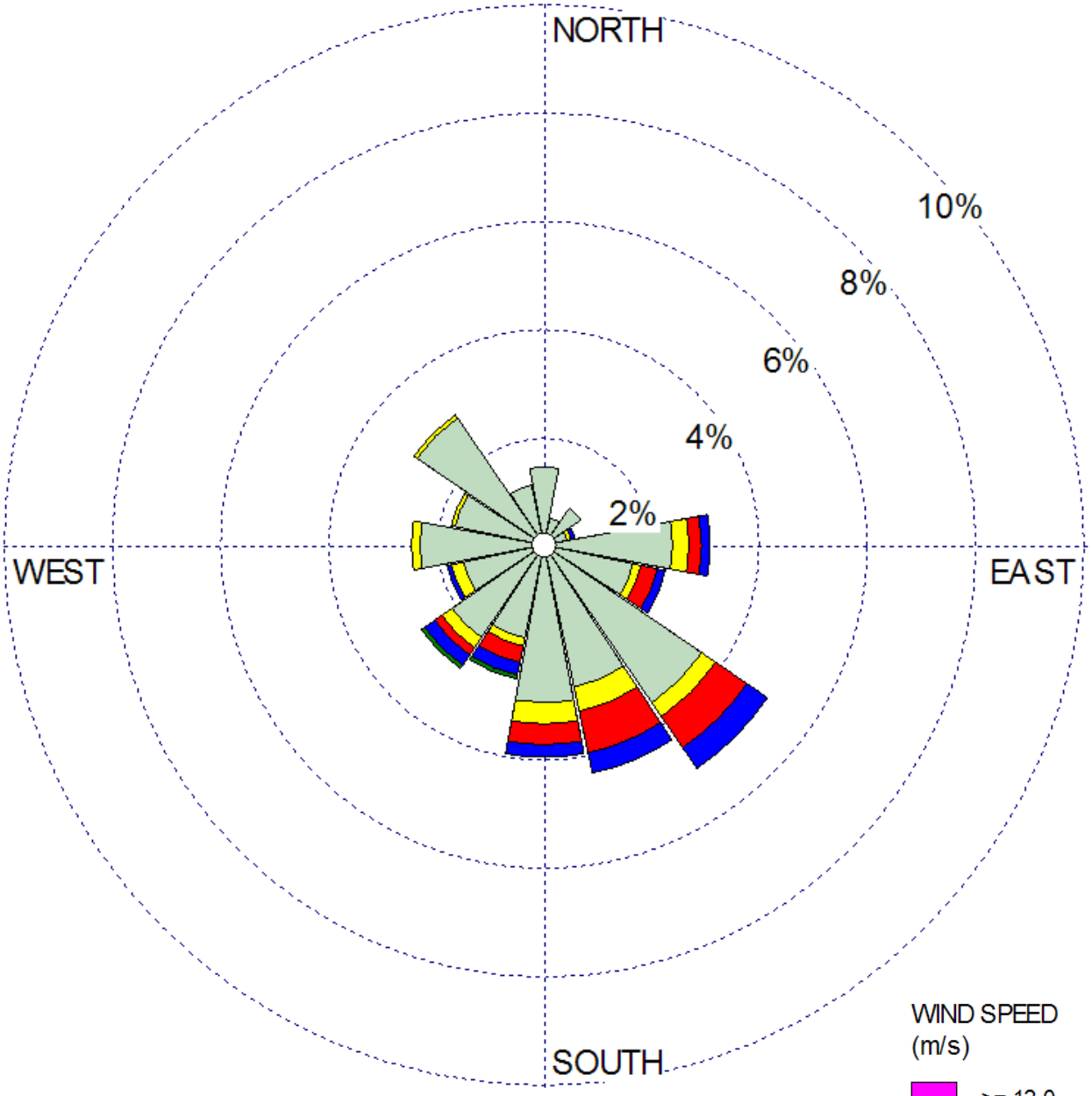
Recorded winds for the Baucau region were only measured on an 8 point compass scale and averaged over an entire day. As such the data is only indicative of generalised wind proportions recorded during 2011. Similar to the Dili region, a high proportion of winds ranging up to 5 m/s were recorded to blow from the south-east.

For both the Beaco and Betano semi-automated meteorological stations a high proportion of winds were measured to blow from the east or north-west respectively. For Betano, this reflects the trend shown across some of the sites of winds predominantly blowing from the landmass to offshore. In contrast the Beaco data indicates a predominant wind blowing from offshore to the landmass.

6.2.8 Extreme Weather Events

The primary source of extreme weather events in the general vicinity of Timor-Leste are tropical cyclones. Tropical cyclone events typically result in strong winds and heavy rainfall and can potentially cause widespread flooding and damage to property if they encounter inhabited areas. The major climatological cycle that regulates the formation of tropical cyclones in the Timor Sea is the ENSO. Tropical cyclones form from thunderstorms over the ocean when favourable conditions are present. Some of the required conditions are listed below:

- Warm ocean temperature (greater than 26.5°C).
- High relative humidity in the lower and middle troposphere (lower atmospheric layer).
  - High humidity reduces the evaporation in the clouds and maximizes the latent heat released from the moisture due to the increased precipitation.
- Poor vertical wind shear (change in wind direction with altitude).



WIND SPEED (m/s)

- >= 12.0
- 10.0 - 12.0
- 8.0 - 10.0
- 5.0 - 8.0
- 3.0 - 5.0
- 2.0 - 3.0
- 0.5 - 2.0

Calms: 62.35%

REV	DATE	REVISION DESCRIPTION	DRN	CHK	DES	ENG	APPD	CUST	PROJECT: 301012-001504
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Figure 6-7
Suai wind rose for recorded data

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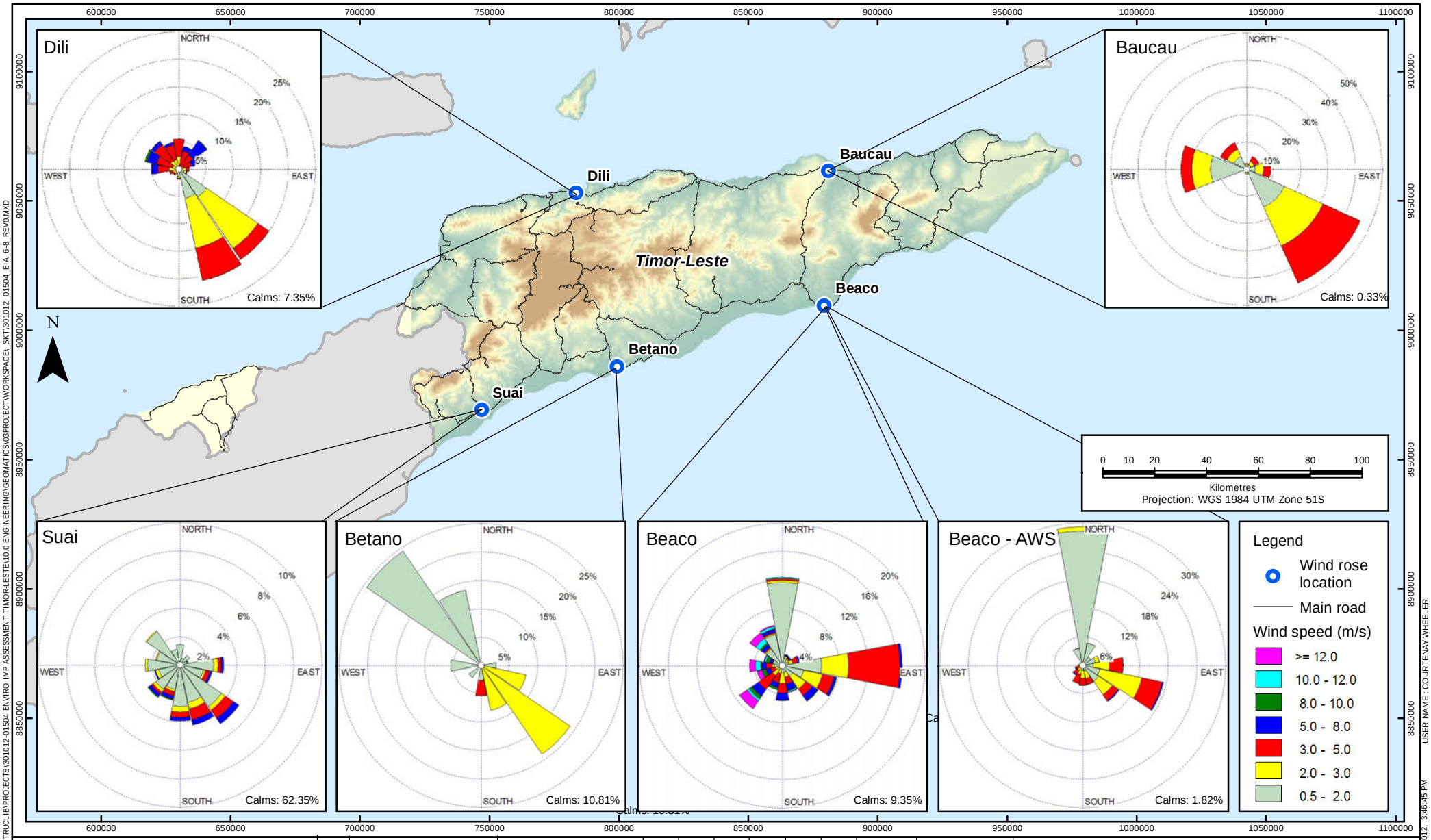

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PLOT DATE & TIME: 07 MAY 2012, 3:46:45 PM

USER NAME: COURTENAY.WHEELER

NOTES:
This map consists of:
1. DEM: SRTM (2011)
2. Rivers: Geographic Information Group TimorLeste (2010)
3. Roads: DivaGIS (2010)
4. Wind roses: WorleyParsons (2012)

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Figure 6-8
Timor-Leste wind roses

Tropical cyclones have their characteristic rotation due to the Coriolis Effect brought about by the rotation of the Earth and in the southern hemisphere, cyclones rotate clockwise.

A search of the Australian Bureau of Meteorology Australian Tropical Cyclone database (http://www.bom.gov.au/clim_data/IDCKMSTM0S.csv) which has data on all recorded cyclones in the southern hemisphere since 1906 revealed that 12 tropical cyclones travelled within a 200 km radius, with 3 of these tropical cyclones passing within a 100 km radius of the Suai study area between 1906 and 2012. These cyclones are listed in Table 6-5 below. The paths for the cyclones within a 100 km radius of the Suai study area are presented in Figure 6-9. (CSIRO, 2010) also reports that in April of both 1918 and 1919, cyclones passed in close proximity to the southern coast of Timor-Leste; however, their exact locations could not be determined. Cyclonic weather patterns were not observed in the Suai study area during the monitoring period. However, tropical cyclonic activity (Tropical Cyclone Grant) occurred off the coast of the Australian Northern Territory between 21 and 31 December 2011.

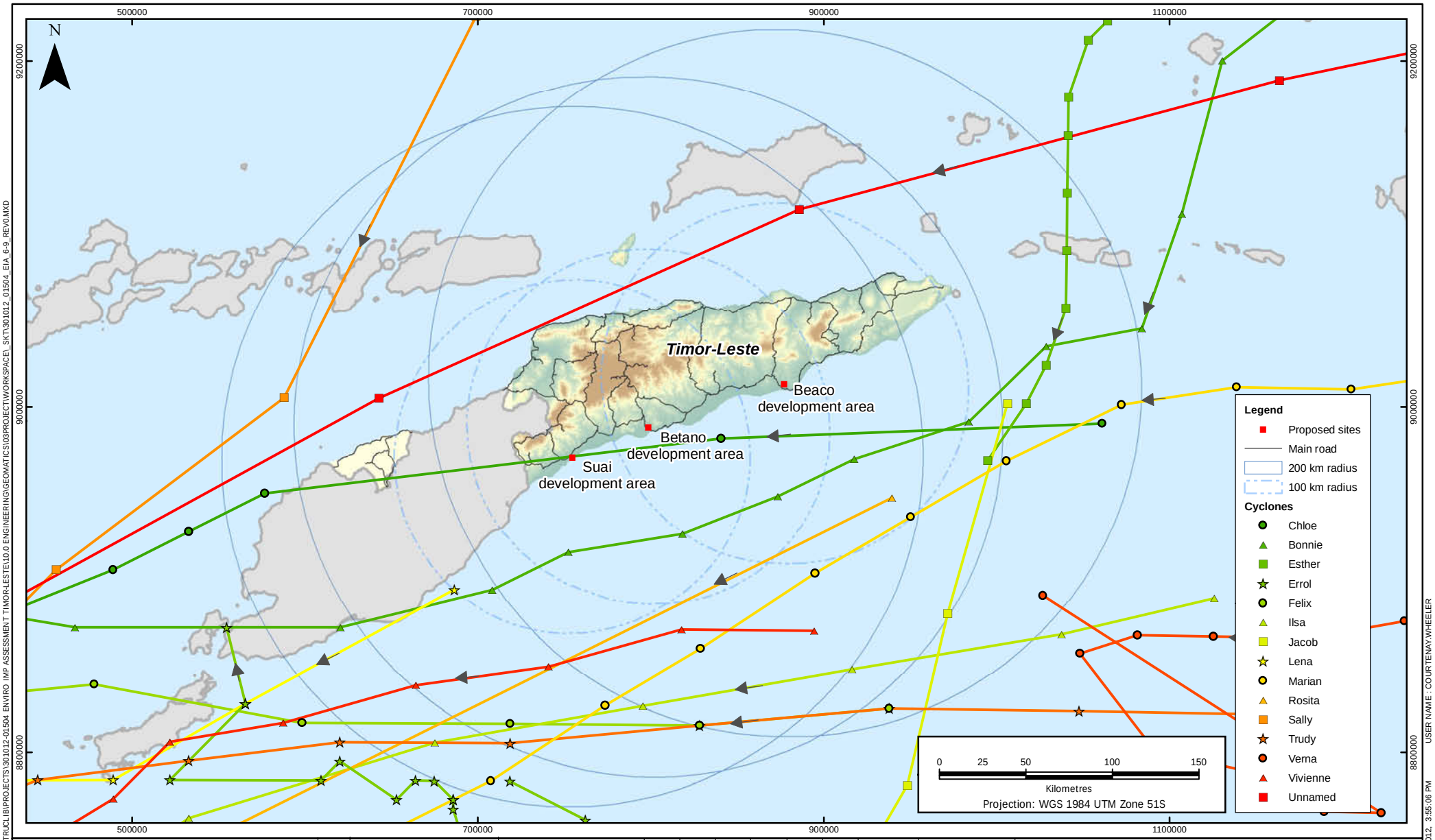
Cyclonic activity in the vicinity of Timor-Leste primarily occurs during the monsoonal wet season focussing around the two maximum rainfall peak periods, December and late April/May.

Table 6-5 Historic tropical cyclones near Suai study area

200 km Radius of Suai		100 km Radius of Suai	
Date Range	**Cyclone Name**	**Date Range**	**Cyclone Name**
6 – 13 April 1920	Unnamed #4	2 – 9 April 1983	Lena
3 – 11 December 1971	Sally	3 – 8 April 1995	Chloe
10 – 16 January 1978	Trudy	7 – 15 April 2002	Bonnie
22 – 31 December 1980	Felix		
2 – 9 April 1983	Lena		
9 – 19 April 1991	Marian		
6 – 12 April 1994	Vivienne		
3 – 8 April 1995	Chloe		
14 – 20 April 2000	Rosita		
7 – 15 April 2002	Bonnie		
15 – 24 March 2009	Ilsa		
12 – 18 April 2011	Errol		

Thunderstorm activity was observed frequently during the site investigation. Storm activity occurred on a near-daily basis in the afternoon to early evening during the rainfall downpours in the highlands. Thunder and lightning was observed to occur regularly, however lightning strikes to ground-level were rare during the site investigation.

Due to the torrential nature of the rainfall in the monsoonal wet season, there is a risk of flooding of river beds in the development area. The Suai study area is defined to be in a high flood risk region due to the low-lying nature of the topography. No information was available regarding specific flooding events in the Suai study area.



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USER NAME: COURTENAY.WHEELER

PLOT DATE & TIME: 07 MAY 2012, 3:55:06 PM

NOTES:
This map consists of:
1. DEM: SRTM (2011)
2. Rivers: Geographic Information Group TimorLeste (2010)
3. Roads: DivaGIS (2010)
4. Cyclone tracking data: Bureau of Meteorology (2012)

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Figure 6-9
Timor-Leste cyclone tracks

6.3 Impacts of Weather Patterns and Extremes of Climate on the Project

When designing and constructing the Suai Supply Base, particular regard should be given to the historical weather patterns and climate extremes. Several meteorological effects will need to be addressed including climate change and cyclone/severe storm events.

The meteorological parameters of concern related to climate change are: sea level, cyclone intensity, rainfall and extreme wind speed. Within the timescale of the development (20 to 30 years), climate change projections in (CSIRO, 2010) indicate that:

- Sea levels are to rise.
- Cyclone frequency is to reduce but, intensity is projected to increase.
- Extreme rainfall events are to become fewer but, more intense, with similar trends projected for extreme wind speeds.

These projections are inherently uncertain and by nature are subject to change; however, as the development is located in a coastal region, the engineering design will need to take into account the projected rise in sea level over the lifespan of the development.

Cyclone and severe storm events are likely to be the most important factors to be considered throughout the project lifespan. As cyclones are known to potentially cause widespread damage to property and endanger human life, it is recommended that a cyclone management plan is developed covering both the construction and operational phases of the Suai development.

Lightning can also pose a safety risk for site personnel, especially during the construction phase where tall metal structures or machinery can attract lightning strikes. It is recommended that a policy is developed in the cyclone management plan regarding reaction to lightning storms.

As the Suai development includes maritime facilities and areas adjacent to the ocean, the effects of high-energy waves need to be considered. These waves may interfere with construction and/or operation activities and potentially pose a safety risk to site personnel. It is also recommended that the cyclone management plan incorporates a construction and operational policy for high-energy waves.

Soil erosion from flooding or high rainfall events also has the potential to affect project infrastructure by subsidence of foundations. This has the potential to affect the project schedule for both the construction and/or operational phases as well as posing a potential safety risk for site personnel.

6.4 Avoidance, Management and Mitigation Measures

The recommended cyclone management plan typically should include, but not be limited to, the following:

- Potential cyclone identification methods and warning systems.
- ‘Warning’, ‘Alert’ and ‘All Clear’ communication methods for workers and the local populace.

- Cyclone-proofing for temporary structures/objects that are at risk of damage.
- Construction and operational policies for lightning strikes and high energy waves.
- Lockdown procedures, describing methods to secure all structures, vehicles and maritime vessels.
- Emergency action plans and evacuation procedures.
- Distress notification methods if additional aid is required.
- Allowance for increased precipitation intensity in the design of water affected infrastructure.

Recommendations for the avoidance, management or mitigation of soil erosion effects, sedimentation, stormwater flow and waste containment are provided in the Topography, Geology and Soils (Chapter 8), Hydrology, Drainage, and River Water Quality (Chapter 11), and Waste Management (Chapter 17) chapters of this document.

6.5 Further Work

Adequate, long-term meteorological monitoring of the study area will be of benefit to SERN and the GoTL, as well as the local community. It will aid in restoring the meteorological network established across Timor-Leste in the early 20th century, provide meteorological information to service aviation traffic at the Suai Airport, and provide input information for various environmental studies as well as providing a valuable information source to agricultural workers for planning and optimising crop yields. It is recommended that the automated weather station (AWS) in the Suai study area be upgraded to provide a more complete dataset than that currently recorded. The upgrade should be conducted in accordance with (AS 3580.14-2011) *Methods for sampling and analysis of ambient air Part 14: Meteorological monitoring for ambient air quality monitoring applications*, or an equivalent guideline. It is also recommended that the following parameters be continuously monitored and averaged on an hourly basis by the AWS:

- Station identification number.
- Date and time of record/observation.
- Air, wet bulb and dew point temperatures.
- Precipitation and evaporation.
- Relative humidity.
- Wind speed and direction.
- Solar radiation.
- Barometric pressure (relative, absolute and QNH {Barometric pressure adjusted to sea level for aviation purposes}).
- Visibility.
- Cloud cover.
- Cloud ceiling height (if practicable).

Some requirements of the above parameters listed in (AS 3580.14-2011) are provided in Table 6-6 below.

Table 6-6 Minimum requirements for meteorological monitoring instrumentation

Parameter	Units	Minimum Requirements		
		Range	Resolution	Accuracy
Wind speed	m/s	0.5 to 30 m/s	≤0.25 m/s	1% or 0.2 m/s*
Wind direction	Degrees to True North	0 to 360°	1°	±3°
Temperature	°C	-10 to 50°C	0.1°C	±0.3°C
Relative humidity	% ratio	5 to 100%	1%	±2% (10 to 90%) ±4% (90 to 100%)
Solar radiation	W/m^2	-	-	±30 to 50 W/m^2
Atmospheric pressure	hPa	750 to 1050 hPa	1 hPa	±3 hPa
Precipitation	mm (or mm/hour)	0 to 400 mm/hour	0.5 mm	±5% (0 to 120 mm/hour)

Note: * Whichever is the greater value.

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Tasi Mane Project – Suai Supply Base Environmental Impact Assessment

CHAPTER 7
LAND USE AND VISUAL AMENITY

301012-01504-EN-REP-0003
May 2012

7 LAND USE AND VISUAL AMENITY

Land use compatibility and changes to visual amenity associated with the Suai development have been identified as issues with the potential to adversely impact surrounding communities.

Currently there are no specific assessment standards or legislation in Timor-Leste addressing landscape and visual impact. In the absence of specific legislation, this preliminary assessment has been carried out using a method in general accordance with *The Guidelines for Landscape and Visual Impact Assessment (2002) Second Edition*, published by the Landscape Institute (LI) and the Institute of Environmental Management and Assessment (IEMA) (United Kingdom), with some minor modifications to reflect the site's Timor-Leste context.

Similarly, in the absence of a national planning scheme that would define preferred land uses in discrete zones, current and future land use compatibility could not be compared at this stage.

7.1 Study Method

This study was designed to undertake a preliminary land use and visual amenity impact assessment of the project. The scope for this study is to:

- Consider how the changes in land use may affect the broader area of Suai, with a more detailed approach for the Suai development area. This includes a discussion of the local topography and landscape, and a description of the compatibility of the current and future land use.
- Conduct a high-level visual amenity assessment of the Suai development area, based on the information available, to consider changes in views experienced by people observing the landscape.

The study method proposed for this assessment is summarised as follows:

- Desktop study: undertake a literature review to identify GoTL or other relevant assessment standards, and understand the prevailing land uses in the Suai development area.
- Site reconnaissance: The Suai development area was visited between 13 and 16 December 2011 with the aim of gathering site specific data for land use and visual amenity assessment purposes, including the topographical context to inform the assessment. Topographical considerations are more formally assessed in Chapter 8 (Topography, Geology and Soils).

7.1.1 Literature Review

As mentioned, the IEMA guidelines have been adopted in order to define the study method. The IEMA guidelines are internationally recognised guidelines that provide advice on assessing the landscape and the visual impacts of development projects.

The following guidance documents have also been referenced for this study:

- *Guidance on the New Approach to Appraisal*. Department of the Environment, Transport and the Regions, 1998. A New Deal for Trunk Roads in England; and
- *Guideline for involving visual & aesthetic specialists in EIA processes*, Cape Town: CSIR, Provincial Government of the Western Cape, Department of Environmental Affairs & Development.

7.1.2 Site Visit

The site visit was undertaken between 13 and 16 December 2011 to gather site specific data for the project from a land use and visual amenity perspective. The objectives of the site visit were to:

- Identify the location and sensitivity of visual impact receptor sites for the project; and
- Gather baseline photographs from the visual receptor locations.

The site visit also included the assessment of aesthetic values (such as viewsheds, coastal vistas) and cultural values; these included:

- Religious and ceremonial significances (e.g. churches, graveyards);
- Traditional and indigenous significance sites (e.g. shrines); and
- Architectural significance (e.g. Traditional and Portuguese forts, offices and houses), as shown in Plate 7-1.

7.1.3 Land Use

The land use aspect of this assessment has been informed by a desktop review of relevant literature and aerial photography, GIS data obtained from the Timor-Leste GIS portal, websites and recent land use maps to provide an overview of the current land use. The existing land uses in and around the Suai development area were noted (access permitting) during the site visits undertaken between 13 and 16 December 2011.

7.1.4 Visual Amenity

The visual amenity aspect of this assessment considers a high level review of the likely visual sensitivity, significance of impact, and visual exposure of the Suai development. Initial information was obtained from existing GIS data during the desktop review of topography and landmarks, and supplemented by field study findings, and photographs and subsequent analysis. Visual amenity impacts relate to how changes in the views resulting from a development are experienced by people who observe that landscape. The magnitude and sensitivity of a receptor would depend on the location and duration of the view of the development. Visual impacts relate to the appearance of the changes that arise in the composition of the view which results from a change to the landscape, to the viewer's response to the changes, and to the overall effects with respect to visual amenity (LI and IEMA, 2002).

Source: Gaspar DaCosta, December 2011

Plate 7-1 Monument to Freedom Fighters, Suai

Source: Gavin Fisher

Plate 7-2 Flat coastal plain topography of the Suai Supply Base site

Visual Sensitivity

Visual sensitivity is typically defined by the duration and the nature of a view. For example, the longer the duration of the view and the more potential viewers who value the view, the higher the level of perceived visual sensitivity. It also relates to the degree of discord of the new view compared to the existing. The degree of discord of the Supply Base and industrial estate with the tropical agrarian setting would be very high, compared to an existing industrialised setting.

The degree of sensitivity is subjective and reflects the attitude of the viewer to a view. Residential land users and medical institutions are often regarded as having a higher visual sensitivity, as opposed to commercial areas for which day-to-day operations are less focussed on the fulfilment of visual amenity. High sensitivity to a view can also result from a short duration of exposure to the view but for a large numbers of potential viewers, for example from a public road or recreational space. The extent of the potential impact for this assessment has been considered objectively according to the sensitivity of the receptor, taking into account potential mitigation measures to consider any residual impact. The identified viewpoints were assessed in the following order of sensitivity (adapted from LI and IEMA, 2002).

- High Sensitivity
- Medium to High Sensitivity
- Medium to Low Sensitivity
- Low Sensitivity

Visual Impact Significance

In the absence of Timor-Leste standard or any other more comparative guideline, the significance of the visual impact of the project has been assessed at a high level, according to the following scale (adapted from DETR 1998):

- Substantial adverse or beneficial
- Moderate adverse or beneficial
- Slight adverse or beneficial
- Neutral

Although there are no recognised Timor-Leste standards and guidelines for determining the significance of visual impact, there is a need to assign significance to this assessment, where possible, for a more consistent method of evaluating visual impact. This is particularly given that a detailed viewshed analysis could not be undertaken at this stage, due to the lack of detailed contour baseline data available and three-dimensional design model of the proposed built structures.

Visual Exposure

Visual exposure refers to the relative visibility of a project or feature in the landscape. Exposure and visual impact tend to diminish exponentially with distance. The exposure is classified as follows (adapted from Oberholzer 2005):

- **High exposure** – dominant or clearly noticeable.
- **Moderate exposure –** recognisable to the viewer.
- **Low exposure** – not particularly noticeable to the viewer.

7.2 Existing Environment

With the exception of the existing Suai Airport, the Suai development area is currently a largely rural area with a concentration of houses along the main roads, and otherwise scattered housing across farming land with a mixture of tree crops (coconuts, teak) and crops such as corn. This is set against a backdrop of mountains rising to the north and the Timor Sea to the south.

7.2.1 Landscape Setting

The topography of Timor-Leste is dominated by the Ramelau mountain range located along the central axis of the island with heights up to 3,000 m above sea level. The mountain range is dissected by deep valleys prone to flash floods. Towards the northern side, the mountains almost extend to the sea without extensive coastal plains. However, on the south coast, the mountains gently slope towards the sea, leaving a wide littoral plain that is more suitable for agriculture (Plate 7-2). The plain is generally between 20 km and 30 km wide running almost the length of Timor-Leste, widening in the east.

The steeply sloping lands generally lie beneath shrubs and grasses with minimal forest cover, as shown in Plate 7-3. Dry and wet arable lands are mainly used for production of food crops including irrigated and rainfed rice. These areas mainly occupy the gently sloping areas of the coastal plains, former river beds and deltas, plateaus and small inland valley floors (da Costa *et al.* 2003).

7.2.2 Land Use

Agriculture is the single largest land use in Timor-Leste, accounting for approximately 24% of the total land area. Subsistence farming (Plate 7-4) and rotational cropping is relied upon by the majority of rural communities in Timor-Leste (Bouma and Kobryn 2002).

Farmers depend on rainfed agriculture, growing corn, cassava and other tuberous crops. Corn was probably introduced into Timor by Europeans in the seventeenth century, and being well suited to the ecology of the island it constitutes a staple of the Timorese diet. Rice is grown in irrigated fields, and where possible has been introduced to the river valleys (Ormeling 1957).

Source: Unknown

Plate 7-3 Steeply sloping lands in the mountainous terrain north of Suai

Source: Gavin Fisher and Joana Fernandes

Plate 7-4 Small scale subsistence agriculture in the Suai coastal plain

It is understood that deforestation is mainly due to fuel wood collection, livestock grazing, and clearing for agricultural use particularly near the flatter, coastal areas. During the site visit, coffee plants were often seen growing beneath larger trees in forested areas. Rice and corn crops were noted to be the most common agricultural activities, and no intensive agricultural areas were apparent. Varieties of farm animals were observed during the site visit and were not usually confined to any one area. Livestock observed included cattle, water buffalo, dogs, horses, donkeys, goats, pigs and chickens.

During the site visit it was noted that the majority of the Suai development area comprises agricultural land used for subsistence farming and natural landscape. The current, dominant negative cover for the development sites is shrub, mixed forest, dry forest, forest and croplands. The primary crops grown were corn, cassava, peanuts, long beans, papaya, watermelon and bananas. Trees in the Suai development area include mango, coconut, teak, kapok, sago and banana. A large area established for rice cultivation within the Suai Supply Base site is now no longer used.

A burgeoning population has resulted in increased competition for natural resources and land use is intensifying. This has seen a reduction in forest and woodland areas, which was observed during the site visit for this assessment.

There are two major watercourses, Rio Raiketan to the east and Rio Camanasa to the west, within the Suai development area. The predominant land use in the catchments of the two streams is agriculture, with natural forests retained in the upper catchments and other areas that are too rugged for agriculture.

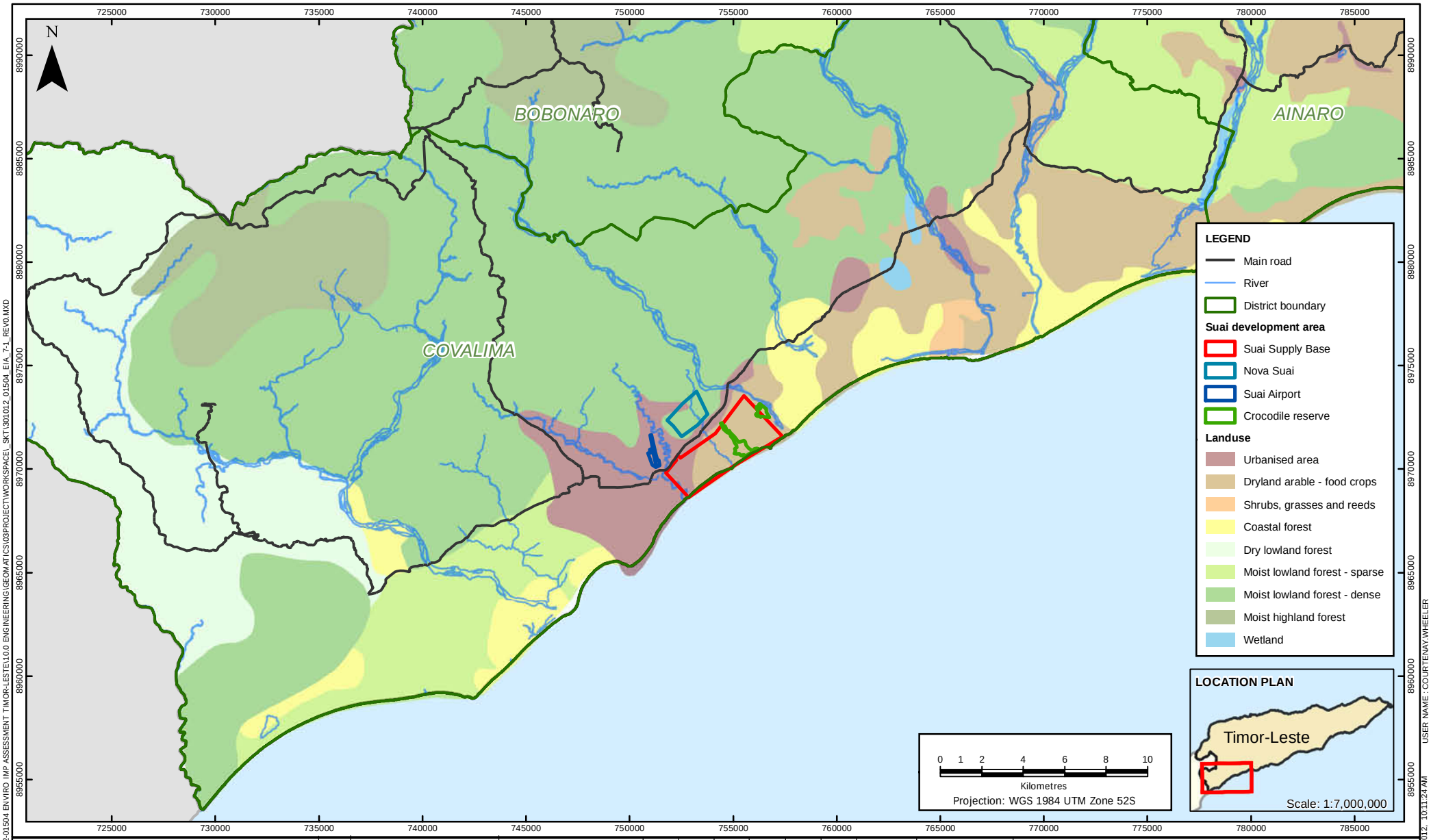
During the site visit, it was also noted that scattered dwellings (associated with farming) were in the vicinity of the proposed Supply Base. The identified land uses in and around the Suai development area are shown in Figure 7-1.

7.2.3 Visual Amenity

Timor-Leste can be broadly divided into six ecological regions; namely, the mountainous areas, highland plains, moist lowland areas, arid lowland areas, coastal areas and urban areas (Metzner 1977).

The coastal landscape of the south coast of Timor-Leste is highly diverse with high aesthetic values. This is primarily due to the mountainous nature of the area inland, the steep coastal gradients, long isolated beaches and interspersed rocky headlands. The coastline is characterised with intact coastal vistas and mountain-sea landscapes.

A series of photographs (Plate 7-5 to Plate 7-25) were taken from many vantage points along existing roads and vehicle tracks during the December 2011 site visit which provide a record of the existing environment from a visual amenity perspective. The locations of these photographs are shown in Figure 7-2.



NOTES:

This map contains:
1. Rivers: Geographic Information Group TimorLeste (2010)
2. Roads: DivaGIS (2010)
3. Landuse: Pacific Disaster Center (2010)
4. District boundaries: Geographic Information Group TimorLeste (2010)

REV	DATE	REVISION DESCRIPTION	DRN	CHK	DES	ENG	APPD	CUST
0	9/05/2012	FINAL FOR ISSUE	MW	GF	CW	-	GH	-

A4 SHEET | SCALE 1:250,000

PROJECT No: 301012-001504

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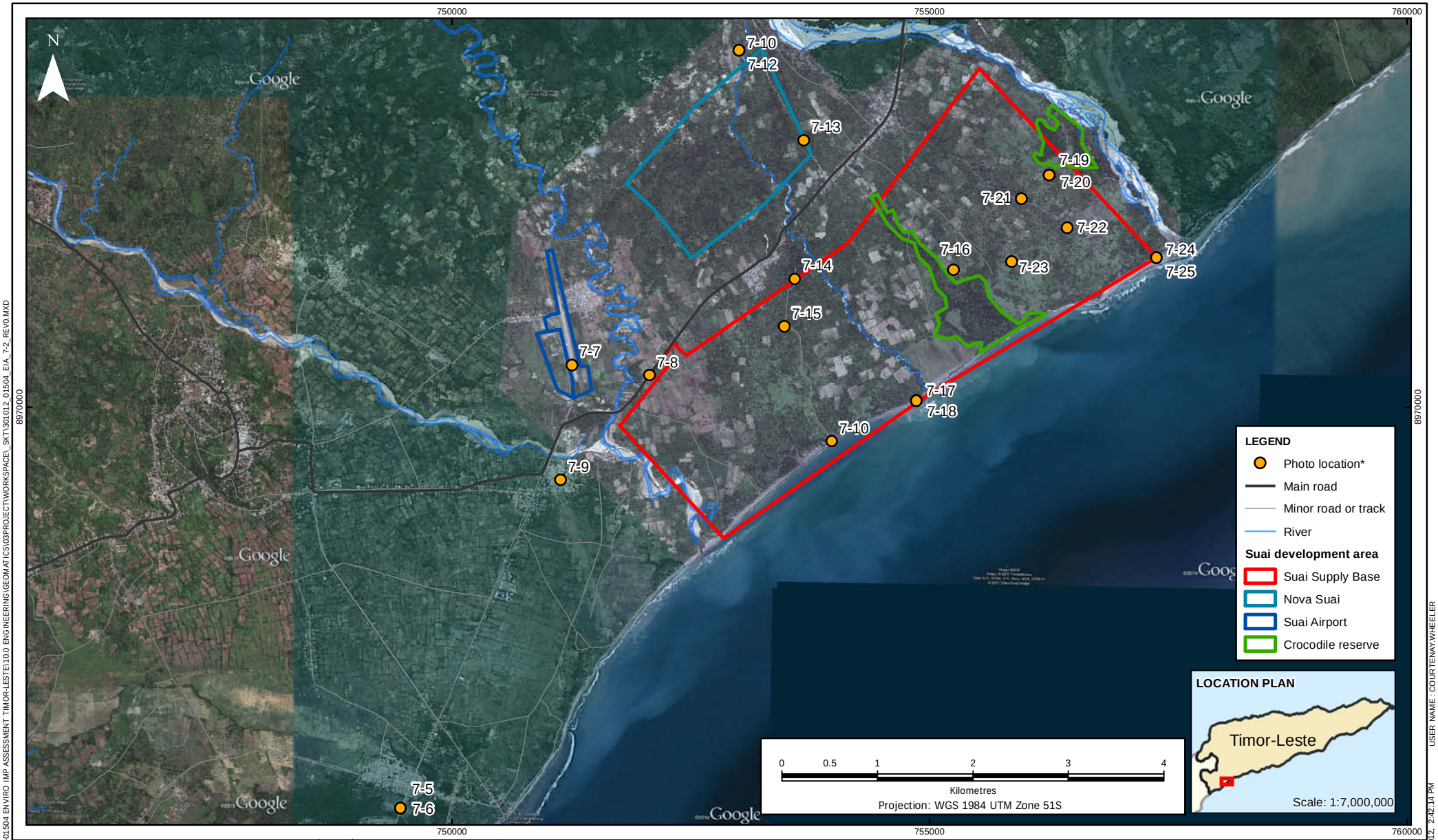
Figure 7-1
Typical agricultural land uses in the Cova Lima district

LOCATION: I:\PROJECTS\301012-01504 ENVIRO IMP ASSESSMENT TIMOR-LESTE\110.0 ENGINEERING\GEOMATICS\03PROJECTWORKSPACE_SKT\301012_01504_EIA_7-1_REV0.MXD

USER NAME: COURTENAY.WHEELER

PLOT DATE & TIME: 09 MAY 2012, 10:11:24 AM



LOCATION: I:\PROJECTS\301012-01504 ENVIRO IMP ASSESSMENT TIMOR-LESTE\110.0 ENGINEERING\GEOMATICS\03PROJECT\WORKSPACE_SKT\301012_01504_EIA_7-2_REV0.MXD

USER NAME: COURTENAY.WHEELER

PLOT DATE & TIME: 07 MAY 2012, 2:42:14 PM

NOTES:
This map consists of:
1. Imagery: DigitalGlobe (2008-2011)
2. Imagery: Google Earth (2010)
3. Rivers: Geographic Information Group TimorLeste (2010)
4. Roads: DivaGIS (2010)

*Photo locations correspond to Plates 7-5 to 7-25

REV	DATE	REVISION DESCRIPTION	DRN	CHK	DES	ENG	APPD	CUST
0	9/05/2012	FINAL FOR ISSUE	MW	GF	CW	-	GH	-

A4 SHEET | SCALE 1:54,500

PROJECT No: 301012-001504

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TASI MANE PROJECT - SUAI SUPPLY BASE ENVIRONMENTAL IMPACT ASSESSMENT

Figure 7-2

Suai development area photo locations

Plate 7-5 on Figure 7-2 (looking south)

Plate 7-6 on Figure 7-2 (looking east)

Plate 7-7 on Figure 7-2

Plate 7-8 on Figure 7-2 (looking north)

Plate 7-6 on Figure 7-2

Plate 7-10 on Figure 7-2 (looking north-east)

Plate 7-11 on Figure 7-2 (looking south)

Plate 7-12 on Figure 7-2 (looking west)

Source: Gavin Fisher, 2011

Plate 7-13 on Figure 7-2 (looking west)

Plate 7-14 on Figure 7-2

Plate 7-15 on Figure 7-2 (looking south-east)

Plate 7-16 on Figure 7-2 (looking west)

Plate 7-17 on Figure 7-2

Plate 7-18 on Figure 7-2 (looking west)

Plate 7-19 on Figure 7-2 (looking north)

Plate 7-20 on Figure 7-2 (looking east)

Source: Gavin Fisher, 2011

Plate 7-21 on Figure 7-2 (looking east)

Plate 7-22 on Figure 7-2 (looking north-west)

Plate 7-23 on Figure 7-2

Plate 7-24 on Figure 7-2 (looking west)

Plate 7-25 on Figure 7-2 (looking north-west)

Source: Gavin Fisher, 2011

7.3 Environmental Impacts

7.3.1 Change in Land Use

The Suai development is expected to introduce a new style of industrial activity to the largely rural landscape setting that is currently characterised by low-intensity agricultural land use and fishing activities. The development is will result in a permanent change to the landscape and existing land uses.

The Suai Supply Base and industrial estate will introduce new and unprecedented land use to the region. This change in land use, combined with increase in industrial and commercial activities in the area, will significantly change the interaction with existing land uses in the area. The upgrade works to Suai airport and the establishment of the crocodile reserves are essentially on-going existing land uses.

The development of Nova Suai and Suai Airport upgrade works will also result in a change in land use with visible impacts on the landscape and the lifestyle of the local residents.

The planned increase in population associated with the development may result in pressure on existing land uses and potentially increase the rate of land degradation (forest clearance, erosion, water harvesting). An increase in population could increase demand for extension of cropland for increasing food production. This will require appropriate consideration as part of an environmental assessment during the detailed design stage of the project.

7.3.2 Visual Impacts

The Suai development would introduce a new development to the largely rural landscape setting which is characterised by agricultural and coastal landscapes. There are no other examples of a similar development within the region at present, either in scale or character.

The introduction of the industrial activities that comprise the Supply Base and industrial estate would change the landscape significantly from the present coastal agriculture setting.

For this reason, the potential visual impact of this aspect is considered in more detail for this assessment than for the developments of Nova Suai and the upgrade works to Suai Airport.

The project will be a new development to rural landscape characterised by low-intensity agricultural and fishing activities. There are no other examples of a similar development within the region, either in scale or character, and the development will transform part of the coastal landscape from the present subsistence agricultural landscape into a light industrial node.

The introduction of the industrial activities of the Supply Base and industrial estate to the undeveloped rural environment is expected to be a significant change the landscape. For this reason, the visual impact of this aspect is considered in more detail than for the development of Nova Suai, the industrial estate and the upgrade to Suai Airport. Establishment of the crocodile reserves will largely be achieved by protecting the existing natural environment and therefore, will not be considered further in this assessment of visual impacts.

The clearing of vegetation and earthworks activities to facilitate construction of the Supply Base and industrial estate is likely to generate the most visible impact on the landscape. The site for the Supply Base and industrial estate are vegetated, and vegetation clearance and the establishment of buildings and structures will significantly alter the visual appearance of the area. The project has a lifespan of 50 years therefore is deemed a permanent change.

Night time lighting will also be a necessary component for most aspects of the project, including security, and night operations and maintenance work. Given the limited distribution of electrical lighting in the area, light spillage during the operation of the Supply Base is likely to be significant. Some light-related impacts are also possible during construction; however, this will be of a smaller scale than the operational phase, and be temporary.

7.3.3 Visual Impact Assessment

Visual Exposure

Due to the relatively flat topography and exposed coastal location, the Supply Base and industrial estate will be highly visible from both higher vantage points and at some areas of lower terrain (e.g. local roads and settlements) in the immediate vicinity. In certain areas, existing vegetation and the topography may offer some screening (Plate 7-26).

Based on the information available to date, Nova Suai and the upgrade works at Suai Airport are expected to be located within a rural based setting with relative remoteness which, along with the topography, are expected to provide a reasonable amount of screening and therefore have a moderate to low visibility.

Sensitivity

Using the order of sensitivity outlined above, the Suai Supply Base and industrial estate is expected to have a ‘high’ visual sensitivity for settlements along the South Coast Road, which are generally located approximately 300 m to the north. The same level of significance would likely apply to users of the southern coastline (Plate 7-27) due to the scale and coastal location of the proposed structures.

The Supply Base and industrial estate is also likely to have a ‘high’ visual sensitivity for the existing residents of Suai (and the proposed Nova Suai) as well as nearby villages and settlements to the north and east. This would be again due to the scale and location of the proposed structures, particularly given the expected visibility from higher elevations and the contrast that the appearance of the development would have with the surrounding agricultural and coastal environments which are natural and visually softer landscapes.

Based on the information available to date, Nova Suai and the upgrade works at Suai Airport are likely to have a ‘medium to high’ visual sensitivity when viewed from the surrounding area.

Significance of the Impact

The intensity of the impact on the landscape from the operation of the Supply Base is likely to be ‘high’ due to the scale of the development and the prominent coastal location on relatively flat topography.

Source: Gavin Fisher

Plate 7-26 The Main South Coast Road is generally well lined by vegetation

Source: Unknown

Plate 7-27 A view of the Suai Region from the Timor Sea

In addition, the significance of the visual impact of the Suai Supply Base and industrial estate is considered to be 'substantially adverse' for most nearby settlements, including those viewers located approximately 700 m to the north and 500 m to the east. This is based on a qualitative evaluation for the visibility of the Supply Base and industrial estate development which is likely to have a 'high exposure' and 'high' sensitivity. While the visibility of the development is likely to remain in the landscape of most viewsheds, the significance of the impact to receptors is expected to be lessened with distance from the site.

Based on information available to date, the significance of the impact of Nova Suai and the upgrade work at Suai Airport is not expected to have significant visual impacts to local residents and nearby land users.

Due to the early stages of the project, the likely visual impact of the Suai development during construction has not been evaluated in this assessment.

Visibility Analysis

Maximum distance of a development is a very important factor that has to be taken into consideration in a viewshed analysis. This is , because the greater the distance, the lower the visual impact that an object can bring to the landscape depending on the size, form, texture, line and colour of it (Matos, 2001). As mentioned in Section 6.1.1 above, a detailed viewshed analysis could not be undertaken at this stage due to the lack of detailed contour baseline data available, however a calculation of the visible distance of the Supply Base from an offshore location can be estimated.

The visible distance can be calculated in nautical miles (nm) using the following equation (BHP, 2006):

Visible Distance (in nm) = 1.17 x the square root of the height (in feet)

If the height of the tallest structure is, for example 20 m (65 feet) including mountains in the background, it could be viewed from 9.4 nm offshore. Plate 7-27 shows the current view of the coastline of the Suai region from the Timor Sea. An accurate calculation is recommended at the next stage once the scale (and location) of built aspects for the complex are known.

7.4 Avoidance, Management and Mitigation Measures

In order to minimise the potential impacts on visual amenity, the strategies in Table 7-1 should be considered as part of an avoidance, management and mitigation strategy to be developed at detailed design stage of the project. This list is not exhaustive, and has been prepared to provide a guide at this early stage.

Visual amenity considerations in site design and layout combined with the application of accepted industry practice (including adoption of environmental management controls for field development activities) will minimise such impacts.

Table 7-1 Avoidance, Management and Mitigation Measures

Potential Issue	Measure	Description
Loss of screening vegetation	Retention of existing vegetation (where possible)	The retention, where practical, of existing landscape and vegetation will assist in partially screening the proposed development areas during construction and operation. Particular attention should be given to the retention of the well-established vegetation around the Suai development area. It is recommended that the visual impact from vegetation loss be given due consideration during the detailed design stage, including the retention of existing vegetation within the development area where possible.
Vegetation restoration	Restore existing vegetation (where possible)	Where it is necessary to remove existing vegetation, such as grasses and trees, the affected area should be restored to its previous or an improved state using the same or similar vegetation species. Screening the development area using indigenous vegetation will not conceal the built aspects, but it will soften the appearance and reduce the visibility.
Appearance and visual impact	Planning of vegetative screens	Further tree plantings should be implemented along the boundaries of the proposed development areas to provide a soft screen and reduce the visibility of infrastructure. In particular, screening should be planted between the proposed development areas and the adjacent local roads, and where practical, should not interfere with existing local activities and infrastructure.
Light spill	Implement a lighting strategy	Where lighting is deemed necessary, low-level lighting should be used to reduce light spill onto sensitive land uses. It is recommended that the visual impact of lighting be given due consideration during the detailed design stage, including the use of down-lighting to angle the light source, shielding, and lighting with lower lux ratings. All lighting should be kept to a minimum within the requirements of safety and efficiency.
Glare	Use of paint finishes	The use of non-reflective paints and coatings for external surfaces should be considered to reduce reflection and glare. Uncoated galvanised metallic surfaces should be avoided where possible, and the use of colours on exterior walls that will blend in with the surrounding landscape should be encouraged.

7.5 Residual Impacts

The Suai development will result in significant changes to the appearance of the landscape and existing land uses. However, if the specified avoidance and management measures are successfully implemented, the visual appearance and identified land use impacts should be reduced.

Potential residual impacts would need to be considered in more detail once an avoidance, management and mitigation strategy has been developed.

7.6 Further Work

A landscape and visual impact assessment is recommended once the project design has been confirmed, in an iterative approach to minimise any adverse impacts on visual amenity. This is particularly relevant to the Suai Supply Base and industrial estate development in terms of structure scale, site configuration (for screening), site appearance, and finishing (where possible) to reduce the impact if its appearance and blend with the landscape.

It is recommended that a vegetation management plan be developed at the next stage to minimise vegetation loss and maintain as much of the boundary vegetation as possible for soft screening of the infrastructure for the closest visual receptors. A re-vegetation strategy should also be developed at the next stage.

It is also recommended that the visual impact of lighting be given consideration at the detailed design stage of the project, including consideration of downlighting, shielding of lights and purchase of lighting with lower lux ratings

7.7 Summary

The significance of the impact of the Supply Base and industrial estate on nearby land users is likely to be ‘substantially adverse’ due to the scale, nature and location of the proposal, and the likely visibility and estimated sensitivity by sensitive receptors.

The significance of the impact of Nova Suai and the upgrade works to Suai Airport on nearby land users is likely to be ‘moderate adverse’.

This assessment provides a preliminary consideration of the potential impacts of the Suai development in terms of the changes in land use and visual amenity impacts for identified sensitive receptors. This assessment has been undertaken in accordance with published guidelines with some minor modifications to reflect the Timor-Leste context.

Further assessment would need to be undertaken to determine the extent to which potential impacts could be avoided, managed and/or mitigated, and subsequent consideration of potential residual impacts.

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CHAPTER 8
TOPOGRAPHY, GEOLOGY AND SOILS

301012-01504-EN-REP-0003
May 2012

8 TOPOGRAPHY, GEOLOGY AND SOILS

8.1 Study Method

A preliminary geological and engineering geological assessment has been made for the Suai development area. The scope of the assessment is:

- Subject the Suai development area to a geological and engineering geology overview, including a description of the prevailing topography, geomorphology, underlying hard rock geology and overlying superficial / soft sediments (soils), as well as soil/geology and vegetation associations. This has been achieved through a combination of desktop study and site walkover.
- Briefly assess the soil profile within the Suai development area through excavation of a limited number of test pits. The soil profile in each test pit would be logged with the aim of describing the physical attributes of the soil and associated broad engineering geological characteristics (including soil erosion potential). Representative soil sampling was also to be undertaken for environmental chemical testing.
- Assess the prevailing geo-hazards within the Suai development area, which could potentially impact on development and the environment. Potential geohazards include expansive clay, collapsible soil, dispersive / erodible soil, compressible soils, saline/sodic soils, acid sulfate soils (ASS), karst conditions, asbestiform materials, slope instability, shallow bedrock, seismic conditions and, flooding and inundation.

Recommendations to achieve a stable and functioning post-construction landform also needed to be made.

This scope has been implemented through the following:

- Desktop study: The topography, geomorphology, geology and engineering geology has been assessed by consulting available literature and previous studies covering the Suai development area.
- Site reconnaissance: The Suai development area was visited on 13 and 14 December 2011 with the aim of assessing the study sites and planning the fieldwork (test pitting) stage of the investigation.
- Fieldwork: Fieldwork was undertaken between 19 and 20 December 2011. A total of five test pits were excavated in the Suai development area, three at the Supply Base site and one each at Nova Suai and the Suai Airport sites. The test pit locations were pre-selected during the site reconnaissance phase and placed in accessible areas which were deemed representative of the local geology. The test pits were excavated by hand to a depth of 1.5 m below surface. They were logged according to an adapted version of the WorleyParsons' geotechnical logging system, thus facilitating description of the physical attributes of the soil and broad engineering geological characteristics (including soil erosion potential). Fifteen representative soil samples were taken from the test pits for environmental chemical testing.

- Laboratory testing: The 15 soil samples taken during the geological test pitting programme were sent to ALS Environmental in Brisbane for environmental chemical testing. ALS is an Australian National Association of Testing Authorities (NATA) accredited laboratory.
- Reporting: An internal field report collating and presenting all relevant site data was produced in the WorleyParsons' Dili office. This field data was subsequently reviewed and evaluated in Perth, culminating in the preparation of this section of the EIA.

8.1.1 Soil Chemistry Sampling

Soil chemistry sampling was conducted primarily to establish baseline soil chemical conditions across the study area. The incremental change to the soil chemical properties once the operations have been established is of primary interest and therefore the results have not been compared to assessment criteria. This will provide a measure of any impact the project operations may have on the chemical profile of the soil.

Soil chemistry samples were collected from the test pit walls at depth intervals of 0.5 m from ground level, to the base of each test pit. Topsoil samples were also collected from each test pit location except at the Suai Airport.

To avoid cross-contamination of samples, a new pair of clinical rubber gloves was worn by the field staff for each sampling event. Samples were placed into individual containers labelled with the following information:

- Unique sample identifier.
- Date and time of sample collection.
- Depth below ground level (BGL), in metres.
- Site staff name.

The list of samples collected from the Suai development area is provided in Table 8-1.

The soil samples were placed directly into a cooler box for temporary storage until they were transferred to a freezer for longer-term storage. This storage method preserves the samples by slowing the degradation due to chemical reactions associated with exposure to the atmosphere. The samples were submitted to ALS Environmental, a NATA accredited laboratory, for analysis under full chain-of-custody protocols at the end of the fieldwork programme.

The samples were subject to analysis for the following criteria:

- Physical parameters: pH; electrical conductivity; and moisture content.
- Nutrient content: total nitrogen; total Kjeldahl nitrogen (TKN); ammonia; and nitrate/nitrite compounds.
- Extractable cations: phosphorus; potassium; and sulphur.
- Total organic carbon.

Table 8-1 Collected soil chemical samples – Suai

Test Pit Number	Sampling Date	Sampling Time	Sampling Depths
Test pit Suai Supply Base I (TPSS I)	19/12/2011	1:23 p.m.	Topsoil 0.5 m 1.0 m 1.5 m
TPSS II	19/12/2011	2:00 p.m.	Topsoil 0.39 m
TPSS III	19/12/2011	3:00 p.m.	Topsoil 0.5 m 1.0 m
Test Pit Nova Suai IV (TPNS IV)	19/12/2011	2:45 p.m.	Topsoil 0.5 m 1.0 m 1.5 m
Test Pit Airport Suai V (TPAS V)	20/12/2011	11:30 a.m.	0.5 m 1.0 m

8.2 Existing Environment

8.2.1 Regional Topographic Setting

The topography of Timor-Leste is dominated by the Ramelau mountain range located along the central axis of the island with heights up to 3,000 m. The mountain range is dissected by deep valleys prone to flash floods. Towards the northern side, the mountains almost extend to the sea without extensive coastal plains. However, on the south coast, the mountains gently slope towards the sea, leaving a wide littoral plain that is more suitable for agriculture. The plain is between 20 and 30 km wide running almost the length of Timor-Leste, widening in the east. Plate 8-1 and Plate 8-2 show the typical flat coastal plain topography at the Supply Base and airport sites respectively.

8.2.2 Topography of the Development Area

The Supply Base and industrial estate are located on the coastal plain directly inland of the beach. The flat coastal plain in this area is interrupted by a few shallow rivers and drainage features, as well as swampy or marshy depressions. These depressions generally coincide with the proposed crocodile reserves. The land rises gradually northwards to the central and upper parts of the coastal plain on which the Suai Airport and Nova Suai are located, respectively.

Source: Gavin Fisher and Joana Fernandes

Plate 8-1 The entire Suai Supply Base site is situated on the flat coastal plain

Source: Gavin Fisher and Joana Fernandes

Plate 8-2 The Suai Airport site is near flat, resulting in poor surface drainage

8.2.3 Regional Geomorphology and Geological Setting

The geology of Timor-Leste comprises predominantly limestone and metamorphosed sediments overlying ancient Proterozoic basement rocks.

Several theories attempt to explain the tectonic and formational history of the island and discussion on the geological history continues. However, all theories agree that the island is composed of contributions from both the north-north-easterly moving Australian continental plate and highly deformed rocks from the Banda Terrane of the southerly moving Eurasian plate. This suggests that Palaeozoic conditions similar to that shown in the Bonaparte Gulf Basin (Northern Australia) should be present. The carbonate sedimentary rocks deposited since the Permian and the lack of non-carbonate material indicate that the area has existed as an island for a long period of time.

The underlying geology of the island has resulted in soils that are of low fertility, relatively unproductive, and susceptible to erosion. The rapid decomposition of organic matter due to the tropical climate further compounds this.

Globally, Timor-Leste is one of the most significant contributors of sediment to the world's oceans (Milliman *et al.*, 1999). Transport of sediments to the marine environment via rivers represents an important process in the global geochemical cycle and is a key component of the global denudation system (Walling & Fang, 2003). Timor, along with other islands of the Indonesian region (Sumatra, Java, Borneo, Sulawesi and New Guinea) contributes 4.2×10^9 tonnes of sediment to the ocean via rivers annually (Milliman *et al.*, 1999). Despite only representing 2% of land area, these islands contribute 20% to 25% of global sediment input (Milliman *et al.*, 1999). The magnitude of fluvial sediment flux has significant implications for the structure, function and susceptibility of surrounding near-shore coastal marine environments.

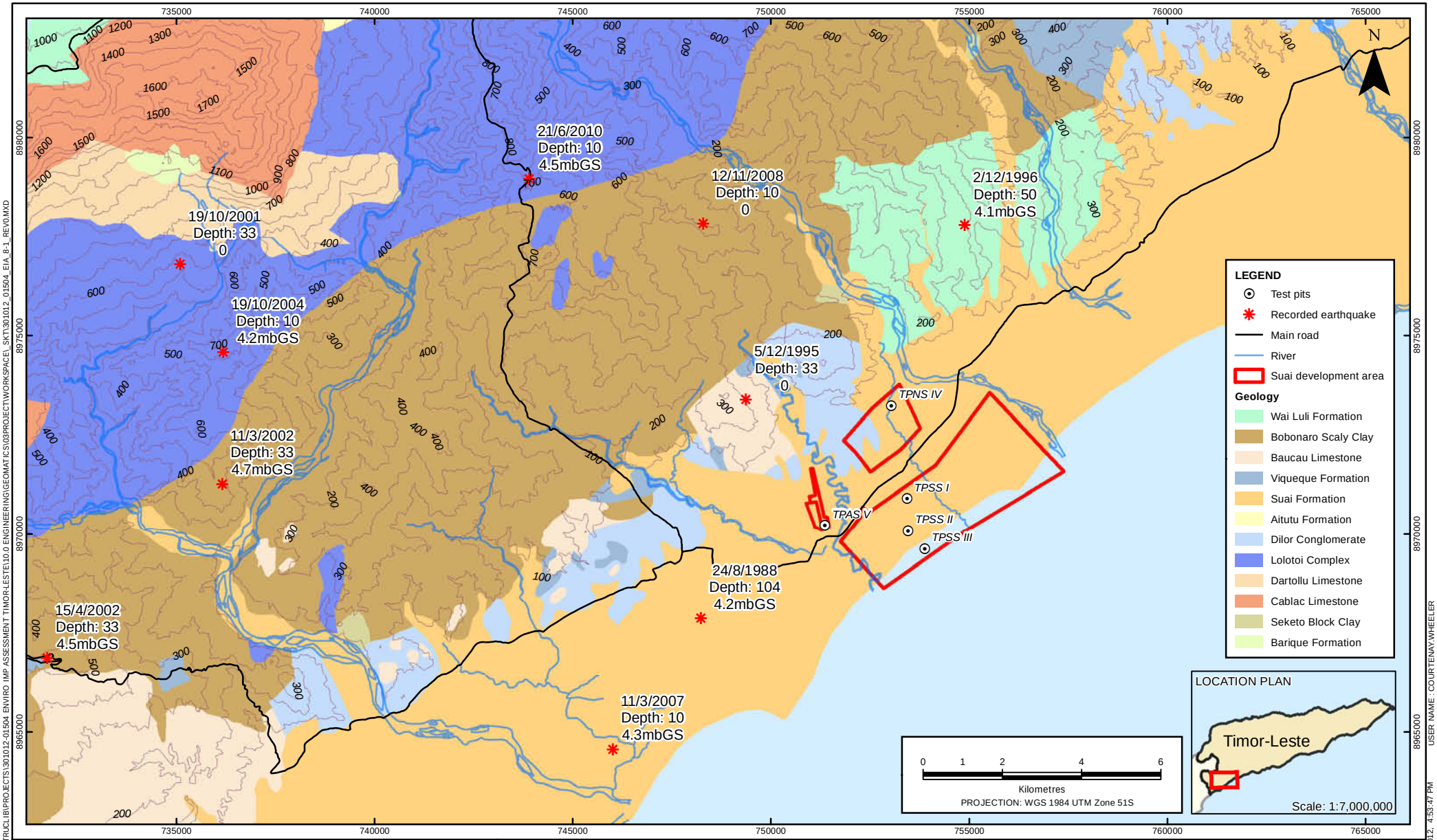
8.2.4 Geology of the Suai Development Area

Published data shows that the proposed Supply Base, industrial estate, Suai Airport and the crocodile reserves are entirely underlain by the Suai Formation, while Nova Suai is partly underlain by the Suai Formation and the Dilor Conglomerate Formation. The latter formation underlies the eastern quarter of Nova Suai (Figure 8-1).

Suai Formation

The Suai Formation overlies the Viqueque Formation and the Dilor Conglomerate. Although not studied in detail, it is expected that the base of the Suai Formation is of late Pliocene age, ranging up through to the Quaternary. This formation is developed in the wide coastal plain that extends from Aliambata in the east to the frontier with Indonesia in the west. This plain is only interrupted in the Betano area.

The Suai Formation is in excess of 600 m thick, and like the Viqueque Formation, probably thickens rapidly to the south, reaching its maximum offshore. The maximum thickness attained within the present limit of Timor is probably under the plain between Betano and Aliambata, where it may be approximately 1,000 m thick. The base is difficult to define accurately on the information available.



LOCATION: \\PERWORFILL1\INFSTRUCL\IB\PROJECTS\301012-01504 ENVIRO IMP ASSESSMENT TIMOR-LESTE\10.0 ENGINEERING\GEOMATICS\03PROJECTWORKSPACE\L SKT\301012_01504_EIA_8-1_REV0.MXD

PLOT DATE & TIME: 04 MAY 2012, 4:53:47 PM USER NAME: COURTENAY.WHEELER

NOTES:
This map contains:
1. River: Geographic Information Group TimorLeste (2010)
2. Geology: Geographic Information Group TimorLeste (2010)
3. Roads: DivaGIS (2010)
4. Earthquakes: US Geological Survey (2011)

REV	DATE	REVISION DESCRIPTION	DRN	CHK	DES	ENG	APPD	CUST
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PROJECT No: 301012-001504

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OneWay to zero harm

TASI MANE PROJECT - SUAI SUPPLY BASE
ENVIRONMENTAL IMPACT ASSESSMENT

Figure 8-1
Geology of the Suai development area

The presence of Foraminifera indicates that the Suai Formation was deposited in a marine environment. Like the upper part of the Viqueque Formation, the Suai Formation may be considered to be a molasse deposit, a regressive facies formed during the emergence of Timor.

The type locality for the Suai Formation is the coastal plain surrounding Suai village. Water bores to the north of Suai village have revealed that most of the sediments are largely unconsolidated rudites and arenites ranging from pebbly gravels to fine silts, often rich in Foraminifera. The Suai Formation is similar to the upper part of the Viqueque Formation except that consolidated sediments are absent from the Suai Formation.

The Suai Formation is generally poorly exposed and typically without relief. The beds are either horizontal or gently dipping to the south (seawards) and outcrop is mostly covered by dense vegetation.

Dilor Conglomerate

The Dilor Conglomerate is widely distributed within the southern part of Timor-Leste (the southern basin), between the River Luca and the South Laclo River, a distance of about 30 km. It has not been mapped outside this area.

The type-locality for this formation is the axis of the Dilor syncline immediately south-east of Dilor village. Within this area, and to the north-west of the village, it is about 300 m thick and comprises poorly sorted conglomerates with coarse unsorted sands that form small hills. The grain-size of these clastic deposits ranges from large boulders to silt, with most of the detritus derived from the quartzites of the Lolotoi Complex. Graded bedding is seldom seen, and in contrast to the Viqueque Formation, cross-bedding is widespread. There are many local unconformities and there is a strong increase in sorting in a southerly direction. In the type-locality and elsewhere, this formation has a dark-red lateritic cover 1 to 2 m thick. Lenses of sand and silt are found within the conglomerates.

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Outside the type-locality the Dilor Conglomerate is similar in composition, but displays a wide range of thickness, generally less than 300 m.

The formation overlies the Viqueque Formation with a slight disconformity in the type locality. Elsewhere, where it does not overly the Viqueque Formation, the Dilor Conglomerate is found to unconformably overlie a variety of formations, notably the Pleistocene Suai Formation nearby Nova Suai.

On the basis of the microfauna contained in sand and mud lenses within the Dilor Conglomerate it has been dated as Pliocene. This is in accordance with its field relations with other formations.

The textural immaturity of the boulder-beds and sands, the strong cross-bedding, absence of graded bedding, and lenticular bodies of sand and mud containing the microfauna, all suggest that this formation represents a marine deltaic deposit. The deltas formed along the southern side of the rising island when crustal movements rapidly regenerated the sub-aerial topography and folded the Viqueque Formation towards the end of the Pliocene. Like the underlying Viqueque Formation, the Dilor Conglomerate is a regressive facies.

Soil Profile

A total of five test pits were excavated in the Suai development area, three at the Supply Base site and one each at Nova Suai and the Suai Airport sites. The locations of the test pits were pre-selected during the site reconnaissance phase and placed in accessible areas deemed to be representative of the local geology. The test pits were excavated by hand to a depth of 1.5 m below surface and confirm the published geology. Test pit positions are indicated on Figure 8-1. The soil profiles are summarised in Table 8-2 and depicted in Plate 8-3 to Plate 8-8. The full set of laboratory results and the quality reports are presented in Appendix C.

Table 8-2 Summarised soil profiles – Suai

Test Pit Number and Coordinates	Depth	Description
TPSS I (Suai Supply Base) X= 753435 Y= 8970886	0 to 0.75 m	GRAVELLY SAND: Medium-grained sand with some fine to medium-grained gravel, dark brown mottled grey, medium dense to dense, wet.
	0.75 to 1.5	SAND: Fine to medium-grained sand, yellow-orange-brown, dense to very dense, wet.
TPSS II (Suai Supply Base) X= 753461 Y= 8970072	0 to 0.39 m	SANDY CLAY: Medium plastic clay, dark grey-brown, stiff. Sand is fine-grained. Wet. Test pit terminated at 0.39 m due to shallow perched water table.
TPSS III (Suai Supply Base) X= 753880 Y= 8969627	0 to 1.29 m	SANDY CLAY: Medium plastic clay, dark grey-brown, firm to stiff. Sand is fine-grained. Wet. Test pit terminated at 1.29 m due to shallow perched water table.
TPNS IV (Nova Suai) X= 753037 Y= 8973219	0 to 0.5 m	SANDY CLAY: Medium plastic clay, grey-brown, firm to stiff. Sand is fine to medium-grained, moist.
	0.5 to 1.5 m	GRAVELLY CLAY: Medium plastic clay, dark grey-brown, firm to stiff. Gravel is fine to medium-grained, sub-angular to sub-rounded in shape. Moist.
TPAS V (Suai Airport) X= 751361 Y= 8970203	0 to 0.4 m	FILL: Sandy clayey gravel (origin unknown).
	0.4 to 1.5 m	SANDY CLAY: Medium plastic clay, dark grey-brown, firm to stiff. Sand is fine-grained. Wet.

Source: Gavin Fisher and Joana Fernandes

Plate 8-3 Test pit TPSS I

Source: Gavin Fisher and Joana Fernandes

Plate 8-4 Test pit TPSS II showing the shallow perched water table conditions

Source: Gavin Fisher and Joana Fernandes

Plate 8-5 Test pit TPSS III

Source: Gavin Fisher and Joana Fernandes

Plate 8-6 Test pit TPNS IV

Source: Joana Fernandes, 2011

Plate 8-7 Test pit TPAS V showing the layer of fill overlying natural ground

Source: Gavin Fisher, 2011

Plate 8-8 A near surface clayey horizon underlies parts of the coastal plain

8.2.5 Geology/Vegetation Associations

Teak (*Tectona grandis*) found in the Suai region is an indicator species for the presence of limestone or calcrete. Teak usually grows on limestone outcrop or where the limestone and/or calcrete occur at a shallow depth. Limestone is generally absent from the project area. However, the occurrences of teak on the coastal plain appear to coincide with accumulations of calcium carbonate within gravelly layers of the Suai Formation.

8.2.6 Geohazards

Significant geohazards which could effect on the Suai development area are discussed in the following section. These may influence the economics and performance of certain infrastructure or may result in environmental impacts. It should be noted that these conclusions are based on a desktop assessment referencing available published geological information and a brief fieldwork phase. Detailed geotechnical investigation will ultimately be required to confirm the presence, extent and severity of these geohazards.

Expansive Clay

Expansive clays exhibit large volume changes corresponding to changes in moisture content (swelling when wet and shrinking when dry). Such volume changes are often seasonal and can result in differential movement beneath structures. Expansive clays can also have poor handling characteristics during moisture conditioning and compacting.

The Suai development area is underlain by a well-developed clayey horizon which is part of the Suai Formation. The clay was encountered at varying depths in the test pits and was noted where it is exposed at the beach and coastal plain interface adjacent to the Supply Base site (Plate 8-8). The clay appears to vary from low to medium plasticity, and construction will need to consider the potential effects of soil shrinkage and swelling on foundation design.

The presence of the clayey horizon beneath the coastal plain also results in a perched water table in places and causes water to pond after rainfall events, as noted during the site reconnaissance visit in December 2011 (Plate 8-9 and Plate 8-10). The resultant perched water tables and marshy conditions could hamper construction activities during the wet season.

To assess the potential risk from expansive clay, ground investigations in this area should include soil plasticity (Atterberg Limits), and natural moisture content determinations to assess soil behavior in response to changes in the moisture content. These may be supplemented with more advanced swelling tests.

Source: Gavin Fisher, 2011

Plate 8-9 Poor surface drainage and shallow water tables occur during the wet season

Source: Gavin Fisher, 2011

Plate 8-10 Ponding occurs on the coastal plain in the northern part of the supply base

Collapsing Soils

Silty sands with relatively low densities and high void ratios can be susceptible to collapse when inundated after loading, which can result in excessive settlement of structures. In the Suai development area, unconsolidated silts, sands and silty sands have been recorded within the Suai Formation. These soils may be prone to collapse settlement and should be investigated during future ground investigations.

Erodible / Dispersive Soils

Soil Erodibility Potential

Soil erodibility potential is the likelihood that erosion will occur when soils are exposed to water (and/or wind) during or, as a result of, land-disturbing activities. Erodibility potential is highest on slopes, and when low-plasticity, silty soils or fine sands are disturbed. Although the Suai development area is fairly flat, areas along the fast flowing rivers and streams will be susceptible to erosion in this manner (Plate 8-11).

Soil Dispersion Potential

Soil dispersion potential is the likelihood that soils will release a cloud of fine clay particles when brought into contact with water. These clay particles may remain suspended for an indefinite period of time, resulting in turbid, ‘dirty’ water, which can affect plant and animal life. Soil dispersion can occur without the influence of slope, mechanical action or run-off velocity i.e., in ‘still water’. It is therefore, imperative that run-off from dispersive soils is retained and treated on-site wherever practicable, before release into the natural or constructed stormwater system. This can be achieved through use of sedimentation ponds during the construction period.

Dispersive soils usually contain significant amounts of clay, with at least moderate levels of chemically exchangeable sodium, if they are not buffered by salinity.

Initial analysis using the simplified Emerson Crumb Test in the field on selected clayey samples indicates that the Suai Formation may contain slightly to moderately dispersive soils in certain clay dominated horizons. This potential phenomenon should be thoroughly investigation during future geotechnical investigations.

Compressible Soils

Soils deposited in the vicinity of the river mouths within the Supply Base site appear to range from silty and clayey fine sands to sandy silts and clays. Soils deposited in such environments are typically of low strength and are highly compressible. Careful consideration and thorough investigation should precede development in these areas.

Source: Joana Fernandes, 2011

Plate 8-11 Sediment size in drainage features suggests a high energy deposition environment

Acid Sulfate Soils

Acid sulfate soils are naturally occurring soils and sediments that contain iron sulphides, predominantly in the form of the mineral pyrite. These soils are most commonly found in low-lying land bordering the coast or estuarine and saline wetlands. In an anoxic state, these materials remain benign, and do not pose a significant risk to human health or the environment. However, the disturbance of ASS, and its exposure to oxygen, has the potential to cause significant environmental and economic impacts.

The high probability/high risk areas for ASS correspond to the river mouths and estuarine areas in the Suai region. Thorough ASS investigation should precede any development in these areas.

Saline / Sodic Soils

Soils that contain sodium salts can become dispersive when wetted with fresh water (such as rainfall), as the dissolved sodium weakens the electrochemical bonds between clay particles. Such soils are also often prone to erosion and the formation of subsurface erosion ‘pipes’ if affected by earthworks. Saline soils often contain recrystallised gypsum and high void ratios that can increase the potential for collapse settlement to occur when inundated after loading. A saline environment also produces aggressive groundwater and increases the corrosion rates of steel.

Parts of the Suai Supply Base site directly adjacent to the coast may contain these types of soils and soil samples should be taken along the coastline during any future site investigation programme in order to confirm this initial assessment.

Dissolution Voids (Karst)

Karst landforms are not particularly well developed within the Suai project area, but were encountered within the intertidal zone in the form of calcarenite. The calcarenite is fairly pitted and voided, confirming that dissolution processes are active.

Identifying the presence of karst features by geophysical investigation in conjunction with boreholes is recommended where key infrastructure straddles the coastal calcarenite.

Asbestiform Materials

Asbestos minerals are unlikely to be encountered within the sedimentary and metamorphic rocks of Timor-Leste, and therefore even less likely to be found within the sedimentary succession of the Suai Formation or Dilor Conglomerate.

Slope Instability

The flat, coastal plain that characterises the Suai development area implies an insignificant risk of natural slope instability. However, cuttings and excavations within the unconsolidated Suai Formation will be susceptible to collapse, further exacerbated by the presence of shallow perched water tables. Test pits were limited to a depth of 1.5 m for this reason during the recent investigations.

Shallow Bedrock

Although shallow bedrock is generally a positive attribute for the founding of heavy structures, it could be classed as a geohazard where roads will be cut into the landscape, or where excavations must be made for underground services.

The Suai Formation will not pose problems in this regard, but the Dilor Conglomerate may result in localised excavation difficulties.

Flooding and Inundation

The rivers flowing off the mountainous terrain to the north of the Suai development area are all prone to high-velocity, flash flooding. These flash floods are; however, generally confined to the incised river channels and associated wide flood plains. Flood studies will nevertheless be imperative to ensure that proposed development is not impacted by flooding.

Low-lying areas adjacent to the coast could also be affected by extreme tides and storm surges. Cyclonic activity, which is common off the southern coast of Timor-Leste, would generally be the catalyst for inundation of this nature.

According to data released by the United Nations Office for the Coordination of Humanitarian Affairs (OCHA), Timor-Leste has a moderate to high exposure to tropical storms and storm surge.

Seismic Conditions

According to data released by OCHA, Timor-Leste has a high to very high exposure to seismic activity and tsunamis, with potential earthquake intensity reaching Degree VIII on the Modified Mercalli Scale. Degree VIII implies slight damage to well-built structures; poorly-built structures are heavily damaged, whilst walls, chimneys and monuments fall.

Earthquakes have been recorded in the area around Suai. Details (localities and magnitude) are provided on Figure 8-1.

Associated with the seismic risk is liquefaction of the soil. Liquefaction typically occurs where deep sandy or silty sand successions are found in conjunction with shallow water table conditions. These conditions are plausible on the coastal plain underlain by the Suai Formation.

8.2.7 Soil Chemistry

The laboratory analysis results are summarised in Table 8-3. A full certificate of analysis, along with chain of custody documents, sample receipt notifications and quality control reports were provided.

The elevated levels of total nitrogen and TKN in the topsoil samples for TPSS II, TPSS III and TPNS IV are indications that organic nitrogen is present at these locations. This can be accounted for by the presence of cattle and other livestock in the region. Livestock scat is a concentrated source of organic nitrogen in the surface soil.

Samples from TPSS III show elevated electrical conductivity values at depths below 0.5 m BGL. This is likely due to increased salinity concentrations in the soil due to the proximity of the sampling location to the coast. Seasonal fluctuations in the brackish groundwater level will result in deposits of salt near the water line.

Topsoil samples from TPSS II, TPSS III and TPNS IV show total organic carbon percentages above 3%. This can be accounted for by decomposing vegetative matter present at the ground surface being collected in the sample.

8.2.8 Soil Contamination

During the site investigation, several redundant oil bores were identified that have not been decommissioned, resulting in contamination of the local soil and potentially, regional groundwater. Significant oil staining was present in the vicinity of these bores as well as oil sheens present on the water surfaces adjacent to the bores. Plate 8-12 presents an example of the contamination observed in the vicinity of the oil bores near Suai Loro approximately 4 km south of the Suai Supply Base. As there is no proposed development in this area, samples of the local soil were not collected during the investigation.

8.3 Environmental Impacts

8.3.1 Contamination of the Soil and Underlying Geological Strata

Contamination of the soil can be caused by a number of activities that are part of the proposed development and can range from direct environmental and human health impacts from spills of chemicals, to secondary and tertiary environmental effects arising from the acidification of the soil.

One of the most common soil contamination risks is spillage of chemicals or waste, particularly when stored in liquid form. Chemicals stored for industrial purposes or as chemical waste can leak from improperly maintained above- or below-ground tanks and contaminate both the underlying soil profile and groundwater. Similar to this type of chemical contamination, the oil bores identified in the site investigation pose a potentially significant environmental and human health issue due to their proximity to residential and proposed recreational areas.

Soil acidification can produce adverse environmental impacts on soils and groundwater. In addition it can also adversely affect the agricultural value of the soil due to increased heavy metals mobilised by the acidified groundwater. The primary cause of soil acidification is the oxidation of potential ASS. ASS are naturally occurring soils that exist near the groundwater level when the organic content of the soil is high. Anoxic conditions below the groundwater level can produce high concentrations of sulphides that will readily oxidise when exposed to the atmosphere. Soil exposure to the atmosphere can occur from both direct excavation of the soil or lowering of the water table during dewatering activities for construction.

The oxidation of the sulphides in the soil results in a significant lowering of the soil pH and can cause deterioration in plant health and the surrounding ecosystem. In addition, heavy metals stored in the soil matrix can be dissolved into the acidified groundwater and mobilised to different areas, poisoning native plant life and crops. Mangroves are known to occupy regions where both potential and actual ASS is prolific.

Source: Grant Hickson, 2011

Plate 8-12 Example of contamination around a Suai oil bore

Table 8-3 Suai soil chemical analysis results summary (Part 1)

		Test Pit	TPSS I				TPSS II		TPSS III		
			Sample Depth								
			Topsoil	0.5 m	1.0 m	1.5 m	Topsoil	0.39 m	Topsoil	0.5 m	1.0 m
Compound	**LOR**	**Unit**	**19/12/11**	**19/12/11**	**19/12/11**	**19/12/11**	**19/12/11**	**19/12/11**	**19/12/11**	**19/12/11**	**19/12/11**
Physical Parameters											
pH	0.1	pH	8.4	9.0	8.5	8.6	8.5	8.4	8.2	8.3	7.9
Electrical conductivity	1	µS/cm	81	64	88	81	500	278	603	1,320	2,400
Moisture content	1.0	%	10.0	4.2	15.9	10.1	30.5	23.4	31.6	26.2	27.5
Nutrients											
Total nitrogen	20	mg/kg	690	100	260	200	3,320	760	4,540	580	580
TKN	20	mg/kg	680	100	260	200	3,320	760	4,520	580	580
Ammonia	20	mg/kg	<20	<20	<20	<20	30	<20	60	<20	<20
Nitrate	0.1	mg/kg	14.9	0.8	0.8	0.8	<0.1	0.2	17.3	0.3	0.4
Nitrite	0.1	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	3.2	0.1	0.1
Nitrite + nitrate	0.1	mg/kg	14.9	0.8	0.8	0.8	<0.1	0.2	20.5	0.4	0.5
Extractable Cations											
Bicarbonate extractable K	10	mg/kg	230	250	230	210	340	340	1,020	230	230
Bicarbonate extractable P	2	mg/kg	6	22	22	11	23	123	22	30	4
Total sulfur	0.01	%	0.01	0.02	<0.01	0.02	0.05	0.02	0.08	0.18	0.16
Organic Carbon											
Total organic carbon	0.02	%	0.62	0.08	0.16	0.10	3.61	0.61	4.91	0.32	0.32

Table 8-3 Suai soil chemical analysis results summary (Part 2)

		Test Pit	TPNS IV				TPAS V	
			Sample Depth					
			Topsoil	0.5 m	1.0 m	1.5 m	0.5 m	1.0 m
Compound	**LOR**	**Unit**	**19/12/11**	**19/12/11**	**19/12/11**	**19/12/11**	**20/12/11**	**20/12/11**
Physical Parameters								
pH	0.1	pH	8.4	8.4	8.4	8.5	9.4	8.6
Electrical conductivity	1	µS/cm	222	104	109	89	426	241
Moisture content	1.0	%	20.1	19.0	8.4	6.0	25.6	24.4
Nutrients								
Total nitrogen	20	mg/kg	2,620	460	570	280	580	460
TKN	20	mg/kg	2,590	460	570	280	580	460
Ammonia	20	mg/kg	40	<20	<20	<20	<20	<20
Nitrate	0.1	mg/kg	16.5	2.0	1.0	0.5	0.4	0.2
Nitrite	0.1	mg/kg	15.7	0.2	0.1	0.1	<0.1	<0.1
Nitrite + nitrate	0.1	mg/kg	32.2	2.2	1.1	0.6	0.4	0.2
Extractable Cations								
Bicarbonate extractable K	10	mg/kg	1,100	230	250	<200	250	260
Bicarbonate extractable P	2	mg/kg	85	23	20	34	6	27
Total sulfur	0.01	%	0.03	0.01	0.02	0.01	0.02	0.01
Organic Carbon								
Total organic carbon	0.02	%	3.09	0.40	0.54	0.24	0.66	0.38

8.4 Avoidance, Management and Mitigation Measures

Avoidance of soil contamination is by far the most effective method to reduce the environmental and human health impact of the project. Methods to avoid direct contamination of soils via chemical spills are in engineering design and management measures. It is recommended that, whenever practicable, above-ground storage tanks for liquid chemicals and appropriate storage containers for non-liquid chemicals are used with containment bunds that are ISO 14001 compliant.

It is also recommended that a spills register is established that lists at a minimum: that date and time of the spill; the quantity of the spilled material; and a description of the spilled material. Material safety data sheets (MSDS) and a dangerous goods list should be kept on site for all chemical materials used. The MSDS should specify the appropriate containment and clean-up methods for each chemical in the event a spill occurs.

In advance of construction and the storage and handling of any chemicals onsite, it is recommended to conduct a baseline environmental assessment in the footprint of the site to benchmark the condition of soil and groundwater at the onset of development.

For acid sulfate soil management, it is recommended that an investigation is conducted into the presence of ASS in regions identified in a desktop study as having an increased risk of potential or actual ASS being present. This investigation should be conducted in general accordance with the *Guidelines for sampling and analysis of lowland acid sulfate soils in Queensland* (Ahern et. al., 1998) and is likely to focus on regions around mangroves and waterways where acidification impacts would be increased. Whenever possible, it is recommended that ASS is not disturbed as it is naturally occurring and only impacts the surrounding environment when influenced by exposure to the atmosphere.

In the event of either actual or potential ASS is present in areas where excavation or dewatering cannot be avoided, it is recommended that an ASS management plan is developed specifying the management and/or treatment of ASS such that the impact to the surrounding environment is minimised. The management plan should be developed in general accordance with (Ahern et. al., 1998) or an equivalent guideline.

The contamination identified in the vicinity of the oil bores near Suai Loro, although unlikely to impact the footprint of the Suai Supply Base, may have implications for the use of the proposed recreational beaches and fishery regions to the south. On this basis, baseline environmental site assessment should be undertaken to delineate the extent and significance of the contaminated soils in this area and potentially, the impact on groundwater quality. The baseline assessment will support the environmental management of this area of the site, identify any potential environmental and/or human health impacts from the leaking oil and, if necessary support the identification of any remedial measures which may be required. It is recommended that the bores are properly decommissioned and ongoing monitoring of the groundwater implemented if the investigation identifies that the contamination has migrated through the overlying layers of soil.

8.5 Residual Impacts

For the proposed developments, if the specified avoidance and management measures are implemented, then there should not be any significant adverse environmental impacts. It is likely that ASS may be an issue for any development near Suai Loro where mangrove vegetation is prevalent but, if managed appropriately, the resulting soil acidification should be manageable. Typically, industrial operations results in some level of contamination that may require remediation in the future; however, the engineering design of chemical storage and management procedures dictating their usage should minimise the potential risk of a contamination event occurring.

The impacts of the oil bore contamination may result in ongoing remediation actions and the impacts may be long term. A detailed investigation of the extent of the contamination will provide information into the extent of the contamination and the required actions to remediate the area.

8.6 Further Work

Detailed engineering geological and geotechnical work will be required to fully assess ground conditions across the Suai development area. Such investigations would be aimed at fully understanding the geology and potential impacts on the sub-surface environment. In addition, these investigations would provide concrete inputs for preliminary designs during the next phases of the project. Two phases of investigation are advocated.

8.6.1 Phase 1

The first phase should consist of further site reconnaissance, followed by detailed geological mapping of the Suai development area. Geological units should be assessed and their surface properties visually confirmed. A seismic risk study should also be included. This process would ensure optimal investigation during the next investigation phase.

8.6.2 Phase 2A (Onshore)

The second phase (onshore) would encompass penetrative investigation in conjunction with soil and rock testing. The following would be undertaken:

- The excavation of test pits with the aim of:
  - Identifying general subsurface conditions across the development footprint.
  - Confirming the presence and extent of geohazards within the project area.
  - Providing shallow foundation and pavement design parameters.
  - Providing information on typical excavation conditions.
  - Delineating and investigating potential sources of construction material identified during the desktop study. This will include collection of representative soil and rock samples for laboratory testing; and

- Conducting hand-held Dynamic Cone Penetrometer (DCP) tests adjacent to some of the test pits. DCP testing has the advantage of being quick and is used as both a profiling tool and to determine strength properties of underlying soils to a depth of roughly 3 m BGL; and
- Drilling of geotechnical boreholes in strategic locations in order to obtain an understanding of the nature of the Suai Formation and Dilor Conglomerate; and
- Limited hand augering may be suitable for the Acid Sulfate Soil investigation in high risk areas; and
- Geophysical studies are also recommended where structures are to be founded on any formation susceptible to karst problems (coastal calcarenite); and
- A detailed laboratory testing programme (soil and rock).

Once the locations of the various structures have been finalised, a second, more detailed investigation phase should be undertaken, in order to obtain final design parameters for detailed design purposes.

8.6.3 Phase 2B (Offshore)

The second phase (offshore) would encompass a geophysical study (seismic survey), followed by a detailed drilling programme in conjunction with extensive soil and rock testing. Based on the geophysical information, the drilling programme would be tailored to provide accurate sub-surface data for dredging and piling (amongst other things).

8.6.4 Soil Chemistry

It is recommended that a detailed baseline study of the soil chemistry is conducted in regions where extensive excavation is proposed to occur. Further work related to soil chemistry required for the project is as follows:

- Additional baseline investigation of the soil chemistry highlighting the potential presence of heavy metals and/or ASS across the study area in general accordance with (Ahern et. al., 1998) or an equivalent guideline;
- A detailed investigation into the contamination observed around the oil extraction bores near Suai Loro. This may lead to ongoing remediation activities; and
- If ASS are identified in regions where soil excavation or dewatering is to be conducted, an ASS management plan is to be developed detailing management procedures and/or soil treatment measures to be implemented.

Engineering design for storage of chemicals on the proposed developments are to be complaint with ISO 14001 to enable management of potential spills/leaks.

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Tasi Mane Project – Suai Supply Base Environmental Impact Assessment

CHAPTER 9
AIR QUALITY

301012-01504-EN-REP-0003
May 2012

9 AIR QUALITY

An air quality impact assessment of the project was conducted to address the terms of reference for the EIA. The section considers the potential air quality impacts associated with the construction and operational phases of the Suai development.

Air pollution is commonly defined as the introduction into the atmosphere of chemicals, particulate matter or biological materials that can cause adverse impacts on human health or other aspects of the environment. The proposed Suai development could affect the local and regional air quality and the purpose of the study is to assess these potential impacts.

9.1 Study Method

This study was designed to establish the baseline air quality within the Suai study area.

The overarching study method adopted for this assessment is as follows:

- Identify air quality sensitive receptors in the Suai study area;
- Collect baseline ambient air samples in the Suai study area for laboratory analysis;
- Measure baseline particulate matter concentrations in the study area via the use of a DustTrak™ Aerosol Monitor and dust deposition gauges;
- Assess the baseline ambient concentrations of particulates and gas pollutants against the assessment criteria;
- Determine the maximum allowable increase in ground-level concentration for pollutants likely to be emitted by the Suai development. This was to be conducted by computer modelling but there was insufficient data to create a model; and
- Provide recommendations of management measures to minimise local and regional air emissions.

9.1.1 Study Scope

The scope of this study incorporates the entire Suai development area as described in Section 1.2.

9.1.2 Assessment Criteria

Currently, the GoTL does not have specific legislation regarding air quality assessment and regulation. In these circumstances, it is common practice in air quality investigations to adopt assessment criteria from other applicable jurisdictions or recognised international organisations. Three internationally recognised authorities on air quality have standards or guidelines that have been adopted for this assessment: the World Health Organisation (WHO); the United States Environmental Protection Agency (US EPA); and the Australian National Environment Protection Council (NEPC).

The WHO has developed a series of assessment guidelines for the most common airborne pollutants. These guideline values are listed in *WHO Air quality guidelines for particulate matter, ozone, nitrogen dioxide and sulphur dioxide. Global update 2005. Summary of risk assessment* (WHO, 2005). The US EPA has a set of National Ambient Air Quality Standards listing a similar set of airborne pollutant standards (US EPA, 2011). In addition, the US EPA provides a list of chemical compounds classified as 'Air Toxics' with chronic inhalation exposure values for screen risk assessment indicating concentrations where long-term exposure would likely result in adverse health impacts (US EPA, 2010). The Australian NEPC developed the *National Environment Protection (Ambient Air Quality) Measure* (NEPC, 2003) which lists a series of 'desired environmental outcomes' that 'allows for the adequate protection of human health and well-being'. These three sets of ambient air quality standards have been adopted in this assessment for regions outside of industrial premises. Table 9-1 lists the assessment criteria for air quality standards based on these standards including comments regarding how they are to be assessed. The inventory of US EPA air toxics is too numerous to list in this document.

The occupational health and safety impacts of air quality have not been investigated in this assessment. Typically, the recommended occupational exposure limits are greater than the criteria used for EIAs.

Table 9-1 Sensitive receptor air quality assessment criteria (Part 1)

Pollutant	Guideline / Standard	Averaging Period	Value*	Comments
Carbon monoxide (CO)	US EPA	1-hour	35 ppm	One allowable exceedance per year
		Rolling 8-hour	9 ppm	
	NEPM	8-hour	9.0 ppm	
Lead (Pb)	US EPA	Rolling 3-month	0.15 µg/m^3	Not to be exceeded
	NEPM	Annual	0.50 µg/m^3	
Nitrogen dioxide (NO_2)	WHO	1-hour	200 µg/m^3	Not to be exceeded
		Annual	40 µg/m^3	
	US EPA	1-hour	100 ppb	98th percentile over 3 years
		Annual	53 ppb	
	NEPM	1-hour	0.12 ppm	One allowable exceedance per year
		Annual	0.03 ppm	Not to be exceeded
Ozone (O_3)	WHO	8-hour	100 µg/m^3	Not to be exceeded
	US EPA		0.075 ppm	Annual 4th highest daily max 8-hour, over 3 years
	NEPM	1-hour	0.10 ppm	One allowable exceedance per year
		Rolling 4-hour	0.08 ppm	
		Annual	8 µg/m^3	

Table 9-1 Sensitive receptor air quality assessment criteria (Part 2)

$PM_{2.5}$	WHO	24-hour	25 µg/m^3	Not to be exceeded
		Annual	10 µg/m^3	
	US EPA	24-hour	35 µg/m^3	98th percentile over 3 years
		Annual	15 µg/m^3	Averaged over 3 years
	NEPM	24-hour	25 µg/m^3	Goal is to gather data for review
PM_{10}	WHO	24-hour	50 µg/m^3	Not to be exceeded
		Annual	20 µg/m^3	
	US EPA	24-hour	150 µg/m^3	One allowable exceedance per year on average over 3 years
	NEPM		50 µg/m^3	Five allowable exceedances per year
Sulfur dioxide (SO_2)	WHO	10-minute	500 µg/m^3	Not to be exceeded
		24-hour	20 µg/m^3	
	US EPA	1-hour	75 ppb	99th percentile, over 3 years
		3-hour	0.5 ppm	One allowable exceedance per year
	NEPM	1-hour	0.20 ppm	One allowable exceedance per year
		24-hour	0.08 ppm	
		Annual	0.02 ppm	Not to be exceeded

Note: * – Values in µg/m^3 assume standard temperature and pressure.

9.1.3 Sensitive Receptors

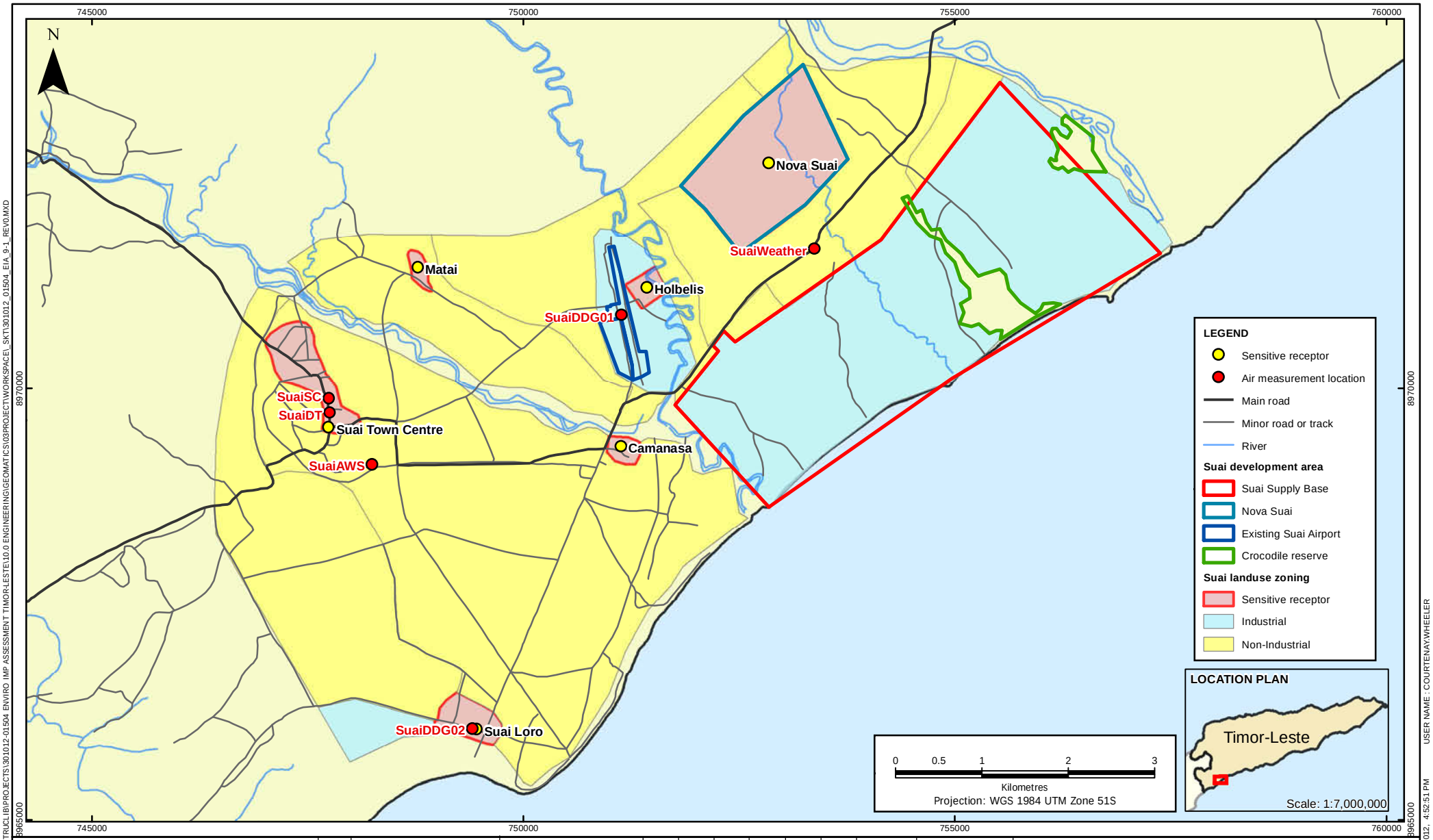
The location of sensitive receptors was identified in a desktop assessment of aerial photography and on-site visual inspection of the local area. Based on the desktop assessment, the regions surrounding the Suai development area is primarily used for residential and agricultural purposes and are considered sensitive receptors. The on-site visual inspection focussed on locations that sensitive members of the public, for example; children and the elderly, tend to congregate (i.e.,schools and hospitals/medical clinics). Two schools were identified along the Suai-Betano southern coastal road in the settlements of Samfuk and Dais.

The specific sensitive receptor locations in which the air quality can be assessed against the criteria are listed in Table 9-2.

Table 9-2 Suai study area specific air quality sensitive receptors

Location	Relevant Project Area	Centroid Coordinates	
		Latitude	Longitude
Suai town centre	Resident settlement	9° 18’ 53.5” S	125° 15’ 19.5” E
Suai Loro	Resident settlement/industrial area	9° 20’ 47.0” S	125° 16’ 16.5” E
Camanasa	Resident settlement	9° 19’ 00.0” S	125° 17’ 10.5” E
Holbelis	Resident settlement/airport	9° 18’ 00.0” S	125° 17’ 20.0” E
Matai	Resident settlement	9° 17’ 53.0” S	125° 15’ 53.0” E
Nova Suai	Primary worker settlement	9° 17’ 12.8” S	125° 18’ 05.9” E

The Suai study area with land use zoning and identified sensitive receptors is shown in Figure 9-1.



LOCATION: \\PERWORFILS1\INFSTRUCL\IB\PROJECTS\301012-01504 ENVIRO IMP ASSESSMENT TIMOR-LESTE\10.0 ENGINEERING\GEOMATICS\03PROJECT\WORKSPACE_SKT\301012_01504_EIA_9-1_REV0.MXD

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NOTES:
This map consists of:
1. Rivers: Geographic Information Group TimorLeste (2010)
2. Roads: DivaGIS (2010)
3. Landuse zoning: RDTL (2011a)

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0	7/05/2012	FINAL FOR ISSUE	MW	GHi	CW	-	GH	-	PROJECT No: 301012-001504	

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Figure 9-1
Suai air quality study area

Baseline Measurement Methods

A conservative estimate of existing air quality was determined by visual inspection using the highest ambient pollutant concentrations in the Suai study area. The baseline air quality monitoring comprised of three separate measurements:

- Ambient air sample collection using a Summa canister for laboratory analysis.
- Monitoring of ambient airborne particulate matter less than ten micrometres in aerodynamic diameter (PM10) using a DustTrak™ aerosol monitor.
- Settled dust sample collection using dust deposition gauges for laboratory analysis.

The locations for each of the measurements and equipment are listed in Table 9-3.

Table 9-3 Suai study area air quality measurement and equipment locations

Label	Type	Location	Coordinates	
			Latitude	Longitude
SuaiSC	Summa canister	Suai market	9° 18’ 42.6” S	125° 15’ 19.6” E
SuaiDDG01	Dust deposition gauge	Suai Airport runway	9° 18’ 10.5” S	125° 17’ 10.3” E
SuaiDDG02		Suai Loro village square	9° 20’ 46.7” S	125° 16’ 14.8” E
SuaiDT	DustTrak™	Suai market	9° 18’ 48.0” S	125° 15’ 20.0” E

Chemical Compound Samples

The baseline ambient air sample was collected in a NATA accredited laboratory supplied and evacuated six litre-capacity Summa canister. The canister included a uniquely numbered flow regulator and inflated over a two-hour period. Once the sampling period was complete, the canister serial number and resulting pressure difference was recorded along with the date and time of the sample.

The location of the collected sample was determined in general accordance with Australian/New Zealand Standard AS/NZS 3580.1.1:2007 Methods for sampling and analysis of ambient air Part 1.1: Guide to siting air monitoring equipment (AS/NZS 3580.1.1:2007). A summary of these requirements are as follows:

- The sample location is deemed a ‘peak site’ where it is likely that the highest concentrations of pollutants, currently present in the study area, are expected to occur;
- The Summa canister was placed greater than 10 m from the adjacent roadway as is required for sampling of gaseous compounds adjacent to roads with a volume of traffic was less than 10,000 vehicles per day; and
- The Summa canister inlet was exposed to a minimum clear sky angle of 120° during the sampling period.

The samples were packaged and sent to ALS Environmental, a NATA accredited laboratory, under full chain of custody protocols. Copies of the chain of custody, sample receipt notifications, certificates

of analysis and quality control reports are provided in Appendix D. Laboratory analysis of the sample was conducted for the following chemical compounds:

- Oxides of nitrogen (NO_X) ; and
- US EPA air toxics suite.

For the air toxics suite, analysis method TO-14A was used. This method uses a Nafion® drier to selectively remove water vapour from the sample. The sample gas is passed through Nafion® tubing removing water and other light polar compounds.

Concentrations of chemical compounds were reported at standard atmospheric conditions and are summarised in Table 9-4.

Airborne Particulate Matter Measurements

The baseline ambient airborne PM_{10} measurements were conducted outside of buildings or structures using a DustTrak™ 8520 Aerosol Monitor housed in a portable environmental enclosure. The DustTrak™ was calibrated within a two year period, prior to the measurements by a NATA accredited laboratory. The calibration certificate is provided in Appendix E. Determination of the location of the DustTrak™ was in general accordance with AS/NZS 3580.1.1:2007 and focussed on areas anticipated to have the highest concentrations of PM_{10}. The monitoring was conducted over a 24-hour period with one-minute interval logging to capture the particulate matter trends throughout a typical day.

Zero concentration checks and air flow rate checks were conducted prior to each monitoring event. The DustTrak™ was calibrated to a flow rate of 1.7 L/min as is required for peak performance in the instruction manual.

The following information was recorded for each particulate matter measurement:

- Date;
- Location coordinates;
- Measurement start and end times;
- Measurement duration; and
- Notable factors relating to the condition, operation or environment surrounding the DustTrak™.

Deposited Dust Samples

The baseline settled dust samples were collected using dust deposition gauges. The sample collection was conducted in general accordance with AS/NZS 3580.10.1:2003 Methods for sampling and analysis of ambient air Method 10.1: Determination of particulate matter – Deposited matter – Gravimetric method (AS/NZS 3580.10.1:2003). These requirements are summarised below:

- The dust deposition gauge bottles were supplied by a NATA-accredited laboratory and pre-dosed with 10 mL of a copper sulfate solution to inhibit algal growth;

- When collecting the deposition gauge bottles, any particulate matter remaining within the funnel was washed into the bottle to ensure the entire deposited particulate matter was collected; and
- Determination of the locations of the dust deposition gauges were in general accordance with AS/NZS 3580.1.1:2007.

Two dust deposition gauges were established in the Suai study area, one at the Suai Loro village sub-centre and the other at the Suai Airport. The gauges were left on site to collect deposited particulate matter for a period of 52 days from 17 December 2011 to 7 February 2012.

Samples were collected, recording the following information:

- Dates of deployment and collection;
- Location coordinates;
- Funnel height above ground level;
- Funnel top diameter; and
- Notable factors relating to the condition and contents of the gauge.

The samples were packaged and sent to ALS Environmental under full chain of custody protocols.. Laboratory analysis of the sample was conducted for the following suite of parameters:

- Total solids (g/m^2/month);
- Soluble matter (g/m^2/month);
- Total insoluble matter (g/m^2/month);
- Combustible matter (g/m^2/month); and
- Ash content (g/m^2/month).

9.1.4 Air Quality Impact Modelling

Air quality impacts resulting from the construction and operational phases of the Suai development were to be predicted using the use of computer modelling software. The input information required to conduct this modelling includes detailed engineering design data, specifying the locations and composition of emitted exhaust plumes, with emission rates of various pollutants of potential concern. Currently, detailed engineering design information is not available for the Suai development and, as a result, air quality impact modelling could not be conducted as part of this assessment.

9.1.5 Data Assumptions and Limitations

Several limitations to this investigation are acknowledged:

- Due to the availability of the equipment, the air quality measurements were not conducted concurrently and the air quality profile may potentially have changed between the measurements;

- A single Summa canister sample was collected for laboratory analysis for the Suai study area. Therefore potential variations in concentrations of chemical compounds across the study area may not have been identified. Due to the time requirements to conduct a DustTrak™ monitoring period, a single PM_{10} baseline measurement was conducted across the study area. Therefore potential variations in concentrations of airborne particulate matter across the study area may not have been identified;
- A 24 hour period of particulate matter monitoring was not obtained due to power supply problems with the DustTrak™ equipment;
- Meteorological data was not available for the DustTrak™ monitoring period;
- Due to logistical and health, safety and environment (HSE) limitations of site access, the length of time the dust deposition gauges were in the field was greater than the recommended 30 ±2 days and not representative of the intended month-long period. The results of the analysis can compensate for this extended duration by averaging the daily particulate matter deposition over the monitoring period, but this may include deposited particulate matter outside of the month-long period; and
- Local people who were aware of the air quality monitoring may have altered their typical behaviour, potentially affecting the results.

Assumptions made during the assessment are as follows:

- Baseline measurements conducted during the fieldwork are representative of the 'typical' air quality in the region; and
- There was minimal influence on the measurements by field personnel.

9.2 Existing Environment

9.2.1 Baseline Air Quality Measurements

Chemical Compound Samples

The laboratory analytical results for the collected sample are presented in Table 9-4. With the exception of NO_X and SO_X, only concentrations of compounds greater than the limit of reporting are listed below. For the full list of results refer to Appendix D.

Table 9-4 Laboratory analysis results of chemical compounds in Suai air sample

Compound	CAS Number	Limit of Reporting	Assessment Criteria	Suai Market 04/01/2012 10:23
US EPA air toxics TO-14 (Chronic inhalation non-cancer)				
Freon 12	75-71-8	0.5 ppbv 2 µg/m^3	---	0.9 ppbv 4 µg/m^3
Benzene	71-43-2	0.5 ppbv 2 µg/m^3	30 µg/m^3	1.0 ppbv 3 µg/m^3
Toluene	108-88-3	0.5 ppbv 2 µg/m^3	5,000 µg/m^3	1.8 ppbv 7 µg/m^3
Additional parameters				
Nitrogen dioxide (NO_2)	10102-44-0	0.0001%	Refer to Table 9-1	<0.0001%
Nitric oxide (NO)	---	0.0001%	---	<0.0001%

All analysed compounds under the US EPA air toxics represent trace level concentrations in the atmosphere and are much less than the assessment criteria.

Freon 12 is a compound used previously as a refrigerant and is now under the banned list of chlorofluorocarbon compounds but in some cases is still used as a propellant for aerosols. Both benzene and toluene are commonly present in vehicle exhaust fumes and given the frequency of vehicular traffic in proximity of the sampling location means the presence of these gases in the sample is not unexpected.

Nitrogen dioxide and nitric oxide are formed primarily during the combustion of fuels at high temperatures. In an air quality context, the primary sources of oxides of nitrogen are motor vehicle and power generation turbine exhausts. The concentrations of oxides of nitrogen were below the limit of reporting and can be considered to be absent from the air sample.

Sulfur dioxide is also produced by combustion of fuels that contain sulphides, for example diesel or ‘sour’ natural gas. The concentration of sulphur dioxide was not able to be determined by the laboratory due to a laboratory procedural failure.

Airborne Particulate Matter Measurements

The PM_{10} monitoring results are presented in Figure 9-2. The average PM_{10} concentration over the monitoring period is approximately 34 µg/m^3 which is less than the 24-hour average WHO and NEPM guidelines of 50 µg/m^3 and much less than the 24-hour average US EPA standard of 150 µg/m^3.

However, the results indicate a consistent increase in concentrations between 6:00 p.m. and approximately 8:30 p.m. A significant increase in the ambient concentration also occurred as an outlying peak approximately 8.00 p.m. on 11 February 2012. In the short study period it was not possible to confirm the source of the particulate matter.

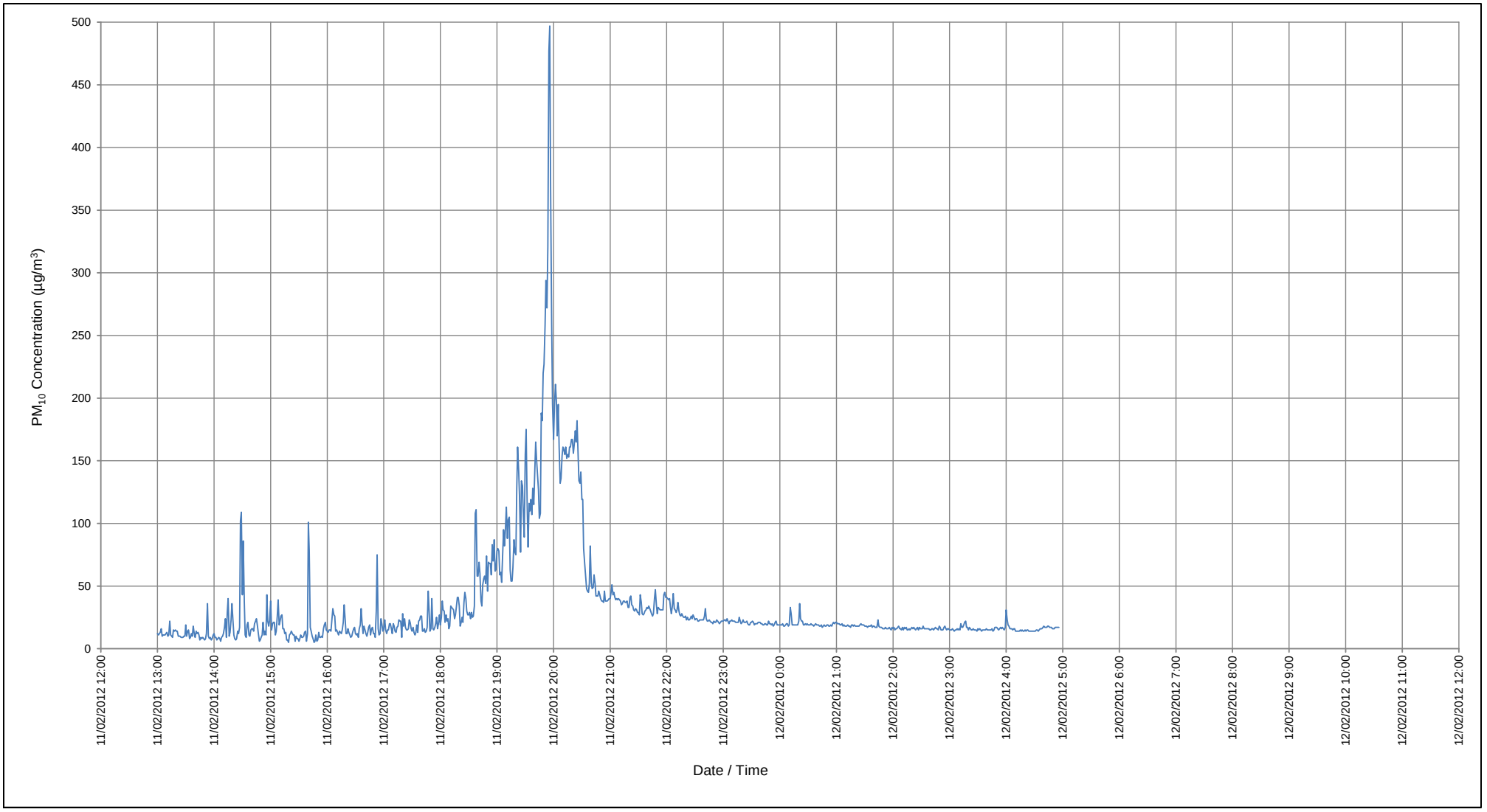

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Figure 9-2
Suai particulate monitoring time series results

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Deposited Dust Samples

As the purpose of the dust deposition samples is primarily to establish baseline deposition rates of particulate matter across the Suai development, the deposition rates are not compared to any specific assessment criteria. Instead, these values provide a measure of current conditions to compare against during future phases of the development.

The various categories of particulate matter (i.e. ash, combustible matter and coarse particulates) provide further information relating to the probable source(s) of the deposited particulate matter. For example, an increase in ash content may indicate an increased frequency or quantity of vegetation or refuse burning activities or an increase in coarse particulate may indicate an increase in bulk materials handling. Continued monitoring of the parameters as outlined in Section 6.5.1 will allow appropriate comparisons to be made and assist in establishing dust deposition rate trends.

9.2.2 Existing Pollutant Emission Sources

Air pollutants are by nature primarily emitted from (i.e., related to human activity) anthropogenic sources. These sources were identified by field observation and are summarised below.

In the Suai region, the primary observed sources of air pollutants are vehicular traffic and smoke produced from burning vegetation for agricultural clearing. To a lesser extent, bulk refuse burning and operation of electricity generators also contributes to air pollutants.

Non-anthropogenic sources are unlikely to be significant contributors to air pollutants in the Suai study area. The primary sources of non-anthropogenic air pollutants are volatilisation of volatile organic compounds (VOCs) from the surface of vegetation, methane emissions from livestock and to a much lesser extent, the generation of NO_X via the ionisation of the atmosphere during lightning events.

Sources of particulate matter can be widespread, ranging from mechanical grinding of materials, wind-generated dust from stockpiles of material, to salt crystals from sea spray. In the Suai region, primary sources of particulate matter are likely to be combustion exhaust from vehicular traffic, smoke from the burning of vegetation and dust generated from agricultural activities (e.g., ploughing fields, livestock movement, grading of roads and paths). Vehicle wheel-generated dust was not observed during the site inspection to be a significant contributor to airborne particulate matter due to the moisture content of the roads and soil although this is likely to be subject to seasonal variation.

9.3 Environmental Impacts

In the absence of a quantitative analysis of air quality impacts, a qualitative impact assessment for the various development phases have been provided below.

9.3.1 Construction Impacts

Construction of the Suai development will generate emissions to air primarily in the form of fugitive dust from the following sources:

- Excavation and earth moving activities;
- Infrastructure construction e.g., roadworks, electricity supply;
- Delivery of equipment;
- Vehicle and equipment movement;
- Vegetation and topsoil removal; and
- Wind erosion from open areas or stockpile areas.

Dust emissions not only affect the environment, but can also affect human health due to the inhalation of fine particular matter. PM_{10} and $PM_{2.5}$ particulate matter is small enough to pass the human upper respiratory tract (nose and throat) and pass into the deepest recesses of the lung. This has the potential to exacerbate pre-existing respiratory and/or cardiovascular problems that are commonly present in 'at-risk' members of the community (e.g., children and the elderly). Studies conducted by the WHO have shown good correlations of increasing mortality rates with increasing PM_{10} and ozone concentrations in urban areas (WHO, 2006).

The proximity of the construction areas to existing residential premises presents a potential human-health risk at the following locations:

- The residential sub-centre of Suai Loro; and
- The residential region around Nova Suai.

These locations will potentially be impacted by construction at the industrial estate and the Supply Base respectively. In addition, the town centre area shows evidence that current activities have the potential to generate high concentrations of airborne particulate matter in excess of WHO guidelines (WHO, 2005). It is therefore, important to ensure that particulate matter generated by construction activities are kept to as low as reasonably practicable.

9.3.2 Operational Impacts

Operation of the Suai development is likely to affect air quality due to fuel combustion in electricity generation and, vehicle and equipment use.

Fuel combustion affects both human health and the environmental due to emissions of chemical pollutants. Table 9-5 lists several known pollutants associated with the combustion of fuels and some of the known human health and environmental associated with these pollutants.

Table 9-5 Human health and environmental impacts of air pollutants

Pollutant	Human Health Impacts	Environmental Impacts
Carbon monoxide (CO)	Toxic gas that is poisonous and can reduce the oxygen carrying capability of blood.	Can contribute to the production of photochemical smog by the oxidation of nitric oxide (NO).
Lead (Pb)	Poisonous metal that can be inhaled when exposed to humans in particulate form.	Can cause a deterioration to the condition of ecosystems and slow the rate of decomposition of organic matter.
Oxides of nitrogen (NO_X)	NO_2 – Increased susceptibility to respiratory infections (e.g., asthma). NO_3 – Can change blood chemistry making it unable to carry oxygen.	NO_X – Can retard growth rates of crops and increase O_3 production as photochemical smog. N_2O – Greenhouse gas and can contribute to global warming.
Ozone (O_3)	Irritation of the eyes and exacerbation of respiratory problems	Strong oxidising agent and can retard growth of plant life
Sulfur dioxide (SO_2)	Exacerbation of existing heart and lung disease especially when attached to small particulate matter	Primary contributor to acid production in the atmosphere (acid rain) that can damage crops and ecosystems

9.3.3 Decommissioning Impacts

Given the project lifespan, the decommissioning phase of the project has not been assessed. It is recommended a decommissioning and closure plan should be developed approximately 10 years prior to commencement of decommissioning and the associated environmental impacts related to air quality assessed as part of the development of this plan.

9.4 Avoidance, Management and Mitigation Measures

9.4.1 Construction Impacts

The following control measures will be implemented during construction to ensure dust does not adversely affect sensitive receptors:

- Restrict operational hours in which construction is permitted;
- Establish appropriate environmental buffer zones between dust sources and sensitive receptors;
- Apply water or wetting agents to roads and/or stockpiles of materials;
- Define occupational dust policies for construction workers (e.g., dust masks when working with materials likely to generate excessive dust); and

- Establish a compliance monitoring regime and define non-compliance incident investigation methods and rectification strategies.

9.4.2 Operational Impacts

The following control measures will be implemented during operation to ensure gaseous air emissions do not adversely impact on sensitive receptors:

- Fit vehicles and equipment with appropriate emission control devices (e.g., vehicle exhaust system, filters);
- Keep vehicles and equipment well maintained to maximize their fuel efficiency;
- Apply water or wetting agents to frequently trafficked roads and/or stockpiles of materials. Locate major emission sources (e.g., electricity generators) to increase separation to sensitive receptors;
- Appropriately design the exhaust stacks (e.g., heights and diameters) to minimise the likelihood of exhaust plumes impacting the sensitive receptors;
- Choose the appropriate machinery to ensure high fuel combustion efficiency to minimise emissions of pollutants; and
- Establish a compliance monitoring regime and define non-compliance incident investigation methods and rectification strategies.

9.5 Residual Impacts

Construction activities are typically temporary in nature and its impacts localised. Provided all dust control measures are properly implemented, residual impacts from construction of the Suai development are considered likely to be minimal. Similarly, gaseous air emissions from operational activities of the Suai development are not considered likely to result in human health or environmental impacts. Consequently, residual impacts are considered to be minimal. However, complaints may still occur from time to time as perception of air quality is subjective by nature and varies considerably between individuals. Proactive engagement with stakeholders is recommended to keep them informed about the progress of the Suai development and reduce the likelihood of complaints.

9.6 Monitoring and Reporting

The following recommendations have been made to assist in the development of an appropriate air quality monitoring and reporting programme:

- Until air quality-related legislation is defined by the GoTL, it is recommended that the project adopts monitoring and reporting procedures and standards from other governmental jurisdictions where it is clearly defined, for example the AS/NZS 3580 series;
- Detailed monitoring of meteorological parameters as specified in Chapter 6;

- Continuous monitoring of ambient pollutants and particulate matter and deposited dust using equipment compliant with the AS/NZS 3580 series to assess compliance with the developed dust management plan and assessment criteria defined in Table 9-1. It is recommended that tapered element oscillating microbalances (TEOMs) or equivalent are established at the proposed Nova Suai development area and at Suai Loro. Monitoring data will be collated monthly and reported to SERN. AS 3580.9.8:2008 Methods for sampling and analysis of ambient air Method 9.8: Determination of suspended particulate matter – PM10 continuous direct mass method using a TEOM analyser states the guidance methods to adopt when siting the apparatus, sampling temperatures, flow rates for the main and auxiliary inlets, averaging periods and the overarching procedure to follow when establishing a TEOM at a new monitoring site; and
- Reporting on the monitored data should be conducted periodically, after each monitoring data collation, detailing the monitoring method, results and comparison to WHO, US EPA and NEPM guideline levels or equivalent.

9.7 Further Work

Further work related to air quality impacts required for the Suai development is as follows:

- Continued baseline monitoring across the study area to establish seasonal variations of chemical compound and particular matter concentrations, and dust deposition rates; and
- A detailed air quality impact assessment for both construction and operational activities including computer simulation of predicted pollutant and dust impacts across the project areas in accordance with a US EPA-approved method or equivalent.

9.7.1 Detailed Air Quality Impact Assessment

A detailed air quality assessment includes computer simulation modelling of predicted ground-level concentrations of pollutants of potential concern across the study area in accordance with a US EPA-approved method or equivalent.

It is recommended that air quality impact modelling is undertaken when proposed operational equipment and infrastructure specifications and locations are identified. The aim of the air quality impact modelling is to determine predicted ground-level concentrations of relevant pollutants of potential concern emitted by construction and operational activities. This modelling will enable the level of impact to be quantified across the study area and inform air quality impact management design and measures to be implemented, to ensure air quality impacts are managed to acceptable levels. An air quality impact assessment will also assist in the development of a dust management plan, and ultimately, help to ensure that the potentially adverse impacts on human and environmental health are minimised.

The meteorological conditions of the region have a significant influence of the dispersion behaviour of pollutant plumes and needs to be taken into account when predicting ground-level concentrations. Pollutant dispersion models use meteorological information as input data sets to simulate the impacts. For example, the humidity of the air and the frequency of rain events in the Suai region may

potentially reduce the ambient concentrations of particulate matter due to wet deposition and/or plume depletion effects.

In order to conduct computer simulation of the air quality impacts emissions of both particulate matter and pollutants of potential concern need to be estimated. Particulate matter emissions can be estimated via calculations based on: the type of activity; activity rate; and any applied mitigation / control measure used. The Australian National Pollutant Inventory (NPI) Emission Estimation Technique Manuals (EETM) for Fugitive Emissions version 2.0 (NPI, 2012a) and for Mining version 3.1 (NPI, 2012b), based on the US EPA AP-42 5th Edition: Compilation of Air Pollutant Emission Factors (US EPA, 2009) calculation methods are effective methods to estimate the particulate matter emissions from construction and operational activities and are recommended to be adopted during the detailed air quality impact assessment.

The NPI EETM for Combustion Engines version 3.0 (NPI, 2008) details methods in which to estimate the emissions of pollutants of potential concern for the assessment. These methods are recommended to be adopted in the assessment.

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

Tasi Mane Project – Suai Supply Base Environmental Impact Assessment

CHAPTER 10
NOISE

301012-01504-EN-REP-0003
May 2012

10 NOISE

Construction and operational noise associated with the proposed Suai development have been identified as an environmental factor with the potential to adversely impact the surrounding environment and populace in the Suai study area.

Currently there are no specific environmental assessment standards or legislation addressing noise or acoustic emissions in Timor-Leste.

In the absence of specific noise-related legislation in Timor-Leste, the Western Australian Environmental Protection (Noise) Regulations 1997 (WA) (DEC, 1997), have been adopted to define the study method for assessing potential noise impacts of the Suai development. Regulation 7 of the regulations states that 'noise emitted from any premises when received at other premises must not cause, or significantly contribute to, a level of noise which exceeds the assigned level in respect of noise received at premises of that kind'.

10.1 Study Method

This study was designed to obtain a baseline of the noise profile for the Suai development area;

The study method proposed for this noise assessment is summarised as follows:

- Undertake a literature review to identify:
  - Existing noise monitoring and assessments undertaken with the Suai study area.
  - GoTL or other relevant noise standards;
- Identify noise sensitive receptor locations in proximity of the Suai development area;
- Conduct baseline monitoring of ambient noise levels at the identified noise sensitive receptor locations in accordance with the Environmental Protection (Noise) Regulations 1997 (WA);
- Establish assigned noise levels for various noise sensitive premises in the study region (L_{Amax}, L_{A1} and L_{A10});
- Develop sound power level predictions for construction and operational sound power levels at the development sites accounting or meteorological conditions;
- Undertake a comparative assessment of baseline and predicted construction and operational noise levels from the Suai development; and
- Provide recommendations for any noise mitigation measures or buffer zones in relation to the Suai development area.

10.1.1 Study Scope

The study area for this assessment includes the Suai development area, which comprises the locations listed below, as well as the surrounding existing and proposed residential areas, as shown in Figure 10-1:

- Suai Supply Base (including associated marine structures).
- Industrial estates.
- Nova Suai.
- Suai Airport upgrade.
- Crocodile reserves.

Literature Review

As stated earlier, the Western Australian Environmental Protection (Noise) Regulations 1997 (WA) have been adopted in order to define the study method. The Western Australian regulations, under the Environmental Protection Act 1986, define a standard process to assign specific allowable noise levels for each category of land use zoning. This is considered an appropriate method to set the noise levels that the resulting noise impacts are to be assessed against across the study area.

The following noise guidance documents have also been referenced within this study:

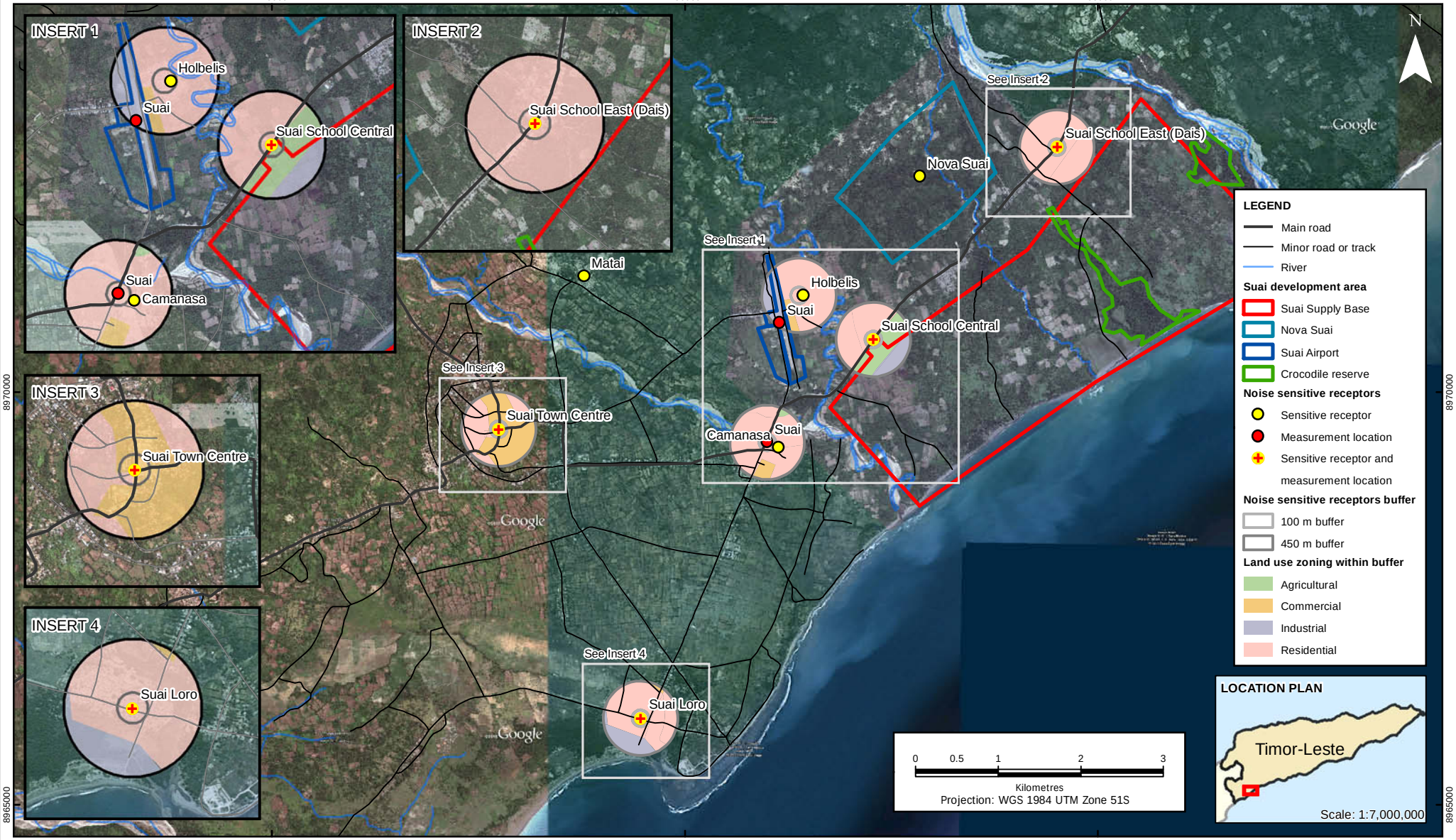
- Guidance for the Assessment of Environmental Factors No. 8 – Environmental Noise (Draft) (WA EPA, 2007a); and
- Australian Standard 2436-2010 ‘Guide to noise and vibration control on construction, demolition and maintenance sites’ (AS 2436-2010).

Noise Sensitive Receptors Locations

The identification of the sensitive receptor locations was conducted using a combination of desktop-level assessment from aerial photography and an on-site visual inspection of the existing local infrastructure.

The on-site visual inspection focussed on identifying the locations of noise sensitive receptors, as defined by the Environmental Protection (Noise) Regulations 1997 (WA). In addition, the locations to take baseline noise measurements included residential areas that are likely to be affected by the construction and operation of the Suai development.

The Environmental Protection (Noise) Regulations 1997 (WA) identify three premises categories as having different relevant assigned noise levels. These are: industrial and utility premises, commercial premises, and noise sensitive premises which are summarised in Table 10-1.



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USER NAME: COURTENAY.WHEELER

NOTES:
This map consists of:
1. Imagery: DigitalGlobe (2008-2011)
2. Imagery: Google Earth (2010)
3. Rivers: Geographic Information Group TimorLeste (2010)
4. Roads: DivaGIS (2010)
5. Noise receptors: WorleyParsons (2012)
6. Landuse zoning: RDTL (2011a)

REV	DATE	REVISION DESCRIPTION	DRN	CHK	DES	ENG	APPD	CUST
0	7/05/2012	FINAL FOR ISSUE	MW	GHi	CW	-	GH	-

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PROJECT No: 301012-001504

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

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TASI MANE PROJECT - SUAI SUPPLY BASE ENVIRONMENTAL IMPACT ASSESSMENT

Figure 10-1
Land use zoning map of Suai study area around sensitive receptors

Table 10-1 Noise related premises categories

Industrial and Utility Premises	Commercial Premises	Noise Sensitive Premises
• Premises used for providing water, electricity, communications, etc • Premises used by aircraft or ships, as a freight yard or for passenger transport • Industrial premises • Mine sites and quarries • Waste disposal sites • Offices, grounds and caretakers' residences which are part of the above.	• Offices and retail shops • Premises in or from which meals or food are sold to the public • Service stations • Indoor amusement centres e.g.,theatres • Outdoor amusement centres • Hotels which don't provide accommodation • Health centres • Hospitals with 150 or more beds • Centres for community meetings • Testing laboratories • Veterinary clinics, kennels and the like • Offices, grounds and caretakers' residences which are part of the above.	• Premises occupied solely or mainly for residential or accommodation purposes • Rural premises • Caravan parks and camping grounds • Hospitals with less than 150 beds • Rehabilitation centres, care institutions and the like; • Educational institutions • Premises used for public worship • Hotels which provide accommodation to the public • Premises used for aged care or child care • Prisons and detention centres • Any other premises not referred to in industrial and utility or commercial premises.

Table 10-2 shows the location of identified noise sensitive premises within the Suai study area for the purposes of this assessment. These receptor locations are shown in Figure 10-1.

Table 10-2 Suai noise sensitive receptor locations

Location	Relevant Study Area	Centroid Coordinates		Measurement Taken at / near Receptor
		Latitude	Longitude	
Suai Town Centre	Resident settlement	9° 18’ 53.5” S	125° 15’ 19.5” E	Yes
Suai Loro	Resident settlement / Industrial Area	9° 20’ 47.0” S	125° 16’ 16.5” E	Yes
Camanasa	Resident settlement	9° 19’ 00.0” S	125° 17’ 10.5” E	Yes
Holbelis	Resident settlement / Airport	9° 18’ 00.0” S	125° 17’ 20.0” E	Yes
Nova Suai	Primary Worker settlement	9° 17’ 12.8” S	125° 18’ 05.9” E	No*
Suai School Central	Supply Base / Nova Suai	9° 18’ 17.2” S	125° 17’ 47.8” E	Yes
Suai School East (Dais)	Supply Base / Nova Suai	9° 17’ 01.0” S	125° 19’ 00.2” E	Yes

*Location was inaccessible preventing noise measurements to be undertaken.

10.1.2 Baseline Measurement Method

Baseline noise measurements were conducted at the locations listed in Table 10-3 over a period of two days: 14 and 15 December 2011. The measurement locations are shown in Figure 10-1.

Table 10-3 Suai noise measurement locations

Figure 10-1 Label	Location	Centroid Coordinates	
		Latitude	Longitude
Suai01	Suai Market – near town centre	9° 18’ 53.5” S	125° 15’ 19.5” E
Suai02	Suai Loro – village square	9° 20’ 47.0” S	125° 16’ 16.5” E
Suai03	Camanasa Bridge (Karoulun River)	9° 18’ 58.0” S	125° 17’ 06.0” E
Suai04	Suai Airport – runway	9° 18’ 10.8” S	125° 17’ 10.6” E
Suai05	Samfuk School	9° 18’ 17.2” S	125° 17’ 47.8” E
Suai06	Dais School	9° 17’ 01.0” S	125° 19’ 00.2” E

Measurements were conducted in general accordance with the Environmental Protection (Noise) Regulations 1997 (WA). All measurements were conducted outside of buildings using a Brüel & Kjær 2238 Mediator Sound Level Meter. The sound level meter was calibrated by a NATA accredited laboratory within the last two years and is considered appropriately calibrated to industry standards.

Where possible, measurements were conducted at the boundary of the premises, nearest to the primary proposed noise source. However, in the case where noise sources are likely to be from multiple locations, a measurement was conducted at a central representative location as shown in Table 10-3.

Measurements were conducted over 15 minute periods with the microphone positioned at a minimum of 1.2 m above the ground and greater than three metres away from any sound reflecting surface. Measurements were attended with field personnel noting the following information:

- Date of measurement;
- Location coordinates;
- Measurements start and end times;
- Measurement duration;
- Calibration field checks before and after measurement period;
- Noise reading values including, equivalent continuous A-weighted sound pressure level (L_{Aeq}); and maximum linear peak sound pressure level ($L_{linear,peak}$) ; and
- Any identifiable sound sources during the measurement period including particular characteristics of the identified noise (e.g., tonality, modulation or impulsiveness). In the specific case of vehicle traffic noise, the times and frequency of the noise events were also noted.

Noise measurement data was unable to be collected at or near the proposed location for Nova Suai as this area was inaccessible to WorleyParsons field personnel during the field work.

10.1.3 Determination of Assigned Noise Levels

Three noise parameters are assigned to noise sensitive premises when determining the allowable noise levels in the Environmental Protection (Noise) Regulations 1997 (WA), these are: L_{A10}; L_{A1}; and L_{Amax}. As these parameters are calculated for each sensitive receptor location, the values are likely to differ between receptors. The definitions of these parameters are as follows:

- L_{A10}: assigned level of noise not to be exceeded for more than 10% of the time (e.g., for more than 10 minutes in 100 minutes);
- L_{A1}: assigned level of noise not to be exceeded for more than 1% of the time (e.g., for more than 1 minute in 100 minutes); and
- L_{Amax}: assigned noise level not to be exceeded at any time.

The L_{A10} and L_{A1} levels allow for brief louder noises experienced at the receptor locations, provided they remain below the L_{Amax} assigned level. As it is impractical to calculate assigned noise levels for each individual structure across the study area, the calculated values apply to the generalised zoned area of premises type. The Environmental Protection (Noise) Regulations 1997 (WA) are not applicable to traffic noise on roads and do not compensate for it.

To calculate compensation noise levels, an influencing factor must be determined and applied to the parameters in Table 10-4 for each noise sensitive receptor above.

Table 10-4 Assigned noise levels

Type of Premises Receiving Noise	Time of Day	Assigned Level (dB)		
		L_{A10}	L_{A1}	L_{Amax}
Noise sensitive premises at locations within 15 m of a building directly associated with a noise sensitive use	0700 to 1900 hours Monday to Saturday	45 + influencing factor	55 + influencing factor	65 + influencing factor
	0900 to 1900 hours Sunday and public holidays	40 + influencing factor	50 + influencing factor	65 + influencing factor
	1900 to 2200 hours All days	40 + influencing factor	50 + influencing factor	55 + influencing factor
	2200 on any day to 0700 hours Monday to Saturday and 0900 hours Sunday and public holidays	35 + influencing factor	45 + influencing factor	55 + influencing factor
Noise sensitive premises at locations further than 15 m from a building directly associated with a noise sensitive use	All hours	60	75	80
Commercial premises	All hours	60	75	80
Industrial and utility premises	All hours	65	80	90

To determine the influencing factor for each noise sensitive receptor location, the proportion of industrial and commercial areas within radii of 100 m and 450 m of each receptor location is calculated. The Transport Factor (TF) is then determined using the following rule:

- Major road (> 15,000 vehicles/day) within 100 m, TF = 6
- Major road within 450 m, TF = 2
- For each secondary road (6,000 to 15,000 vehicles/day) within 100 m, TF = 2
- TF cannot be greater than 6.

The influencing factor (IF) is then calculated by:

$$IF = I + C + TF$$

Where: I = (%industrial area within 100 m + %industrial area within 450 m) / 10

C = (%commercial area within 100 m + %commercial area within 450 m) / 20

According to Regulation 9 of the Environmental Protection (Noise) Regulations 1997 (WA), if the generated noise cannot be free of annoying characteristics (i.e., tonality, modulation and/or impulsiveness), the noise source emissions are to be adjusted to compensate.

Adjustments to noise emissions are to be cumulative to a maximum of +15dB as listed below:

- +5dB, where tonality is present (e.g., whining or droning)
- +5dB, where modulation is present (e.g. like a siren)
- +10dB, where impulsiveness is present (e.g., banging or thumping).

10.1.4 Sound Power Predictions and Comparative Assessment of Noise Levels

Given the lack of detailed engineering specifications for the proposed noise sources, computer simulation of the predicted noise levels cannot be conducted at this stage of the project. As such, accurate prediction of noise impacts across the study area could not be determined nor assessed against assigned noise levels.

10.1.5 Data Assumptions and Limitations

Several limitations to this noise study must be acknowledged. These are:

- Due to logistical and HSE limitations of the fieldwork, baseline noise measurements were only conducted between 0800 and 1800 hours;
- Due to the time requirements to conduct a measurement, a limited number of baseline measurements could be conducted across the study area;
- All conducted measurements were attended for security reasons;
- Unanticipated sources of noise from local onlookers were unavoidable in certain cases due to the presence of the field personnel (i.e.,curious passers-by, sounding of vehicle horns, etc.);
- Local people who were aware of the measurements being conducted may have altered their typical behaviour to increase or reduce the noise emitted; and
- Environmental sources of noise beyond human control (e.g., wind, thunder, rain and local fauna) were experienced during the baseline measurements;

Access to the sensitive receptor locations identified in the desktop-level assessment of the aerial photography Table 10-3 had to be taken into account when conducting the on-site visual inspections and measurements. Access to the Supply Base area in particular was limited, and as such, baseline measurements were conducted at the nearest noise sensitive location along the main road (A02-7).

The following assumptions were made during the noise assessment:

- That the baseline measurements conducted during the fieldwork are representative of ‘typical’ noise sources at each location;
- That the influence by field personnel on measured noise levels is minimal; and

- Predicted vehicular traffic volumes are less than 6,000 vehicles/day for all relevant roads in the study area.

10.2 Existing Environment

10.2.1 Baseline Noise Measurements

The baseline noise measurements conducted at each location provides a measure of the existing noise source profile across the Suai study area. The measurement results are summarised in Table 10-5.

For all measurements, the results show the primary noise source was associated with vehicle traffic as the measurement locations were situated adjacent to roads. In addition, for all measurements the $L_{linear,peak}$ values were above 100 dB and were associated with vehicles passing the sound level meter in close proximity.

These short-term, high noise events have influenced the L_{Aeq} value and as such are disproportionately high. Therefore the L_{Aeq} values do not represent the 'background' noise profile across the Suai study area. Considering that the $L_{linear,peak}$ values for each measurement are greater than 30 dB above the L_{Aeq} values, the incremental change in noise levels during the construction and operational phases of the development cannot be assessed when incorporating vehicle-related noise sources. It is inappropriate to incorporate traffic noise into the cumulative impact from the development works at Suai.

Further noise monitoring is required to establish a representative 'background' noise profile for the Suai study area. It is stated in (WA EPA, 2007a) that noise levels should be logged continuously 'over a reasonably representative period, including a weekend where relevant'. The L_{A90} value, where 90% of all logged noise values are above, will be calculated and taken to be representative of the 'background' noise.

10.2.2 Existing Noise Sources

As stated above, the primary source of noise observed during the baseline measurements is vehicular traffic. Other noise sources observed included:

Anthropogenic:

- Local populace talking / playing;
- Small-scale construction work (i.e., use of hand tools and power tools);
- Music (primarily played through electronic devices); and
- Sporting events.

Non-anthropogenic:

- Weather effects (i.e., wind, thunder and rain); and
- Animals (e.g., chickens, roosters, ducks, dogs, pigs and cattle).

Table 10-5 Suai baseline noise measurement results

Label	Date	Coordinates	Time			Calibration (dB)		Measurements (dB)		Primary Noise Source	Traffic Counts
			Start	End	Duration	Before	After	LA_{eq}	$L_{linear.peak}$		
Suai01	15/12/2011	9° 18' 53.5" S 125° 15' 19.5" E	1620	1635	15 mins	94.0	94.0	67.3	101.9	Vehicle Traffic / Talking	MB: 90 Car: 7 Truck: 3
Suai02	14/12/2011	9° 20' 47.0" S 125° 16' 16.5" E	1715	1720	15 mins	94.0	94.0	57.4	101.6	Vehicle Traffic	MB: 17 Car: 0 Truck: 0
Suai03	14/12/2011	9° 18' 58.0" S 125° 17' 06.0" E	1633	1648	15 mins	94.0	94.0	66.4	115.6	Vehicle Traffic	MB: 24 Car: 4 Truck: 1
Suai04	15/12/2011	9° 18' 10.8" S 125° 17' 10.6" E	1538	1553	15 mins	94.0	94.0	55.0	105.8	Wind / Vehicle Traffic	MB: 19 Car: 0 Truck: 2
Suai05	14/12/2011	9° 18' 17.2" S 125° 17' 47.8" E	1349	1404	15 mins	94.0	94.0	60.8	104.8	Farm Animals / Vehicle Traffic	MB: 24 Car: 2 Truck: 3
Suai06	14/12/2011	9° 17' 01.0" S 125° 19' 00.2" E	1311	1326	15 mins	94.0	94.0	59.2	102.5	Vehicle Traffic	MB: 17 Car: 4 Truck: 0

Note: MB - Motorbike or other powered two-wheel vehicle.

10.3 Environmental Impacts

10.3.1 Assigned Noise Levels

The calculated proportions of industrial and commercial zoned areas within the 100 m and 450 m radii of each noise sensitive location / receptor are listed in Table 10-6. The land use zonings near the sensitive locations / receptors are presented in Figure 10-1.

Table 10-6 Land use zoning near noise sensitive receptor locations

Location	Industrial and Utility Premises		Commercial Premises	
	100 m Radius	450 m Radius	100 m Radius	450 m Radius
Suai01	0%	0%	83%	60%
Suai02	0%	22%	0%	1%
Suai03	0%	0%	0%	7%
Suai04	0%	13%	0%	7%
Suai05	0%	16%	0%	0%
Suai06	0%	0%	0%	0%

It is assumed that the volume of vehicular traffic during construction and operation will not be greater than 6,000 vehicles/day, for any relevant roads in the Suai study area. Therefore the Transport Factor (TF) for all receptors is considered zero. The calculated parameters for each influencing factor are listed in Table 10-7.

Table 10-7 Influencing factor calculation parameters

Location	Calculation Parameter			
	Industry (I)	Commercial (C)	Transport Factor (TF)	Influencing Factor (IF)[1]
Suai01	0	7.15	0	7
Suai02	2.2	0.05	0	2
Suai03	0	0.35	0	0
Suai04	1.3	0.35	0	2
Suai05	1.6	0	0	2
Suai06	0	0	0	0

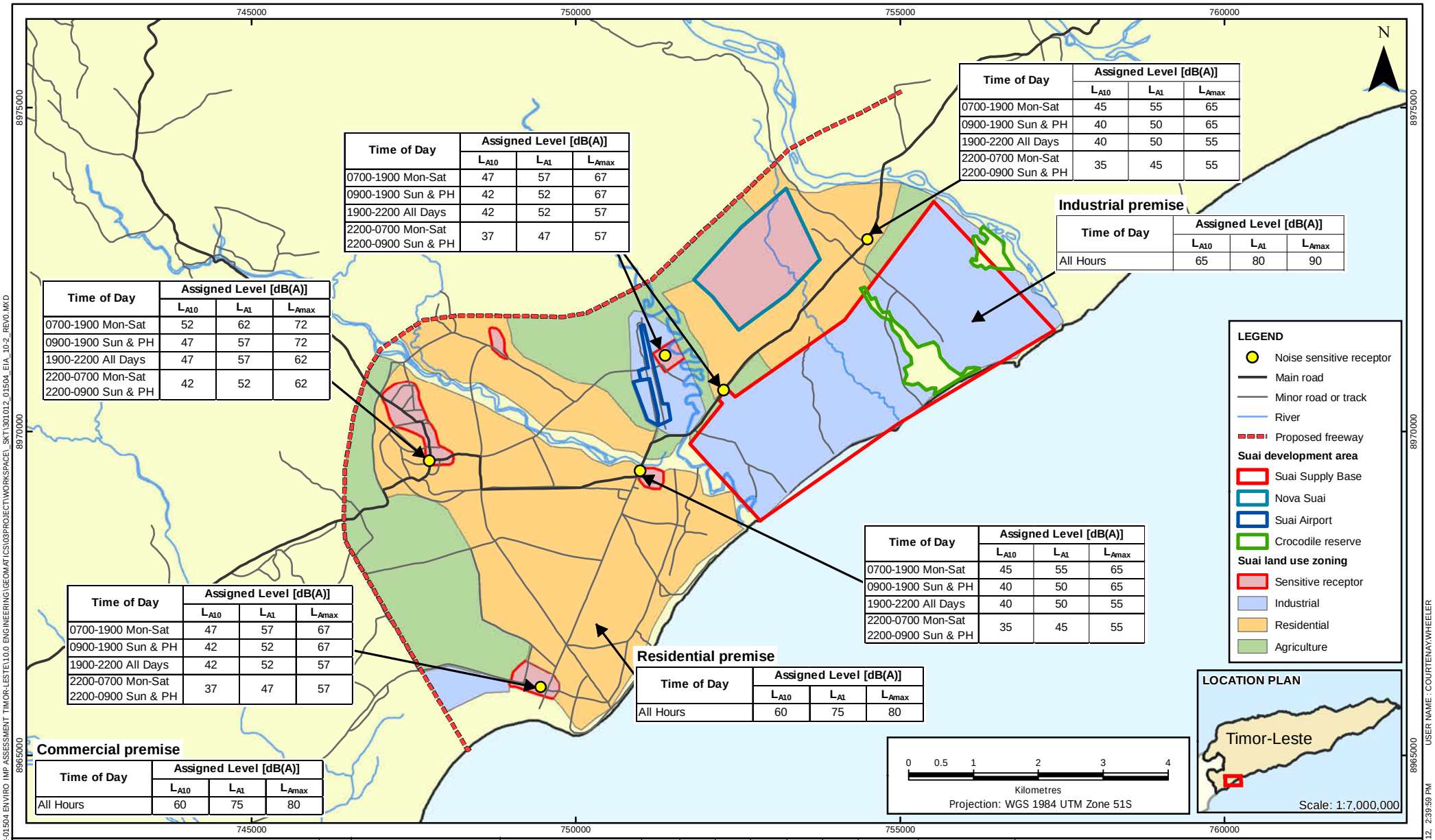
Note: 1 – Influencing Factor rounded to the nearest whole number.

The resulting allowable noise levels for each premises zone type is listed in Table 10-8.

Table 10-8 Calculated allowable noise levels for Suai

Type of Premises Receiving Noise	Time of Day	Location	Assigned Level [dB(A)]		
			L_{A10}	L_{A1}	L_{Amax}
Noise sensitive premises at locations within 15 m of a building directly associated with a noise sensitive use	0700 to 1900 hours Monday to Saturday	Suai01	52	62	72
		Suai02	47	57	67
		Suai03	45	55	65
		Suai04	47	57	67
		Suai05	47	57	67
		Suai06	45	55	65
	0900 to 1900 hours Sunday and public holidays	Suai01	47	57	72
		Suai02	42	52	67
		Suai03	40	50	65
		Suai04	42	52	67
		Suai05	42	52	67
		Suai06	40	50	65
	1900 to 2200 hours All days	Suai01	47	57	62
		Suai02	42	52	57
		Suai03	40	50	55
		Suai04	42	52	57
		Suai05	42	52	57
		Suai06	40	50	55
	2200 on any day to 0700 hours Monday to Saturday and 0900 hours Sunday and public holidays	Suai01	42	52	62
		Suai02	37	47	57
		Suai03	35	45	55
		Suai04	37	47	57
		Suai05	37	47	57
		Suai06	35	45	55
Noise sensitive premises at locations further than 15 m from a building directly associated with a noise sensitive use	All hours	N/A	60	75	80
Commercial premises	All hours	N/A	60	75	80
Industrial and utility premises	All hours	N/A	65	80	90

The relevant assigned noise levels for each land use zone within the study area are presented in Figure 10-2.



NOTES:
This map consists of:
1. Rivers: Geographic Information Group TimorLeste (2010)
2. Roads: DivaGIS (2010)
3. Noise receptors: WorleyParsons (2012)
4. Landuse zoning: RDTL (2011a)

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ENVIRONMENTAL IMPACT ASSESSMENT

Figure 10-2
Assigned noise levels across the Suai study area

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10.3.2 Construction Noise

In the absence of a quantitative analysis of estimated noise emissions, computer simulation of the predicted noise levels cannot be conducted at this stage. As such, accurate prediction of noise impacts across the Suai study area could not be obtained and a qualitative impact assessment has been provided below.

It is likely that noise associated with construction activities for the Supply Base, industrial estate and airport upgrade works will have tonal, modulated and/or impulsive characteristics associated with them. Piling activities for foundations in particular have either tonality or impulsiveness depending on the method of installation. For sheet piling installed by vibration methods, tonality is the primary characteristic. For piles driven into place by a conventional pile driver, impulsiveness is the primary characteristic. In addition, vibrational impacts from piling activities have the potential to affect the structural integrity of adjacent buildings. Foundations and binding materials, for example, mortar, are especially susceptible to excessive vibration.

Excavation activities, including drilling, are known to be consistently high noise contributors. It is anticipated that extensive earthwork and excavation activities will be required for the construction of all the development areas. The use of power tools, in particular impact hammers or ‘jackhammers’, have the potential to have adverse noise impacts on both construction personnel and the local populace at the sensitive receptor locations. The impulsive nature of the emitted noise from these tools and the tonality associated with other tools, for example, circular saws, would require the additional adjustment factors mentioned above to be applied.

The proximity of proposed construction areas to existing residential premises is a major factor to the potential noise level impact at the following locations:

- The southern and western edges of Suai Loro; and
- The residential region immediately south-east of Nova Suai.

These locations will potentially be impacted by construction at the industrial estate area and by the Supply Base respectively. In addition, impacts may potentially occur at existing and/or proposed residential regions across the Suai study area.

In the absence of an effective noise mitigation program, construction noise impacts may adversely affect the public in ways ranging from annoyance/complaints to loss of sleep.

10.3.3 Operational Noise

Operational noise associated with the Supply Base, industrial estate and airport upgrade may potentially adversely affect both existing noise sensitive receptors and noise sensitive receptors proposed as a component of the development (e.g., the new settlement at Nova Suai). However, similar to the construction phase, at the time of writing, there is no project-specific engineering data regarding the operation of the Suai development. Therefore accurate prediction of the noise impacts via computer simulation could not be completed at this time.

It is anticipated that tonality will be present within the noise profile emitted from operational activities at the Supply Base and industrial estate. In addition, aircraft noise from the Suai airport is likely to affect the residential premises in close proximity to the airport upgrade. Noise associated with air traffic is by nature high in intensity but, short in duration. However, vibrational impacts from air traffic, especially when it is taxiing on the ground, have the potential to adversely impact the sensitive receptors in proximity to the Suai Airport upgrade. Permanent structures in the village of Holbelis to the immediate east of the current Suai Airport may experience adverse impacts to their foundations due to settling of the supporting soil. In addition, vibration has the potential to provide nuisance impacts on the local populace, particularly if experienced during night hours.

Based on the assessment undertaken at this stage, it is also likely that operational noise will impact the surrounding regions on a long-term basis which will include existing and proposed noise sensitive receptors. However, given the unavailability of any engineering design specifications, the long-term noise impacts cannot be quantified at this stage.

10.3.4 Decommissioning Noise

Given the project lifespan, the decommissioning phase of the project has not been assessed. It is recommended that a decommissioning and closure plan be developed approximately 10 years prior to commencement of decommissioning, and the associated environmental impacts related to noise are assessed as part of the development of this plan.

10.4 Avoidance, Management and Mitigation Measures

10.4.1 Detailed Noise Impact Assessment

Given the unavailability of detailed design information, a baseline field investigation has been undertaken at this stage. The most effective management measure that will need to be implemented is a detailed investigation into the environmental and occupational noise impacts, including computer simulation modelling of predicted noise levels across the study area in accordance with the Guidance for the Assessment of Environmental Factors No. 8 – Environmental Noise (Draft) (WA EPA, 2007a).

It is also recommended that noise modelling be undertaken when proposed operational equipment specification and locations are identified. The aim of the noise modelling will be to determine accurate sound power levels generated from operational activities. This modelling will enable the magnitude of potential noise impacts to be determined and inform noise impact management measures that should be implemented during the operations managing noise to acceptable levels.

A detailed impact assessment can only be conducted once detailed engineering design information for the major noise sources is available. Therefore, generalised management and mitigation measures are provided below.

As part of the detailed assessment, in accordance to Regulation 9 in Environmental Protection (Noise) Regulations 1997 (WA) an adjustment to the emitted sound levels associated with construction or operational events will need to be considered (refer to Section 10.1). This is to

account for any identified characteristics that may be present in the emitted noise (e.g., tonality, modulation or impulsiveness).

10.4.2 Construction Noise

Construction noise does not have as many established avoidance or mitigation measures as other types of noise. By nature, noise associated with construction activities cannot by avoided. It is also impractical to implement noise mitigation measures, for example noise barriers, for construction activities as they are more suited to longer-term or permanent installations or operations. As such, the primary method to minimise noise impacts from construction activities at sensitive receptor locations is to implement an appropriate noise management plan. It is recommended that a noise management plan specify the following:

- Construction operation hours in which construction-related noise can be emitted;
- Appropriate environmental buffer zones from noise sources;
- Occupational noise policies for construction workers;
- Recommendations for construction methods (e.g., vibrational piling versus pile driver, etc.); and
- The compliance monitoring regime and non-compliance incident investigation methods and rectification strategies.

Regulation 13 of the Environmental Protection (Noise) Regulations 1997 (WA), states that construction noise falls under the 'special case regulation' category. As an example of management measures that could be implemented, the following excerpt from the regulations describes how the noise impacts are regulated in Western Australia:

Under the special case regulation dealing with construction sites –

- *A 'construction site' is defined as a premises or public place on which the sole or principal activity is the carrying out of construction work;*
- *'Construction work' is clearly defined as in the Occupational Safety and Health Act 1994;*
- *The assigned noise levels set in regulations 7 and 8 do not apply to noise emitted from a construction site as a result of construction work on Mondays to Saturdays, under certain conditions; and*
- *Work may be done between 7 p.m. and 7 a.m. and on Sundays and public holidays, under a stricter set of conditions.*

Daytime Construction

- *For construction work carried out between 7 a.m. and 7 p.m. on any day which is not a Sunday or public holiday;*

- *The construction work must be carried out in accordance with control of noise practises set out in section six of Australian Standard 2436-2010 'Guide to noise and vibration control on construction, demolition and maintenance sites' (AS 2436-2010);*
- *The equipment used for the construction work must be the quietest reasonably available; and*
- *The chief executive officer (CEO of the Department of Environmental Protection) may request that a noise management plan be submitted for the construction work at any time.*

Construction Out of Hours

- *For construction work done outside the hours shown above –*
- *The work must be carried out in accordance with section six of AS 2436-2010;*
- *The equipment used must be the quietest reasonably available;*
- *The builder must advise all nearby occupants of the work to be done at least 24 hours before it commences;*
- *The builder must show that it was reasonably necessary for the work to be done out of hours; and*
- *The builder must submit to the CEO a noise management plan at least seven days before the work starts and the plan must be approved by the CEO.*

If a builder failed to comply with these conditions, or with the approved noise management plan, the noise from the construction site would be treated the same as noise from any other premises and would need to meet the assigned levels.

10.4.3 Operational Noise

Mitigation measures for noise associated with the operation of machinery are more established than for construction noise. The Guidance for the Assessment of Environmental Factors No. 8 – Environmental Noise (Draft) (WA EPA, 2007), lists the following generic noise mitigation measures commonly used in construction and operational noise management:

- Procurement specifications for new equipment;
- Retrofit treatments for existing equipment or groups of items (e.g., enclosures, silencers, etc.);
- Adjustments to site layouts to increase separation between sources and receivers and to provide shielding;
- Provision of noise barriers; and
- Management procedures to control the types of equipment or operating conditions at certain times of the day or under certain weather conditions.

The procurement of appropriate equipment will have a significant effect on the anticipated noise emissions from the project areas. Selection of low-noise equipment wherever possible will assist in reducing noise impacts at the sensitive locations / receptors.

In the event that equipment is deployed in the field and subsequently determined to be excessively noisy, retrofitting equipment with noise reducing measures can significantly reduce their noise emissions. In the case of stationary noise sources like power generation turbines, enclosures can be created around the source tailored to the specific mitigation requirements. Shielding of noise sensitive locations on-site, for example site offices, via noise barriers can be effective mitigation measures for occupational impacts; however, the design of each barrier should be specific to the location and requirements.

As for the consideration of potential construction noise impacts, a detailed assessment of the predicted operational noise impacts to both existing and proposed noise sensitive receptors by computer simulation will provide information relating to what mitigation measures will be the most effective for the Suai development.

10.4.4 Decommissioning Noise

Given the project lifespan, the decommissioning phase of the project has not been assessed. It is recommended that a decommissioning and closure plan be developed approximately 10 years prior to commencement of decommissioning, and the associated environmental impacts related to noise are assessed as part of the development of this plan.

10.4.5 Noise Management Plans

Separate noise management plans will need to be developed for the construction and operation phases of the Suai development, detailing the implementation of the proposed noise mitigation measures and operational policies. The noise management plans should refer to relevant legislation and standards for guidance, for example (DEC, 1997), (WA EPA, 2007a) and (AS 2436-2010).

10.5 Residual Impacts

As the residual impacts cannot be quantified at this stage, a qualitative assessment of the residual impacts is provided below. With the implementation of a detailed noise impact assessment, predicted noise levels can be determined across the Suai study area, therefore specific and appropriate mitigation and management measures can be determined and recommended in noise management plans. The implementation of suitable management plans for both construction and operational phases of the development are likely to result in residual noise impacts kept to reasonable levels and times of the day.

As stated in Section 10.4.2, construction noise is by nature not easily avoided or mitigated, hence the implementation of an effective management plan is crucial to ensure that noise impacts at sensitive receptors are minimised. This can be achieved by conducting the construction work in accordance with standardised guidelines, for example the Environmental Protection (Noise) Regulations 1997 (WA) (DEC, 1997).

Although operational noise can be mitigated more effectively than construction noise, it is still likely to measurably affect the noise environment at sensitive receptors across the Suai study area in the long term. Complaints may occur on occasion as perception of noise levels are subjective by nature and

vary between individuals. It is recommended that all complaints are investigated and actioned appropriately. If the investigation reveals the complaint to be valid, the contributing noise source should be addressed by applying an appropriate management measure(s).

In the event that the local populace consider the noise impacts from the development to be unacceptable, relocation of the affected people may need to be considered.

10.6 Monitoring and Reporting

A noise monitoring and reporting program will be required to ensure compliance with the developed management plan. The following recommendations have been made to assist in the development of an appropriate monitoring and reporting programme:

- Until noise-related legislation is defined by the GoTL, it is recommended that monitoring and reporting procedures be adopted from other governmental jurisdictions where it is clearly defined, for example the *Environmental Protection Act 1986* for Western Australia;
- Conduct sound power level measurements, or obtain engineering specification sheets for anticipated major noise sources (e.g., major machinery, power generation turbines, etc.) prior to procurement;
- Conduct compliance monitoring of sound power levels at each of the identified sensitive receptor locations for both construction and operation phases of the Suai development. Compliance monitoring events are to be conducted at a frequency in accordance with (DEC, 1997) and (WA EPA, 2007a) spanning the different defined time categories list below:
  - 0700 to 1900 hours, Monday to Saturday
  - 0900 to 1900 hours, Sunday or public holidays
  - 1900 to 2200 hours, All days
  - 2200 to 0700 hours, Monday to Saturday
  - 2200 to 0900 hours, Sunday or public holidays; and
- Conduct compliance measurements over a period between 15 minutes and 4 hours in length to obtain a ‘representative assessment period’ for each time category.

Once both sound power measurements of machinery and compliance monitoring events have been completed, the level of contribution from the noise source at the receptor will be calculated by the method detailed in Environmental Protection (Noise) Regulations 1997 (WA). If the noise source(s) are deemed to be ‘significantly contributing’ to a level of noise greater than the assigned noise level at the receptor, noise management measures will need to be undertaken.

Reporting on the monitored data should be conducted periodically - after each monitoring event detailing the monitoring method, results and calculation of noise source contribution to measured values.

10.7 Further Work

The recommended further work related to noise-impacts that will be required to assess the Suai development is as follows:

- Conduct baseline monitoring at the identified sensitive receptor locations in accordance with (DEC, 1997) and (WA EPA, 2007a). This will supplement existing measurement data, establish 'background' noise levels at each sensitive receptor and incorporate seasonal variation in population behaviour, village growth and the development of additional new villages. Required 'background' noise levels are for the following time periods and at all sensitive receptor locations:
  - 0700 to 1900 hours, Monday to Saturday
  - 0900 to 1900 hours, Sunday or public holidays
  - 1900 to 2200 hours, All days
  - 2200 to 0700 hours, Monday to Saturday
  - 2200 to 0900 hours, Sunday or public holidays;
- A detailed noise impact assessment of both construction and operational activities including computer simulation of predicted noise impacts on existing and proposed noise sensitive receptors across the Suai study area in accordance with Guidance for the Assessment of Environmental Factors No. 8 – Environmental Noise (Draft);
- Development of separate noise management plans in accordance with (DEC, 1997), (WA EPA, 2007a) and (AS 2436-2010) for the construction and operation phases of the Suai development detailing management procedures and mitigation measures to be implemented; and
- Compliance monitoring and reporting in accordance with the developed management plans.

The detailed noise impact assessment requires the provision of detailed engineering design specifications for the proposed works to be able to simulate the impacts adequately.

The implementation of the above further work will facilitate noise from the construction and operation of the Suai Supply Base and associated infrastructure to remain within acceptable noise levels across the development area.

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Tasi Mane Project – Suai Supply Base Environmental Impact Assessment

CHAPTER 11

HYDROLOGY, DRAINAGE, AND RIVER WATER QUALITY

301012-01504-EN-REP-0003
May 2012

11 HYDROLOGY, DRAINAGE, AND RIVER WATER QUALITY

A hydrological impact assessment of the proposed Suai Supply Base was conducted based on a desktop review of existing data, previous reports and information obtained from a site visit in December 2011. This has allowed a limited, general description of current surface water conditions; an assessment of potential impacts due to the proposed development; a description of possible avoidance/mitigation measures; and development of an outline of future surface water investigation requirements.

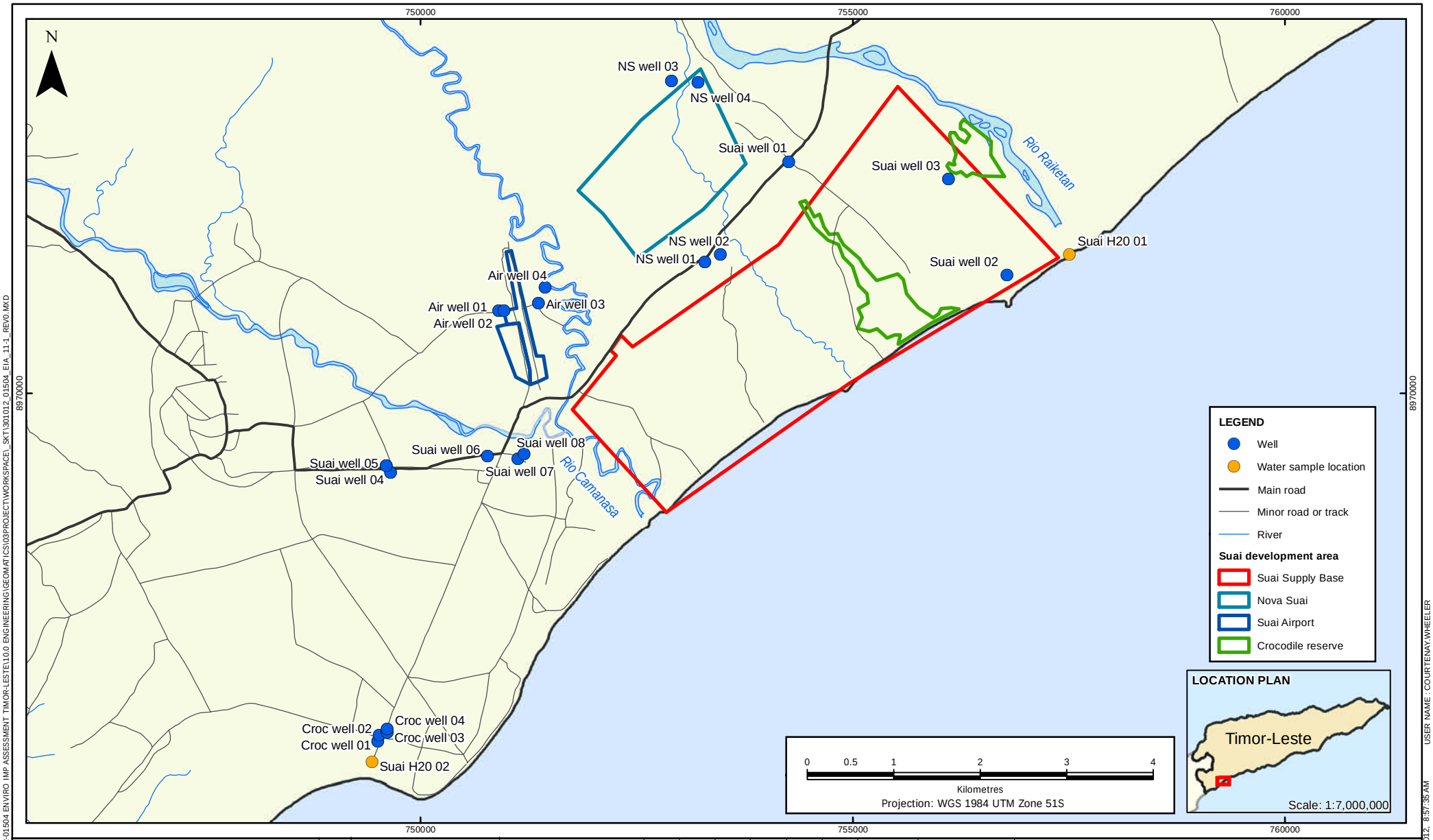
11.1 Study Method

11.1.1 Baseline Assessment

Available Data

Information available for this project is listed below:

- GIS-based topographic information, which was used to delineate catchment areas for the major waterways.
- Continuous rainfall records (at half hourly intervals) for Suai Airport for a six week period commencing 16th December 2011.
- Water quality samples taken during the site visit from two locations (refer to Figure 11-1) which were tested for the following physical properties:
  - Temperature.
  - pH.
  - Total Suspended Solids.
  - Total Dissolved Solids.
  - Turbidity.
  - Electrical conductivity.
  - Salinity.
- Map showing mean annual rainfall for Timor-Leste.
- Map showing flood risk areas in Timor-Leste.
- A report prepared in 2004 for the Asian Development Bank which assessed water resource availability and demand in Timor-Leste titled, *Assessment of Water Availability and Water Demand in Timor-Leste at River Basin Level* (ADB 2004).



NOTES:
This map consists of:
1. Rivers: Geographic Information Group TimorLeste (2010)
2. Roads: DivaGIS (2010)

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TASI MANE PROJECT - SUAI SUPPLY BASE
ENVIRONMENTAL IMPACT ASSESSMENT

Figure 11-1
Wells and water sampling points

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Limitations of Available Data

The surface water assessment was limited by a lack of suitable information. Ideally, an assessment of surface water hydrology would be able to draw on the following data:

- At least 20 years of data from daily rainfall gauging stations spread across the region. This data would underpin assessments of long-term water availability for water supply purposes.
- Data from at least one continuous recording rainfall gauging station (pluviograph) in the region capable of giving rainfall at sub-daily time intervals (hourly, minutes). This data is essential for estimating flood behaviour and design of drainage facilities.
- At least 10 years of data from one or more stream flow gauging station in the region. This data is essential for estimating flood flows and would assist in assessing long-term water availability for water supply purposes.
- Topographic information to assist in delineating catchment areas.
- Details of historical flooding at the proposed site including the extent of inundation and frequency of flooding.
- Water quality sampling results for streams in the region addressing physical, chemical and biological properties to provide baseline water quality information against which the impact of any future development would be assessed. The samples should be taken over a long enough period to demonstrate variations in water quality throughout the year in response to seasonal and land use behaviour; as well variations in response to different flow rates. Samples should be taken at sufficient locations to demonstrate variations in water quality due to different catchment conditions and land use patterns.

Comparison of the available data with that which is required shows significant shortfalls. These are discussed further below:

- Rainfall

  Daily rainfall records for Suai were provided by the Ministry of Agriculture for the period from February 2008 to December 2011 (with missing data in some months). Six weeks of pluviograph records were recorded by the study team commencing in December 2011. These records were too short to be of value in determining design rainfall intensities or for assessing water availability. However, the rainfall records are presented and discussed in further detail in Chapter 6: Climate and Meteorology.

- Streamflow

  There are no stream flow records available for the study.

- Water Quality

  The available water quality samples were for two sites only, taken on one occasion and only physical parameters were examined. Key chemical and biological parameters were not tested due to logistic issues. Special equipment is required to acquire the samples and store them for

transport to testing laboratories in Australia. Therefore, only some of the parameters of interest can be tested in Timor-Leste. This was not sufficient to draw any meaningful conclusions about the current water quality or to assess the likely water quality impacts arising from the planned works.

A detailed investigation into available data was made for the Assessment of Water Resource Availability (ADB, 2004). It found that there were 64 rainfall stations in Timor-Leste but, data for the period after 1974 was unreliable. As a result, ADB based its study on monthly rainfall data recorded for the period from 1952 to 1974, which they obtained from the Indonesian Meteorological and Geophysics Agency (BMG). Of the six stream flow gauging stations that had been established in Timor-Leste, four had automatic continuous water level recorders and two had manually-read staff gauges. However, three of the automatic stations had equipment problems and had never recorded data and records for the other stations had been lost.

The current status of the rainfall and stream flow gauging stations is not known.

11.1.2 Study Method- Impact Assessment

The adopted study methods have been chosen taking into consideration the available data and are described below.

Water Resource Availability

The assessment of available water resources is based on information contained in ADB 2004. Water resource availability was assessed by the ADB using monthly rainfall runoff models that were established for each river valley and run over a 22 year period, using monthly rainfall data recorded for the period 1952 to 1974. There was no data in Timor-Leste to calibrate the models and so, a model was established and calibrated in a gauged catchment in West Timor and the derived model parameters applied in Timor-Leste.

Flood Flows

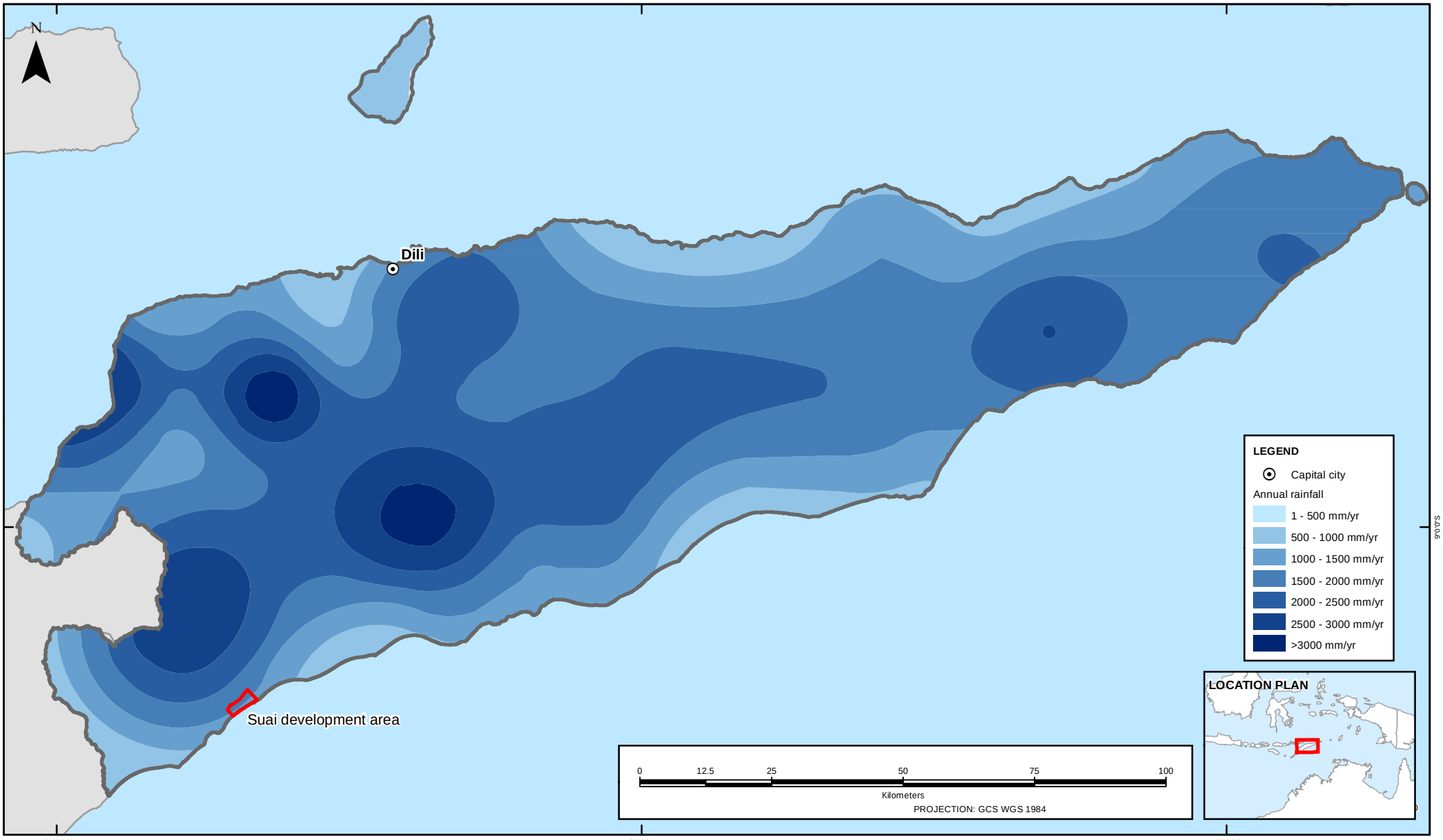
Design flows for the streams adjacent to the site have been estimated using the Rational Method and design rainfall intensities transposed from northern Australia. It is expected that design rainfalls in Timor-Leste will be lower than those that have been adopted for this report hence, the design flows are considered conservative estimates.

Water Quality

Only general comments on possible water quality impacts and mitigation measures could be made.

11.2 Existing Environment

Timor-Leste has a tropical climate dominated by the Asian monsoon. The North West (wet) monsoon occurs between November and May, whilst the South West (dry) monsoon occurs between June and October. Seasonal rainfall patterns vary between the north and south coast due to the central mountain range that generates orographic rainfall and rain shadow effects. As shown in Figure 11-2 mean annual rainfall varies across Timor-Leste from 500 mm to 3,000 mm.



NOTES:
This map consist of:
1. Rainfall data: Timor-Leste agricultural library and virtual library (2004)

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TASI MANE PROJECT - SUAI SUPPLY BASE
STRATEGIC ENVIRONMENTAL IMPACT ASSESSMENT

Figure 11-2
Mean annual rainfall for Timor-Leste

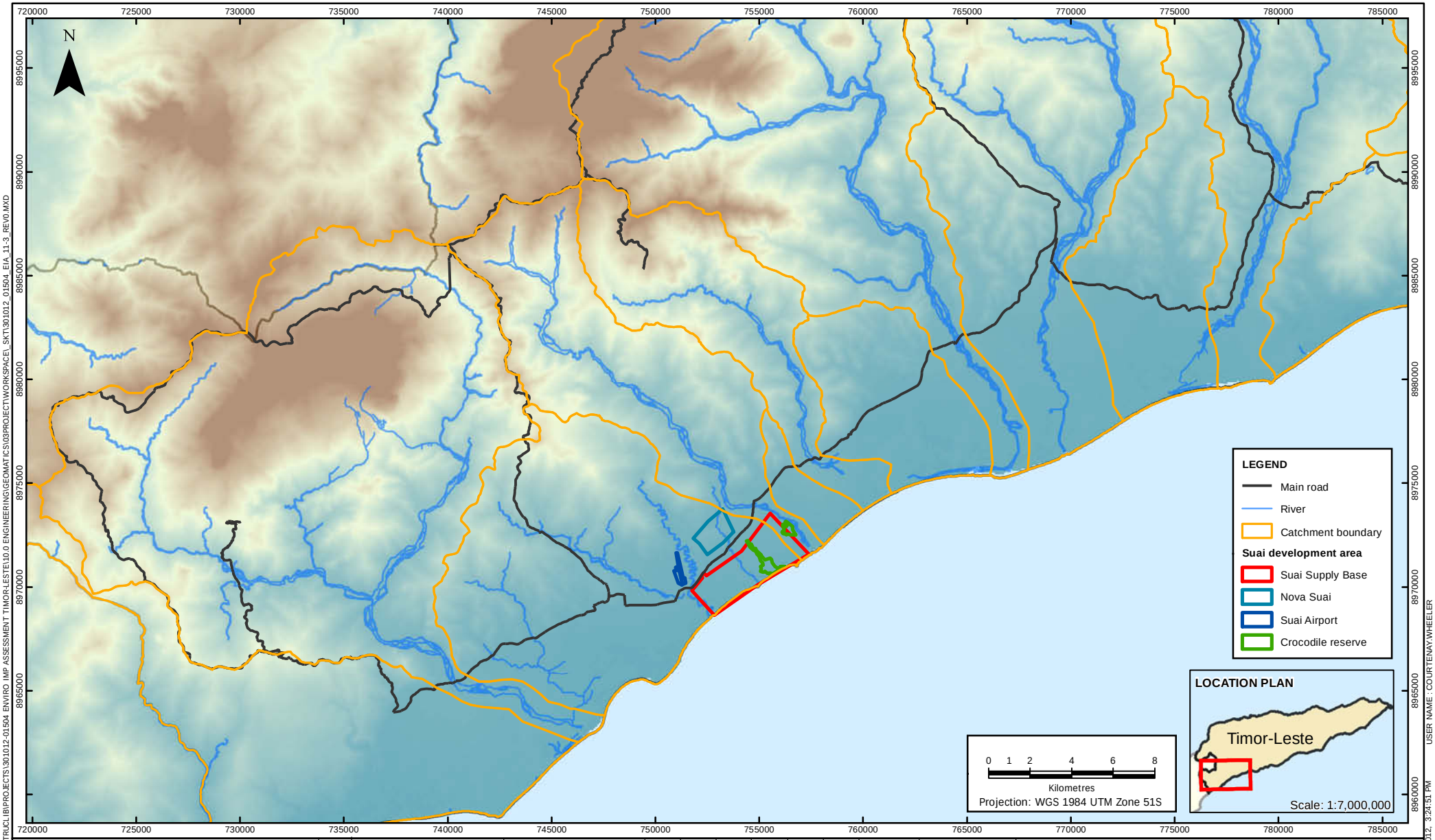
The Suai site is located on the southern coast, between two sizable watercourses Rio Raiketan (to the east) and Rio Camanasa (to the west) which have catchment areas of approximately 110 km^2 and 75 km2 (Figure 11-3). Examination of satellite images shows:

- Both streams have braided channels, which is characteristic of steep watercourses that have high energy and high sediment loads;
- Evidence of prior channels which cross the site where these two water courses have previously followed different alignments.

The predominant land use in the catchments of the two streams is agriculture although natural forests remain in the upper catchments and other areas that were too rugged for agriculture.

The two available water quality samples have high levels of turbidity, which is to be expected due to the high level of agriculture in the catchments. Also, soils in Timor-Leste are generally highly erodible. Information on chemical and biological properties is not available but, it is expected that the water quality would exhibit elevated levels of nutrients, BOD (biological oxygen demand) and pathogens as a result of agricultural land use and human occupation. Water quality is also expected to varying seasonally in response to agricultural practices and rainfall. Higher pollutants loads are expected during the wet season with high levels of rainfall generating erosion and mobilizing pollutants.

The Suai site is located within the Mola and Tafara Hydrologic Unit. The ADB study showed that irrigation was the dominant water use and that average flows greatly exceeded the average consumptive water demands. However, demands during periods of drought may approach, or exceed flows. Key hydrologic statistics describing water availability and demand are summarized in Table 11-1. Whilst this information is useful in providing a general appreciation of water availability, caution should be exercised in applying to results to future projects, as the generated flows are based on rainfall recorded prior to 1974, which may or may not be representative of current or future climate. Furthermore, the rainfall runoff models used to generate the flows have not been calibrated to recorded streamflows and may be over predicting runoff.



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NOTES:
This map contains:
1. DEM: SRTM (2011)
2. Rivers: Geographic Information Group TimorLeste (2010)
3. Roads: DivaGIS (2010)
4. Catchment boundaries: Geographic Information Group TimorLeste (2010)

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Figure 11-3
Suai development area catchment boundaries

Table 11-1 Key hydrologic statistics for water availability and demand, Suai

Month	Mean Monthly Rainfall (mm)	Mean Monthly Streamflow (ML/month)		1 in 5 year Monthly Low Flows (ML/month)		Mean Monthly Irrigation Demands (ML/month)	
		Rio Raiketan[1]	Rio Camanasa[2]	Rio Raiketan[1]	Rio Camanasa[2]	Rio Raiketan[1]	Rio Camanasa[2]
Jan	174	8,900	5,251	8,900	5,251	400	272
Feb	179	13,100	7,729	13,100	7,729	400	272
Mar	126	10,100	5,959	10,100	5,959	100	68
Apr	126	9,900	5,841	9,900	5,841	1,500	1,020
May	140	14,300	8,437	14,300	8,437	1,600	1,088
June	115	13,800	8,142	13,800	8,142	900	612
July	96	10,300	6,077	10,300	6,077	400	272
Aug	36	4,100	2,419	4,100	2,419	-	-
Sep	14	1,400	826	1,400	826	-	-
Oct	35	500	295	500	295	-	-
Nov	89	5,000	2,950	5,000	2,950	-	-
Dec	180	7,700	4,543	7,700	4,543	1,400	952
TOTAL	**1311**	**99,000**	**58,410**	**99,000**	**58,410**	**7,000**	**4,760**

[1] *From ADB 2004*
[2] *Estimated*

The site could potentially be flooded from either the Rio Raiketan or the Rio Camanasa in large flood events. Indeed, the site has been mapped as a high flood risk area (refer to Figure 11-4).

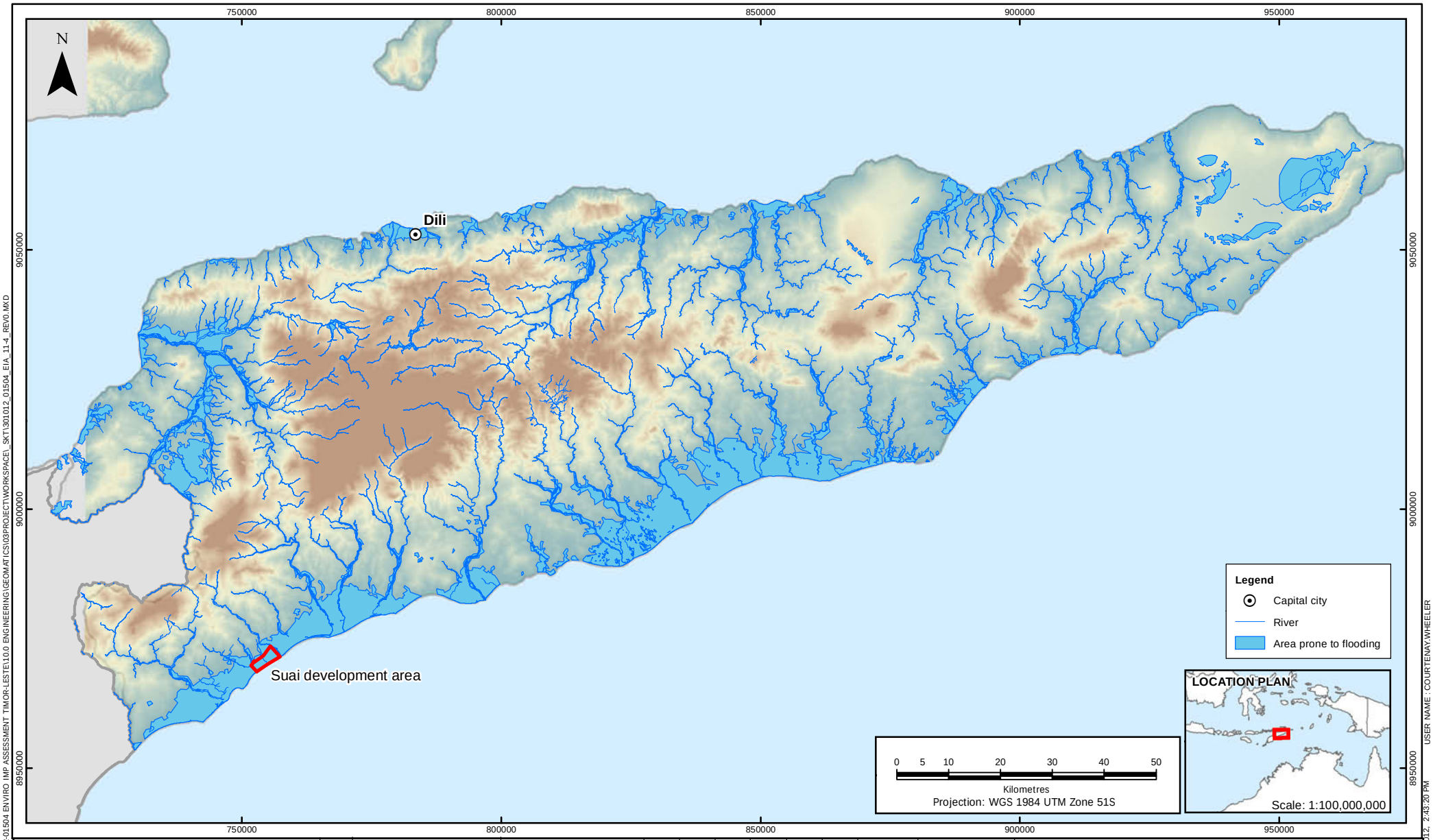
There is also a possibility of the channels breaking their banks and creating a new alignment across the site.

A preliminary hydrologic assessment was undertaken to estimate peak flood flows, which are provided in Table 11-2. Site survey information is not available to allow an assessment of the channel capacity or likelihood of flood inundation across the site.

Table 11-2 Estimated peak flows

Waterway	10 year ARI# (m^3/s)	20 year ARI (m^3/s)	50 year ARI (m^3/s)	100 year ARI (m^3/s)
Rio Raiketan	611	684	807	929
Rio Camanasa	517	583	683	767

 # ARI: Average recurrence intervals in years



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This map contains:
1. DEM: SRTM (2011)
2. Rivers: Geographic Information Group TimorLeste (2010)
3. Area liable to flooding: Durand (2006)

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ENVIRONMENTAL IMPACT ASSESSMENT

Figure 11-4
Flood risk in Timor-Leste

11.3 Potential Environmental Impacts

Potential environmental issues related to surface water include:

- The site could potentially be affected by flooding and may require flood protection works.
- The adjacent waterways, especially the Rio Raiketan, may migrate over time.
- Development at the site may restrict future channel migration and erosion protection works may be required to protect infrastructure located close to the two major streams.
- High rates of erosion could occur from exposed areas of soil during construction of the site infrastructure.
- The development will require a water supply to meet commercial and industrial needs as well as the domestic needs of the workforce. It is expected that it will be sourced from the reverse osmosis of seawater; however, if a portion of this supply comes from surface waters, it will affect the flow regime, particularly during low flow periods. Any diversion structures or in-stream storage dams could impact migration of aquatic fauna and modify habitat conditions in the impounded area.
- Following development, runoff from the site may include contaminants including sediment, litter, heavy metals and hydrocarbons which could pollute receiving waters including the adjacent streams and the near shore. Without further treatment, disposal of sewage effluent from Nova Suai may also pollute receiving waters.
- Following development, the volume of runoff and peak discharge rate from the site is likely to increase due to the conversion from natural vegetation to impervious surfaces. This could potentially exacerbate downstream flooding but, it is not expected to be an issue due to the proximity of the site to the downstream end of the catchment.

11.4 Avoidance, Management and Mitigation Measures

The following measures may be required to avoid, manage or mitigate surface water environmental impacts:

- Flood protection measures, such as flood levees and diversion channels, may be required to prevent inundation of the site by flood waters.
- Erosion protection/river training works may be required to protect site infrastructure from being undermined from channel migration. Infrastructure may need to be set back from the channel to minimize the risk of erosion. Assessment by an experienced geomorphologist may assist in establishing suitable setback distances.
- An appropriate soil management and erosion control plan should be prepared and implemented during the construction phase.

- If it is proposed to extract water supplies from surface waters then environmental water requirements will need to be investigated and suitable extraction rules established, with particular regard to protecting flows during drought periods.
- Diversion structures and storage dams, if required, will need to be sited away from environmentally sensitive areas.
- Water quality control measures will be required for treatment of stormwater runoff prior to discharge from the site, which may include use of sediment and litter traps, water quality ponds, wetlands, grassed swales and oil separators (for target areas such as car parks). The aquatic ecologist should identify if there are any sensitive aquatic environments (such as the crocodile reserves) that may be affected by polluted stormwater runoff or changed flow regimes. Care may need to be taken to ensure polluted site runoff is not directed towards these habitats. The aquatic ecologist should also provide target water quality (and flow) criteria to be achieved by the water quality treatment system, based on relevant international standards (such as the *Australian and New Zealand Guidelines for Fresh and Marine Water Quality, ANZECC 2000*) taking into account the characteristics of the receiving waters (existence of threatened species, sensitivity to modified flows and water quality, current level of degradation, future use).
- Stormwater detention ponds may need to be installed to attenuate flows and ensure that peak discharges do not increase.

11.5 Residual Impacts

Following development and implementation of mitigation measures potential residual impacts include:

- A reduction in average flows and change to the flow regime as a result of any surface water extractions;
- A possible decline in water quality due to pollutants from the site not completely removed by the treatment system.

11.6 Monitoring and Reporting

Stormwater Quality

Following commissioning of the Supply Base, a monitoring program should be implemented to assess the water quality of runoff from the site and the adequacy of the storm water treatment system. The monitoring program should persist for a period of two years to ensure that the system achieves the project water quality targets. If the system proves to be satisfactory then the monitoring program can be terminated. However, if the system does not achieve the target water quality standards then suitable augmentation measures will need to be implemented.

11.7 Further Work

The following investigations are required to better quantify surface water impacts and to design appropriate mitigation measures:

11.7.1 Survey

A survey of the proposed site should be undertaken to accurately define ground levels. The survey should also acquire cross sections of the adjacent streams (channel and adjacent floodplains), for a reach that extends from the mouth to a distance of at least 2 km upstream of the site.

11.7.2 Hydrologic Investigations

Detailed hydrologic investigations should be undertaken to assess.

- Assess long term water availability for surface water supplies.
- Appropriate peak design discharges for the adjacent streams.
- Assess the flood liability of the site.
- Design any mitigation measures required.
- Determine suitable design rainfalls for site drainage design.
- Determine suitable environmental flow/water extraction rules to protect the aquatic environment. This will require input by an aquatic ecologist.

Rainfall and streamflow data should be recorded over a period of at least 12 months.

11.7.3 Water Quality

Water quality measurements should be collected to establish baseline water qualities for creeks and significant waterways potentially affected by the proposed development.

11.7.4 Soil and Erosion Management Plan

A soil and erosion management plan should be developed for the construction phase, to minimise soil erosion and transport of sediment from the site during construction.

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Tasi Mane Project – Suai Supply Base Environmental Impact Assessment

CHAPTER 12
HYDROGEOLOGY

301012-01504-EN-REP-0003
May 2012

12 HYDROGEOLOGY

12.1 Background

A hydrogeological impact assessment of the project was conducted to address the terms of reference for the EImpact Statement. This section provides a general description of the regional hydrogeology, an assessment of potential impacts, a description of possible avoidance, management and mitigation measures and identifies areas for further groundwater investigations.

Groundwater is an important source of water for domestic and agricultural use in urban and rural areas across the island of Timor-Leste; however, little is known about either the quantity or quality of groundwater resources, including the extent of foreseeable impacts due to industrial development (UNDP, 2009).

The proposed Suai development will involve a number of activities that could potentially impact groundwater resources both locally and regionally. In general terms, these can be classified in terms of groundwater quantity or flow, and groundwater quality. Groundwater is also an important component to surface water quantity and quality and linkages to surface water are discussed herein as appropriate.

12.2 Study Method

To understand the potential impacts of the project on groundwater resources, a conceptual understanding of the geologic and hydrogeologic framework is typically first developed. An understanding of the potential aquifer, groundwater flow patterns, geochemical distribution and groundwater recharge/discharge patterns is part of that study. A conceptual model of the hydrogeological system has been developed through a desktop assessment, and a brief field program was undertaken which involved the collection of groundwater samples from a number of water wells throughout the Suai development area.

Water wells were sampled opportunistically during a field visit in December 2011. Field parameters (pH, temperature and electrical conductivity) and water samples for laboratory analysis were collected at twenty wells throughout and adjacent to the Suai development, as shown in Figure 11-1 (Chapter 11). Samples were collected using 500 ml plastic bottles and were submitted to the Direcção Nacional Serviço de Agua e Saneamento (DNSAS) or National Directorate for Water and Sanitation for analysis of pH, electrical conductivity (EC), total dissolved solids (TDS), salinity, temperature and turbidity.

12.2.1 Assessment Criteria

Currently, Timor-Leste does not have specific legislation to protect groundwater resources. A draft national water policy was finalized in July 2004 and is yet to be adopted by the GoTL (USAID, 2011). In the absence of drinking water guidelines or standards, the World Health Organization (WHO) drinking water guidelines will be used for assessment (WHO, 2011) to compare groundwater collected from the water wells to an international drinking water standard.

12.2.2 Data Assumptions and Limitations

A limited understanding of hydrogeological conditions for the project has been obtained due to time constraints. The following data gaps and limitations were identified during this desktop study:

- Specific knowledge/data regarding local and regional aquifers within the proposed project area is not available; therefore no quantification of impacts has been made;
- A number of water wells have been located. However, current water users within and adjacent to the Suai development area have not been identified and local groundwater use has not been quantified;
- There is currently limited information available on the quality of groundwater within and adjacent to the Suai development area. Consequently, local groundwater quality and hydrogeochemical types have not been characterized;
- There is currently no data available to quantify surface water-groundwater interactions (including baseflow) within and adjacent to the proposed site; and
- Estimates of groundwater extraction rates were not available and no aquifer testing was conducted at the collected water well samples.

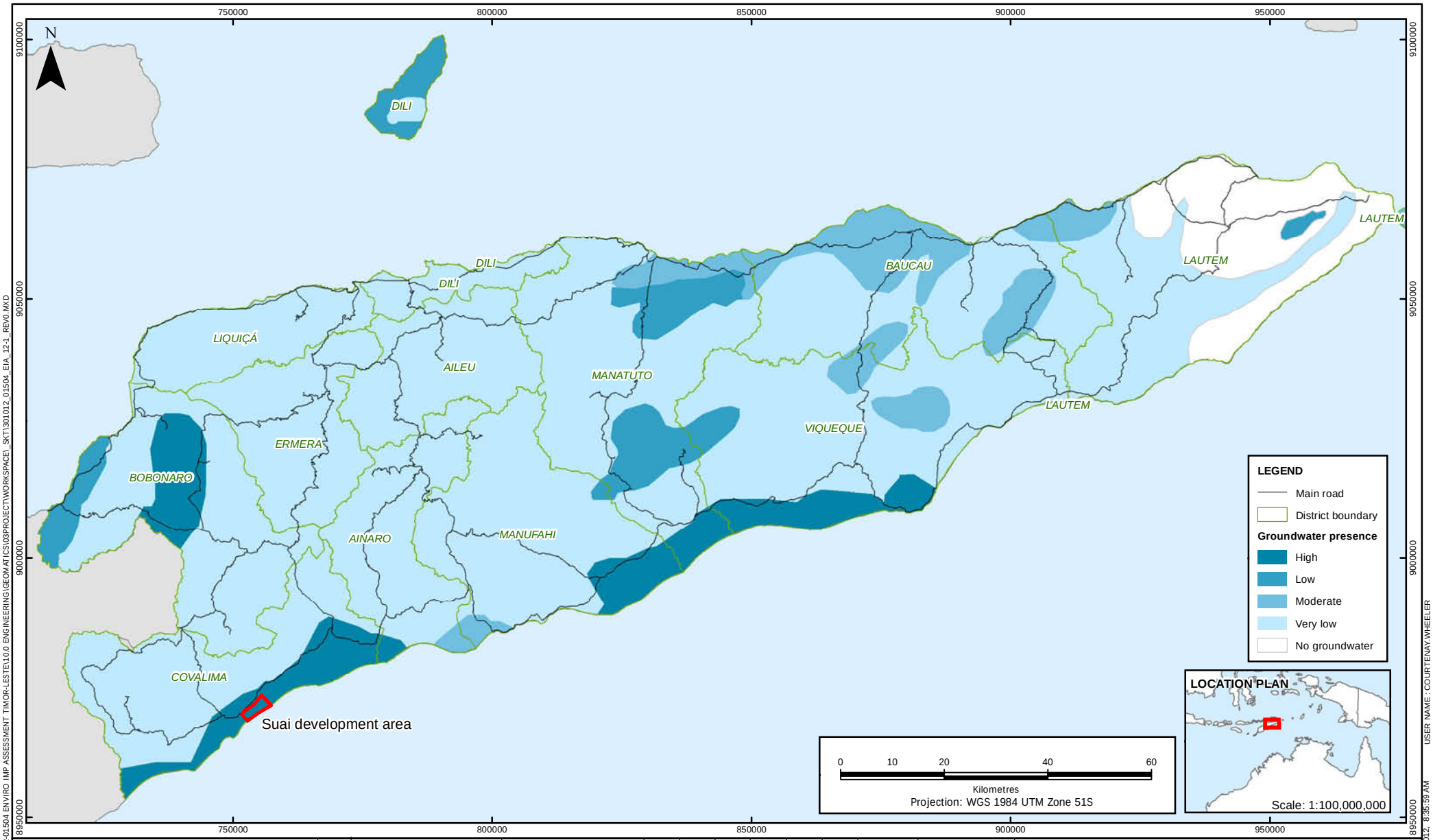
12.3 Existing Hydrogeological Concept

12.3.1 Desktop Assessment

Timor Island was formed by a collision complex between the Australian continent and the Banda Arc subduction systems. The peak of collision occurred during Late Miocene-Pliocene and resulted in wide-spread metamorphism. In late Pliocene time, Timor began to emerge as an island and four post-Pliocene units (the marine Baucau Limestone, the Poros Limestone, the Suai Formation and the Ainaro Gravels) were deposited. By the end of the Pliocene, Timor-Leste was covered with alluvial systems and local basins had developed.

Regionally, the Suai Formation outcrops beneath the Suai development area. The Suai Formation is generally poorly exposed and not well known. North of Suai village, the sediments are rudite and arenite ranging to gravels. Foraminifera are common in this 600 m thick unit but, they represent a death assemblage and are thought to have been derived from elsewhere (UN, 2003).

Natural groundwater springs are considered the primary source of water for domestic and agricultural uses for most villages in Timor-Leste (AusAID, 2009). Alluvial deposits and Cenozoic and Quaternary limestones are likely to constitute more productive aquifers than underlying metamorphic complexes and deformed Permian-Jurassic strata, although faulting may have a large impact on groundwater flow even in poorly permeable rocks (BGS, 2007). Figure 12-1 indicates that the presence of groundwater along the southern coast is generally considered high relative to other areas of Timor-Leste.



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1. Roads: DivaGIS (2010)
2. District boundaries: Geographic Information Group TimorLeste (2010)
3. Groundwater: Durand (2006)

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Figure 12-1
Presence of groundwater in Timor-Leste

12.3.2 Baseline Groundwater Quantity

Regionally, the Suai development area is situated within the hydrological region of Mola and Tafara (AWRF, 2006), which is estimated to have a total annual groundwater resource (AGWR) budget of 23 million cubic metres (MCM). Estimates of groundwater withdrawals per capita within the Mola and Tafara area were 59 m^3 per year, less than 1% of the total water resources per capita (8,822 m^3; ADB, 2004) in an average year. However, during a dry (1 in 5 low flow) year, groundwater withdrawals can account for up to 1.5% of total water resources due to limited water availability (3,853 m^3 per year; ADB, 2004). At this time, estimates of groundwater recharge and discharge have not been conducted.

In 2004, the Asian Development Bank (ADB) Integrated Water Resources Management (IWRM) Project estimated annual groundwater recharge, storage and sustainable aquifer yield for each of the hydrologic units. Hydrogeological units from a map of West Timor were extrapolated to Timor-Leste and a recharge factor was applied based on rock type, estimated permeability, slope and vegetation cover (ADB, 2004). Within the Mola and Tafara hydrologic region, a total sustainable yield of 23.1 MCM/year (732 L/s) and a total storage of 6,160 MCM were calculated based on an average aquifer extent of 308 km^2 and 100 m in thickness. These values indicate an abundance of groundwater within the region. However, they should be considered very approximate estimates of deep (>100 m) aquifers which are likely difficult and expensive for local residents to access.

Natural groundwater springs are the dominant sources of water supply in rural areas, supplying potable water to approximately 60% of the population (ADB, 2001). Shallow wells are used extensively in villages and rural areas, especially those near the sea or on river plains. Numerous shallow wells exist across Timor-Leste, both in urban and rural areas. However, many of these were damaged or contaminated during years of conflict. A small number of boreholes also exist, most notably in the southern alluvial plain (BGS, 2007]).

12.3.3 Baseline Groundwater Quality

It is expected that concentrations of inorganic constituents in groundwater will be dependent on the pH and redox (oxidizing/reducing) conditions of regional and local aquifers, and current information and assessments of potential groundwater quality are made on the basis of available geological information. Site-specific groundwater quality characterization has not been performed, as a geochemical characterization of the groundwater samples collected from water wells at the Suai development area has not been collected.

Regionally, reports of inadequate sanitation and waste management systems (Pederson and Arneberg,1999) imply that shallow groundwater is potentially under threat from pollution, especially in urban and peri-urban areas. In rural areas, pollution from agricultural sources is also a potential problem although it is noted that limited industrial development to date in Timor-Leste would suggest that industrial pollution is currently a comparatively minor threat to water quality (UNDP, 2009).

Groundwater data, including laboratory analyses, are summarized in Table 12-1. Average temperatures of the groundwater samples ranged from 28.5 to 35.5°C, with pH values ranging from 7.01 to 7.97, which is within the WHO drinking water guideline range of 6.5 to 8.5 (WHO, 2011).

Groundwater samples were analyzed for TDS, salinity and turbidity and are summarized in Table 12-1. TDS values ranged from 6 to 7,935 mg/L, with two water samples above the WHO drinking water guideline criteria of 1,000 mg/L. Salinity values ranged from 0.04 to 19%. However, there is currently no WHO drinking water guideline for salinity. Turbidity values ranged from 0.9 to 384 nephelometric turbidity units (NTU); with a majority of the samples reporting values above the WHO drinking water guideline criteria of 5 NTU.

Table 12-1 Groundwater quality analyses: physical parameters

	Physical Parameters Analysed						
Well Name	**pH**	**EC (uS/cm)**	**TSS (mg/L)**	**TDS (mg/L)**	**Salinity (%)**	**Temp. (C)**	**Turbidity (NTU)**
WHO DWQG[1]	6.5-8.5	---	---	1000	---	---	5
Suai Wells							
Suai Well 01	7.9	387	0.03	193	0.2	24.2	384[1]
Suai Well 02	7.5	169	0.02	84	0.1	23.1	7.1[1]
Suai Well 03	7.8	577	0.04	288	0.3	23.5	3.8
Suai Well 04	7.4	686	0.04	343	0.3	24.6	3.7
Suai Well 05	7.4	782	0.05	391	0.4	24.1	14.2[1]
Suai Well 06	7.3	834	0.05	412	0.4	24.5	2.4
Suai Well 07	7.6	908	0.05	454	0.4	24.6	5[1]
Suai Well 08	7.7	88.1	0.01	44	---	23.8	2.8
Croc Well 01	7.6	1184	0.07	592	0.6	24.2	1.2
Croc Well 02	7.9	1275	0.07	640	0.6	24.2	1
Croc Well 03	7.6	1168	0.07	584	0.6	24	1.8
Croc Well 04	7.5	1278	0.07	639	0.6	24.2	1.7
Air Well 01	7.2	839	0.05	419	0.04	23.1	6.3[1]
Air Well 02	7.6	834	0.05	417	0.4	24.2	1.4
Air Well 03	7.3	1013	0.06	507	0.5	23.9	2.3
Air Well 04	7.4	815	0.05	407	0.4	24	5[1]
NS Well 01	7.4	1113	0.07	556	0.6	24.2	1
NS Well 02	7.3	853	0.05	426	0.4	24	1.1
NS Well 03	7.7	1011	0.06	505	0.5	24.3	0.9
NS Well 04	7.5	716	0.05	358	0.4	23.9	4.8[1]

Notes:
1. --- in guideline row(s) denotes no criteria for that parameter
2. --- in detail row(s) denotes parameter not analysed
3. Highlighting indicates parameter above applied guideline/criteria
4. Superscript [1] denotes value exceeding World Health Organization Drinking Water Guideline, 2011

12.4 Environmental Impacts

A brief overview of potential impacts to groundwater resources has been provided. It is expected that impacts to groundwater during construction and operation phases of the Suai development will be similar.

Construction and operation of the Suai development has the potential to adversely affect groundwater and could potentially result in one or more of the following:

- Localised changes in groundwater quality;
- Localised changes in groundwater flow patterns;
- Minimal effects on groundwater recharge and discharge; 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) ; and
- Accidental spills or releases of chemicals and fuels.

An overview of potential impacts to groundwater resources has been provided. However, a more precise definition of impacts to groundwater quantity and/or quality cannot be quantified at this time due to the lack of sufficient information on local groundwater conditions.

12.4.1 Impacts to Groundwater Quality

A review of the geology within the Suai development area indicates that shallow sediments are primarily comprised of unconsolidated pebbly gravels, sands and fine silts of the Suai Formation. Depth to the water table is between 2 to 10 m below ground surface (mbgs) and the unconsolidated material of the Suai Formation is expected to have a relatively high permeability. Consequently, mitigation measures will need to be undertaken to ensure the impacts of accidental releases of chemicals and fuels are identified in a timely manner such that they do not adversely affect shallow groundwater resources.

New surface facilities for the proposed development include jetties, shore-based facilities, fuel tank farm, RO system and water storage tanks, fire-fighting facilities and accommodation facilities. Accidental releases (including spills and leaks) from surface facilities could negatively impact shallow groundwater quality. The potential risk to receptors (e.g., groundwater users or surface water bodies) will depend on the spatial and temporal nature of the release, the materials released, the site-specific subsurface hydraulic conditions (e.g., depth to groundwater, groundwater flow velocity and adsorption capacity of the soil) and the effectiveness of mitigation measures at the release location.

Onsite disposal of process water also has the potential to introduce contaminants into groundwater and subsequently by groundwater discharge, to surface water systems (i.e., rivers, streams and/or creeks). In many rural to semi-rural areas of Timor-Leste, residents access water through shallow water wells or natural springs. The potential contamination of groundwater via disposal of process water may affect residents that use groundwater for drinking water purposes or as a potable water supply for agricultural purposes. If disposal of process-affected water is incorrectly handled, the potential to adversely affect the quality of baseflow (groundwater discharge to surface water) also exists. The disposal of process water is described in Chapter 17 (Waste Management).

During construction and operation phases, non-hazardous solid waste will be generated from accommodation facilities and during site preparation and construction of surface facilities as described in Chapter 17. Solid waste and effluent that are expected to be generated from the project development may adversely affect shallow groundwater if not properly contained. Domestic effluents are also anticipated during the construction phase. However, it is expected that domestic effluents will be diverted to the waste water treatment plant and as such considered to be non-significant.

Hazardous solid waste and medical waste are also expected to be generated during construction and operation activities. These wastes can potentially affect groundwater quality if not properly handled. Leachate of hazardous waste can potentially cause permanent deterioration of groundwater quality and should be considered a significant potential impact.

Chemicals used during the construction and operation phases of the project may contain a variety of constituents that have the potential to adversely affect groundwater quality if leaked or spilled from tanks/vessels, holding ponds, and/or malfunction of equipment (including pumps or piping). These constituents and their by-products may include various hydrocarbons, glycol, salts, metals, diesel, gasoline, hydrochloric acid, sodium hydroxide, and corrosion inhibitors.

12.4.2 Impacts to Groundwater Flow, Recharge and Discharge

The topography of the island of Timor-Leste is generally mountainous, characterized by rugged terrain and small narrow valleys, with decreasing elevation towards the coastline. It is expected that the topography of Timor-Leste influences the general direction of shallow groundwater flow and also influences groundwater recharge and discharge. It is expected that shallow groundwater recharge occurs regionally within mountainous areas into zones of saturation and generally follows the topography towards the coastline. Groundwater data indicates that shallow groundwater is generally considered fresh (<1,000 mg/L, expressed as TDS), which suggests precipitation is likely the main source of recharge.

The primary impact on the groundwater flow system at the Suai development would be expected from groundwater dewatering and extraction of groundwater for industrial or domestic (i.e., drinking water) purposes. Significant lowering of the groundwater table may adversely affect existing users of groundwater in the future, primarily during dry times (low flows) of the year. Natural springs are fed by groundwater and cannot be maintained if the groundwater table falls. A continued reduction in the water table level from groundwater mining may lead to land subsidence in geologically susceptible areas.

12.4.3 Impacts to Groundwater - Surface Water Interaction

Groundwater is recharged from surface water precipitation and infiltration. Surface water and groundwater interaction are complex events and are susceptible to changes in surface recharge, due to variations in surface features. Interaction may be described as occurring in four basic ways:

- Streams gaining water from inflow of groundwater through the streambed;
- Streams losing water to groundwater by outflow through the streambed;
- Streams that do both, gaining in some parts and losing in others; and

- Alternating between gaining and losing depending on relative stream and groundwater levels.

Adverse impacts to groundwater-surface water interactions may result in changes to surrounding surface water flow volumes due to changes (increases or decreases) in groundwater flow or impacts on surface water quality from contaminated groundwater (baseflow) contribution. Any adverse impacts on groundwater quality (noted above) could also impact surface water systems in which groundwater is the primary source of baseflow. Baseflow contributions have not been calculated as part of this study and therefore no quantification of impacts can be conducted.

12.4.4 Decommissioning Impacts

Given the project lifespan, the decommissioning phase of the project has not been assessed. It is recommended a decommissioning and closure plan will be developed approximately 10 years prior to commencement of decommissioning and the associated environmental impacts related to groundwater assessed as part of the development of this plan.

12.5 Avoidance, Management and Mitigation Measures

To mitigate the potential of adversely affecting groundwater, control measures that can be implemented to minimise the potential adverse impacts on groundwater quantity and quality include:

- Development of groundwater monitoring plans to include a site assessment, baseline monitoring and continued groundwater monitoring, as outlined in Section 12.7;
- Development of a comprehensive spill response plan;
- Development of an environmental monitoring plan for surface and subsurface petroleum storage and distribution facilities; and
- Development of a comprehensive sanitation system and waste disposal plan that complies with internationally-recognized best practice standards.

12.6 Residual Impacts

At this time, there is not enough site-specific groundwater data to quantify residual impacts. However, if mitigation measures and proper management of groundwater resources are not implemented, the Suai development has the potential to adversely affect groundwater resources and these impacts could extend past the life of the project.

Mitigation measures and groundwater monitoring can be implemented in the vicinity of surface facilities and areas of potential groundwater impacts to identify releases and minimize potential impacts. Depending on the nature and volume of the releases, the impacts could extend past the operational life of the project. However, as the conditions of potential spills/releases are unknown the duration of impact can only be predicted as long-term. Effective mitigation measures, such as monitoring, would reduce any residual impacts.

12.7 Monitoring and Reporting

The following recommendations are provided to assist in the development of an appropriate groundwater monitoring plan for the groundwater monitoring and reporting program. The groundwater monitoring plan should be developed in alignment with relevant legislation and regulations (as applicable) and international standards (e.g., WHO Drinking Water Guideline). Components of the groundwater monitoring plan should include:

- Site Assessment
  - Identification of source, pathway and receptors.
  - Description of measures, activities and procedures that will be implemented to ensure groundwater quality and quantity is protected from potential impacts;
- Baseline Monitoring
  - Development of a groundwater monitoring well network to collect further data prior to construction of surface facilities and to establish site-specific baseline conditions for groundwater quality and quantity
  - Establishment of site-specific triggers and limits for groundwater quality and quantity based on an established method; and
- Groundwater Monitoring Plan
  - Rationale for proposed monitoring wells, including location, spatial coverage and target geological zones
  - Selection of primary and secondary indicator parameters to be analysed at specified monitoring wells
  - Proposal of monitoring frequency for specified monitoring wells
  - A summary of the site-specific approaches for assessing and managing potential impacts (e.g., should an established groundwater trigger or limit be exceeded)

12.8 Further Work

Further work is required to further characterize groundwater quality and quantity within and adjacent to the Suai development. This work should include:

- An assessment of existing groundwater users in the vicinity of the Suai development area including drinking water and irrigation water users; and
- A detailed site survey to identify groundwater recharge and discharge areas, potential groundwater dependent ecosystems and current land uses.

Installation of a groundwater monitoring network to determine local groundwater conditions, including, current groundwater quality, groundwater surface elevation and flow direction, estimates of groundwater storage, potential hydraulic connection between surficial aquifers and underlying bedrock and groundwater-surface water interactions.

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Tasi Mane Project – Suai Supply Base Environmental Impact Assessment

CHAPTER 13
TERRESTRIAL BIODIVERSITY

301012-01504-EN-REP-0003
May 2012

13 TERRESTRIAL BIODIVERSITY

A flora and vegetation assessment, and a vertebrate fauna assessment of the Suai development area was carried out in December 2011 and February 2012. The full report is presented as Attachment 1.

Throughout this chapter, the following definitions apply:

- *Conservation status* refers to a species' status listed under the International Union for Conservation of Nature (IUCN) Red List of Threatened Species or in the Convention on International Trade in Endangered Species (CITES); and
- *Conservation significant species* refers to species that have a higher risk of extinction, i.e., those listed as Critically Endangered, Endangered, Vulnerable and Near Threatened under the IUCN Red List of Threatened Species.

The legislation relevant to environmental protection and biodiversity conservation in Timor-Leste includes the following laws and regulations:

- 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;
- United Nations Transitional Administration in East Timor Regulation No. 2000/17; and
- United Nations Transitional Administration in East Timor Regulation No. 2000/19.

The United Nations Transitional Administration in East Timor Regulation No. 2000/19 is particularly relevant to the project as it protects endangered species, wetlands and mangroves, historical and cultural sites, biodiversity conservation, and biological resources.

13.1 Study Method

The flora and vegetation, and fauna study methods are summarised below. Further detail on the methods is provided in Chapter 3 of Attachment 1.

The field surveys were undertaken over 10 days in December 2011 and 6 days in February 2012 at the proposed Suai development site. The field surveys are discussed in more detail below.

13.1.1 Flora and Vegetation

Desktop Review

Historical information and data from previous surveys undertaken in the vicinity of the Suai development area was reviewed. Locally relevant information was also sourced from reference text and academic experts. Data from the IUCN Red List of Threatened Species and CITES was also reviewed.

A list was then compiled of the flora and vegetation species identified and the conservation status of these species, as listed under the IUCN Red List of Threatened Species. For species not listed on the IUCN Red List of Threatened Species, CITES was used to provide an indication of the relative global conservation status of the species.

Vegetation Field Survey

WorleyParsons undertook a broad assessment of plant communities and their distribution, floristic composition and structure in the Suai development area. The assessment included sampling vegetation communities opportunistically at various observation points within the study area. It was not possible to complete a quadrat sampling design in the time available for the surveys, therefore a focus was placed on determining broad vegetation units (i.e., agricultural areas, remnant areas of primary and secondary forest, coastal areas, mangroves and riparian vegetation).

Vegetation descriptions were adapted from those developed by Cowie (2006 and 2007) and presented in Table 4 of Attachment 1. The vegetation classes; lowland forest, highland forest, montane forest, wetland forest, coastal forest and man-made forest, and descriptions were used during the field survey to identify vegetation communities, structure and dominant species composition.

Flora Field Survey

Within the Suai development area, a greater emphasis was placed on the flora survey than the vegetation survey. The flora field survey focussed on common and dominant species, and species of conservation and economic importance. Quantitative sampling and recording structural attributes was not undertaken given the limited timeframe for assessment.

During the field survey, WorleyParsons took photographs of live specimens and collected various samples of plant life forms including trees, shrubs, herbaceous species, vines, ferns, and epiphytes (non-ferns). WorleyParsons also recorded the conservation status of the flora species, and obtained their local Tetum names, where known.

All of the plant specimens collected were pressed for several days in a field press, before being preserved (for the short term) using a technique described by Forman and Bridson (1989) in Attachment 1. This technique is suited to the wet tropical conditions experienced at the time of survey. On return to Australia, the pressed plant specimens were submitted for gamma irradiation to meet Australian Quarantine Inspection Service (AQIS) regulations. This process took approximately four weeks for the plant species collected in December 2011, and three weeks for the plant species collected in February 2012. The species were then submitted to the Northern Territory herbarium for identification.

13.1.2 Fauna

Desktop Review

Similar to the flora and vegetation survey, the vertebrate fauna survey involved a review of historical information and data from previous surveys undertaken near the Suai development area. Data from

the IUCN Red List of Threatened Species, the Birdlife International Database and CITES was also reviewed. Locally relevant information was also sourced from reference text and academic experts.

Following review of this data, a comprehensive inventory of local fauna species was developed. 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, i.e., extinct species, were excluded from this inventory.

Fauna Field Survey

The focus of the fauna field survey was to identify broad fauna habitats based on vegetation associations and known landforms. Once identified, the fauna habitats were mapped and 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. Seven vertebrate fauna habitat assessments were conducted in the Suai development area.

Opportunistic observations were undertaken of vertebrate fauna species present, as it was not possible to conduct a detailed fauna survey in the time available.

Acoustic ultrahigh frequency equipment (Anabat) was used to record the presence of microbats. The equipment was placed in the study area to achieve a broad coverage but, is also designed to target potential maternal and breeding roosts. The location of the anabat recordings and the habitat assessment areas are shown in Figure 13-1.

Active searching for ground dwelling reptiles and mammals was also undertaken, which included searching and recording scats, tracks and other traces; digging up burrows; turning over rocks and logs; splitting fallen timber; raking soil and leaf litter; peeling off bark; and searching rock habitats (in cracks and caves, around water bodies and in holes in fence posts).

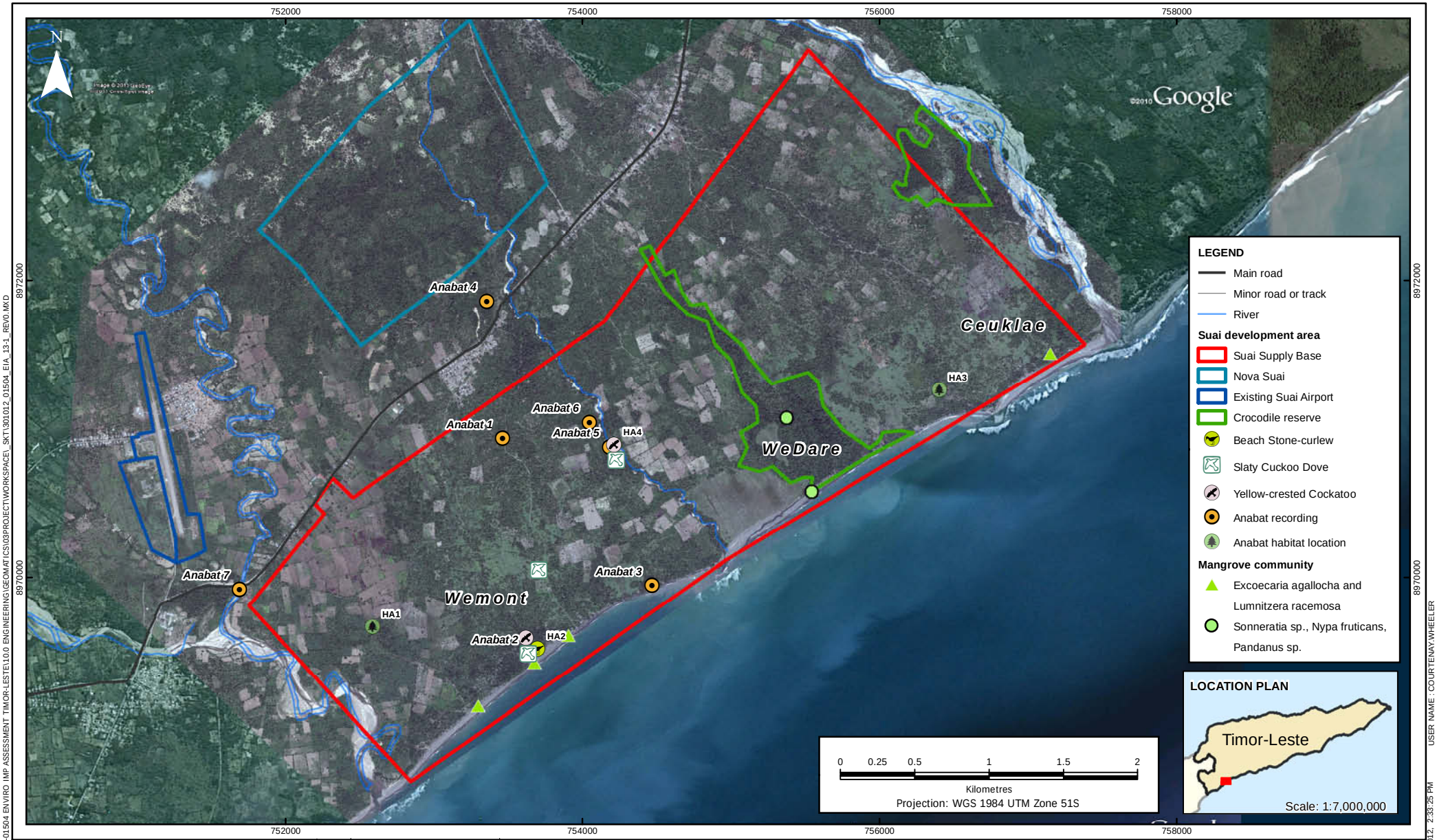
In addition, call play back was used for avian species which are known to respond to species calls for active identification in the study area.

Limitations

Flora and Vegetation

Due to the limited time available for field surveys, the flora and vegetation assessments were undertaken at the same time. The surveys focused on determining vegetation structure, dominant species and plants of interest. Less emphasis was placed on ferns, herbs and other non-dominant flora.

Detailed mapping of vegetation communities was not undertaken during the field surveys as extensive ground-truthing and detailed inventories from plots/quadrats is required for this level of assessment.



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5. Cultivated land: WorleyParsons (2012)

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Figure 13-1
Suai study area biodiversity key sites

In addition, it was not possible to record all species present at the Suai development area given the limited survey period. Lichens, bryophytes (mosses and liverworts), epiphytes, and parasitic plants occurring high up in the tree canopy, were also not included in survey.

Flora surveys are ideally undertaken at the best time of year for detecting the most plant species, and across multiple seasons in order to capture seasonal variation. As such, the timing of the field surveys, during the wet season, has limited the plant species that were able to be recorded at the site.

Fauna

Similar to flora surveys, fauna surveys are ideally undertaken at the best time of year for detecting the most fauna species, and across multiple seasons in order to capture seasonal variation. As such, the timing of the field surveys, during the wet season, has limited the fauna species that were able to be recorded at the site. The length of the surveys (16 days) was also insufficient to accurately identify all species that potentially occur in the study area.

The lack of existing baseline data limited the assessment of project impacts on population, distribution and ecological occurrences of fauna. Further work recommendations, such as additional surveying and ground-truthing, have been made in Section 13.6 to address these limitations.

13.2 Existing Environment

Timor-Leste is located in the Malay Archipelago and represents the largest and eastern-most of the Lesser Sunda Islands (World Bank, 2009 in Attachment 1). The island is 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 in Attachment 1).

13.2.1 Vegetation Communities

Vegetation within the Suai development area consists primarily as narrow bands of open coastal forest with small areas of mangroves, riparian vegetation and moist deciduous lowland forest. The coastal plain has largely been cleared for villages, associated agriculture and small teak and coconut plantations. A large area established for rice cultivation within the Suai Supply Base site is now no longer used.

Remnant vegetation exists as highly fragmented and secondary communities along drainage channels and in isolated patches that are no larger than 20 ha. Most of the understorey within remnant vegetation and agricultural land is dominated by invasive weeds, particularly Siam weed (*Chromolaena odorata*).

The Suai Supply Base lies between two major rivers; Rio Raiketan (to the east) and Rio Camanasa (to the west), on a broad coastal plain, and is intersected by several minor (predominantly dry) rivers and numerous drainage channels. Low lying areas between the rivers and drainage channels are frequently inundated during the wet season (October to January).

The vegetation communities recorded in the Suai development area are summarised below, with their recorded distribution shown on Figure 13-2.

Coastal Vegetation

Coastal vegetation within the Suai development area includes the *Pes-caprae* formation. *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* This formation was highly degraded and largely disturbed by cattle grazing and water erosion. The area is dominated by *Borassus flabellifer* and *Corypha utan* palms and introduced timber trees along with some thickets of *Acacia*/*Vachellia* spp. Also present were introduced crop trees such as candlenut and tamarind, teak, and weed tree species such as coffee bush. There are also food plants including Timor cherry, mango, breadfruit and jackfruit. The majority of tree species appear to be deciduous in the dry season, apart from palms, and the vegetation community lacks floral diversity overall.

The *Borassus flabellifer* open forest was recorded within the Suai Supply Base area with *Schleichera oleosa* and occasional *Casuarina* sp. affin. *junghuhniana* interspersed with agricultural land. The majority of the understorey had been invaded by *Chromolaena odorata and Jatropha* sp. shrubs. Introduced pasture grasses have been extensively grazed by buffalo.

The vegetation at Nova Suai is predominantly open coastal forest with very little understorey and a heavy infestation of Siam weed and bellyache bush. 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 understorey dominated by *Tabernaemontana pandacaqui*.

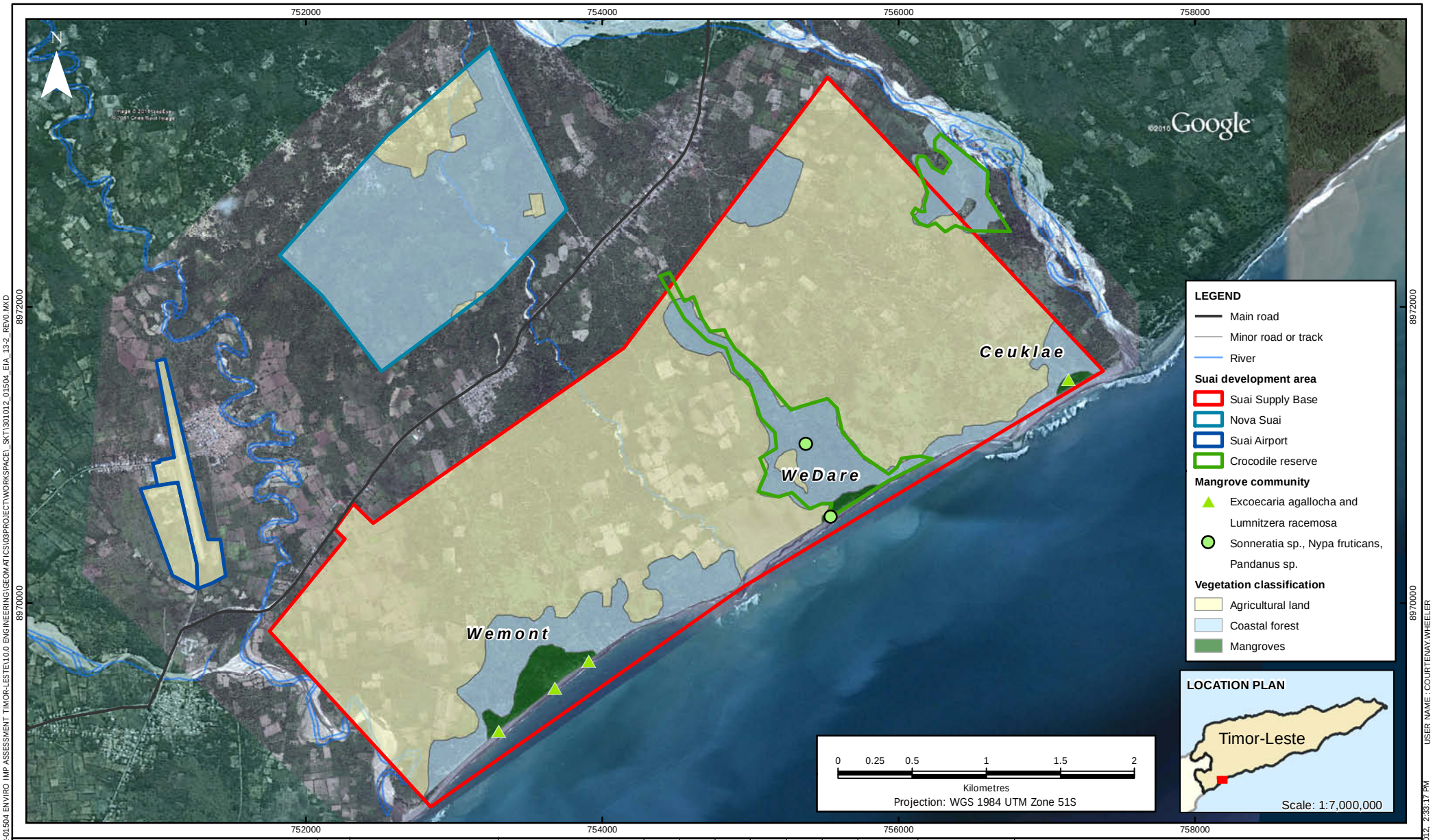
Riparian Vegetation

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 present within the Suai development area includes *Bambusa vulgaris* (bamboo), occasional *Pterocarpus indicus*, *Albizia lebbeckoides* and infestations of Siam Weed. Riparian vegetation is predominantly deciduous during the dry season (Plate 13-1).

Mangroves

Several mangrove communities were present at the Suai Supply Base on beaches, at brackish inlets and at lagoons (Plate 13-2), including at the proposed location of the jetty infrastructure as shown in Figure 13-2. The dominant mangrove present was *Excoecaria agallocha* (ai-tano). It was found growing on the beach and in mud further back from the beach. *Lumnitzera racemosa* (ai-biku) was the second dominant mangrove found in sand and mud.

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. Vegetation within this mangrove community included trees, shrubs and epiphytes including *Drynaria quercifolia* (basket fern), *Pyrrosia longifolia* (fern) and *Dischidia major* (rattle skulls) on large trees.



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5. Vegetation communities: WorleyParsons (2012)

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Figure 13-2
Vegetation communities within the Suai development area

Source: Unknown

Plate 13-1 Riparian vegetation on a dry river bank

Source: Unknown

Plate 13-2 Mangroves in the Suai development area

One of the proposed crocodile reserves is located in an area known by the Suai community as 'We Dare'. The vegetation within this area is relatively undisturbed deciduous coastal forest. A mangrove community was recorded on the beach within this area, with the dominant species being *Sonneratia alba* (white-flowered apple mangrove), *Pandanus* sp. and *Nypa fruticosa* (mangrove palm).

Vegetation of Conservation Interest

Mangroves are of particular conservation interest in the Suai development area as they stabilise soils, reduce coastal and soil erosion, and provide important marine and fauna habitat. Mangroves are also valued for their economic benefits; however, they are regularly cut for timber. While the mangroves are under the UNTAET Regulation No. 2000/19: Section 5 'Wetlands and Mangroves', prohibiting any destruction of this vegetation type, exploitation still occurs.

13.2.2 Flora

These results focus on the dominant flora species, conservation significant flora, economically important flora species and weed species.

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 of the Terrestrial ecology report (Attachment 1). Local Tetum names have been recorded where possible.

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

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 (Attachment 1). None of these were recorded in the Suai development area during the field surveys.

Santalum album (Sandalwood), listed as Vulnerable on the IUCN Red List, was identified in very low numbers at Nova Suai. It is a highly sought after timber and was found as a young tree and not at harvestable age.

Pterocarpus indicus (Tetum ai-na), a tall timber species useful for soil stabilisation and adding nitrogen to soil, was also identified at Nova Suai. It was found on the banks of a dry river bed. It is listed as Vulnerable on the IUCN Red List, mainly because of overexploitation which has seen a decline in its population.

Also present in low quantities, sheoak trees (*Casuarina* sp. aff. *Junghuhniana)*, thought to be an important habitat for the yellow-crested cockatoo, were recorded in various locations along the sandy beaches of south Timor-Leste.

Species of conservation interest identified in the Suai development area are shown on Figure 13-1.

Species of Interest and Economic Importance

Eleven species were identified in the Suai development area as having local and economic importance (see Figure 13-1). These species are listed below in Table 13-1:

Table 13-1 Species of local importance and/or economic interest 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

Estates

Small plantations or estates of coconuts, bananas and occasionally mango were present in the Suai development area.

Teak Plantations and Woodlots

The Suai Supply Base will be located near various State Forest Plantations (Plate 13-4). The following species had been planted in the area:

- *Tectona grandis* (Teak);
- *Gmelina arborea* (Gmelina);*Senna siamea* (Johar);
- *Albizzia chinensis* (Sengon);
- *Pterocarpus sp*. (Kayu merah);
- *Swietenia sp*. (Mahogany);
- *Santalum album* (Sandalwood);
- *Aleurites moluccana* (Kemiri); and
- *Anacardium occidentale* (Cashew).

Weeds and Invasive Species

A total of nine major weed species were identified in the Suai development area, including:

- *Chromolaena odorata* (Siam weed); all locations
- *Imperata cylindrica* (Cogan grass); all locations
- *Lantana camara* (Lantana); Suai Supply Base
- *Vachellia nilotica* (prickly *Acacia*); Suai Supply Base, Suai Airport
- *Calotropis gigantea* (crown flower); all locations
- *Jatropha gossypifolia* (bellyache bush); all locations
- *Chrysopogon aciculatus (*golden false beardgrass); all locations
- *Leucaena leucocephala* (coffee bush); all locations
- *Zizyphus mauritiana* (jujube, Chinese apple); all locations.

Siam weed was the most widespread weed throughout the Suai development area. It is a highly invasive weed, estimated to cover more land than any other plant species in Timor-Leste (Cowie, 2006 and 2007 in Attachment 1), and affects about one-fifth of all cropland (World Bank, 2009 in Attachment 1).

13.2.3 Fauna

Fauna Habitat

Four broad habitat types were identified in the Suai development area and these include:

- Deciduous Woodland/Forest: Woodland defined as trees and shrubs that are less than 30 percent of the tree canopy cover;
- Coastal: Includes three subclasses; Mangrove forest, Dune forests – mixed species and Coastal dunes and reef platforms;

Source: Unknown

Plate 13-3 Typical corn crop

Source: Unknown

Plate 13-4 Typical teak plantation

- Riparian: Includes drainage lines (major and minor), drainage basins, creek lines and water catchments, associated vegetated banks; and
- Swidden Agriculture: Includes man-made plantations and associated fringing vegetation and habitat.

Fauna Assemblages

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 research considered a wide range of habitats. The vertebrate fauna list is presented in Appendix 5 of the Terrestrial Ecology Technical Report (Attachment 1).

Within the Suai development area, a total of 68 vertebrate fauna species were recorded, including 2 species of amphibians, 7 species of reptiles, 48 species of birds and 11 species of mammals. These are discussed below.

Amphibians

The two amphibians identified within the Suai development area were the common Indian toad (*Duttaphrynus melanostictus*) and the Indian bullfrog (*Fejervarya* sp.).

Reptiles

Seven species of reptiles were identified in the Suai development area, 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

Forty-eight species of birds were identified within the Suai development area. 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

Eleven species of mammal were recorded in the Suai development area, including: domestic dog/dingo (*Canis familiaris*), domestic pig (*Sus scrofa*), Bali cattle (*Bos javanicus*), domestic cattle (*Bos taurus*) and the domestic goat (*Capra hircus*).

Bats

Two species of bats were recorded in the Suai development area. These were 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. The bat analysis results are presented in further detail in Appendix 6 of the Terrestrial Ecology Report (Attachment 1).

Conservation Significant Fauna

The desktop review identified 34 species of conservation significance that either had the potential to occur, or had been previously recorded, in Timor-Leste.

Five of these species were recorded in the Suai development area (Figure 13-1) in the recent field survey, with the remaining 29 species either being 'Likely', 'Possible' or 'Unlikely' to occur in the development area (Figure 13-1). The conservation status of the five recorded species is listed in Table 13-2.

Table 13-2 Conservation status of the fauna species recoded during the field survey

Common Name	Conservation Status (IUCN Red List of Threatened Species)
Beach thick-knee	NT (Near Threatened)
Slaty cuckoo dove	NT (Near Threatened)
Yellow-crested cockatoo	CR (Critically Endangered)
Timor (white-bellied) bushchat	NT (Near Threatened)
Canut's horseshoe bat	VU (Vulnerable)

Two of the fauna species identified, the Christmas Island frigatebird ('Possible' to occur) and the yellow-crested cockatoo ('Recorded') are listed on CITES Appendices I or II and therefore, considered 'Endangered' under Regulation 2000/19.

The yellow-crested cockatoo, listed as Critically Endangered on the IUCN Red List of Threatened Species, was sighted at the Suai Supply Base location. Up to 11 individuals were recorded on five occasions within the Suai development area only. This species was recorded foraging and roosting in sheoak (*Casuarina* sp. affin *junghuhniana*) as well as flying overhead.

Two cave-roosting bats were identified as species of conservation interest. These were the horseshoe bats, i.e., 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 of Threatened Species.

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.

Endemic Fauna

Timor-Leste has the highest rates of endemism recorded in Indonesia (10.3%), especially for frogs, skinks and geckos. The yellow-crested Cockatoo, Timor white eye and the black banded fly catcher are all endemic to Timor-Leste.

13.3 Environmental Impacts

In the absence of detailed engineering design for the Suai development area, this ecological assessment was based on the conservative assumption that there is to be 100% clearance of all

vegetation and agricultural land within the Suai development area, with the exception of the natural habitat area to be retained for the crocodile reserves.

Potential environmental impacts for flora, vegetation communities and fauna as a result of construction and operations therefore includes:

- Loss of individuals of IUCN listed species; sandalwood (*Santalum album*), rosewood (*Pterocarpus indicus*), 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;
- Loss of fauna habitat, specifically important habitat for species of conservation significance;
- Changes to fauna habitat and assemblages.
- Changes to conservation significant fauna.
- Increased noise disturbance to fauna species;
- Increased potential of vehicle strike due to construction and operational vehicles; and
- Increased erosion potential and sedimentation due to soil disturbance.

Impacts to conservation significant species

Species listed as Critically Endangered, Endangered, Vulnerable and Near Threatened under the IUCN Red List constitutes 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 as reported previously in Section 13.2.3. 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.

In addition, mangrove communities in the Suai development area represent some of the only remnant vegetation in good condition and are considered to have conservation significance.

13.4 Avoidance, Management and Mitigation Measures

13.4.1 Flora and Fauna

Retention of Native Vegetation and Habitat

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.

Mitigation measures will be developed for construction works to reduce the extent of vegetation clearance. A reporting and responses system will be implemented to ensure that vegetation clearing activities are controlled and monitored.

As previously reported, the yellow-crested cockatoo is Critically Endangered and was recorded on five occasions within the Suai development area, making Suai potentially sensitive to environmental impacts proposed by the project. Vegetation clearance, specifically of *Casuarina sp. affin junghuhniana*, identified as a key habitat of this species, should therefore be avoided.

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 of temporary use during construction (such as lay-down areas and labour camps) within the Suai Supply Base area can be rehabilitated and revegetated.

Weed Hygiene

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.

A weed management plan will be prepared as part of the environmental management system for the Suai Supply Base.

Water Discharge and Drainage Controls

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 any remnant mangrove vegetation and the two crocodile reserve areas.

13.5 Monitoring and Reporting

13.5.1 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.

13.6 Further Work

13.6.1 Flora and Vegetation

It is recommended that additional baseline flora and vegetation assessments are undertaken at the Suai development area, including:

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

13.6.2 Fauna

It is recommended that additional fauna surveys are undertaken in each season. It is also recommended that:

- The duration of field trips are extended to ensure a more thorough survey. This will also ensure potentially critically endangered species are recorded; and
- Seasonal surveys
- Further work on the yellow-crested cockatoo to identify specific habitat requirements, the abundance and distribution of nesting sites and their tolerance to varying disturbance. A species-specific monitoring program should be established.

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Tasi Mane Project – Suai Supply Base Environmental Impact Assessment

CHAPTER 14
MARINE ECOLOGY AND FISHERIES

301012-01504-EN-REP-0003
May 2012

14 MARINE ECOLOGY AND FISHERIES

A marine ecology and fisheries assessment of the Suai development area was carried out in December 2011 and February 2012. The full report is presented as Attachment 2.

There are several laws and regulations from previous administrations (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.
- United Nations Transitional Administration in East Timor (UNTAET) Regulation No. 2000/17.
- United Nations Transitional Administration in East Timor (UNTAET) Regulation No. 2000/19.

UNTAET Regulation No. 2000/19 on protected places (30 June 2000) was established 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 East Timor. 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.

14.1 Study Method

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 and 22 February 2012.

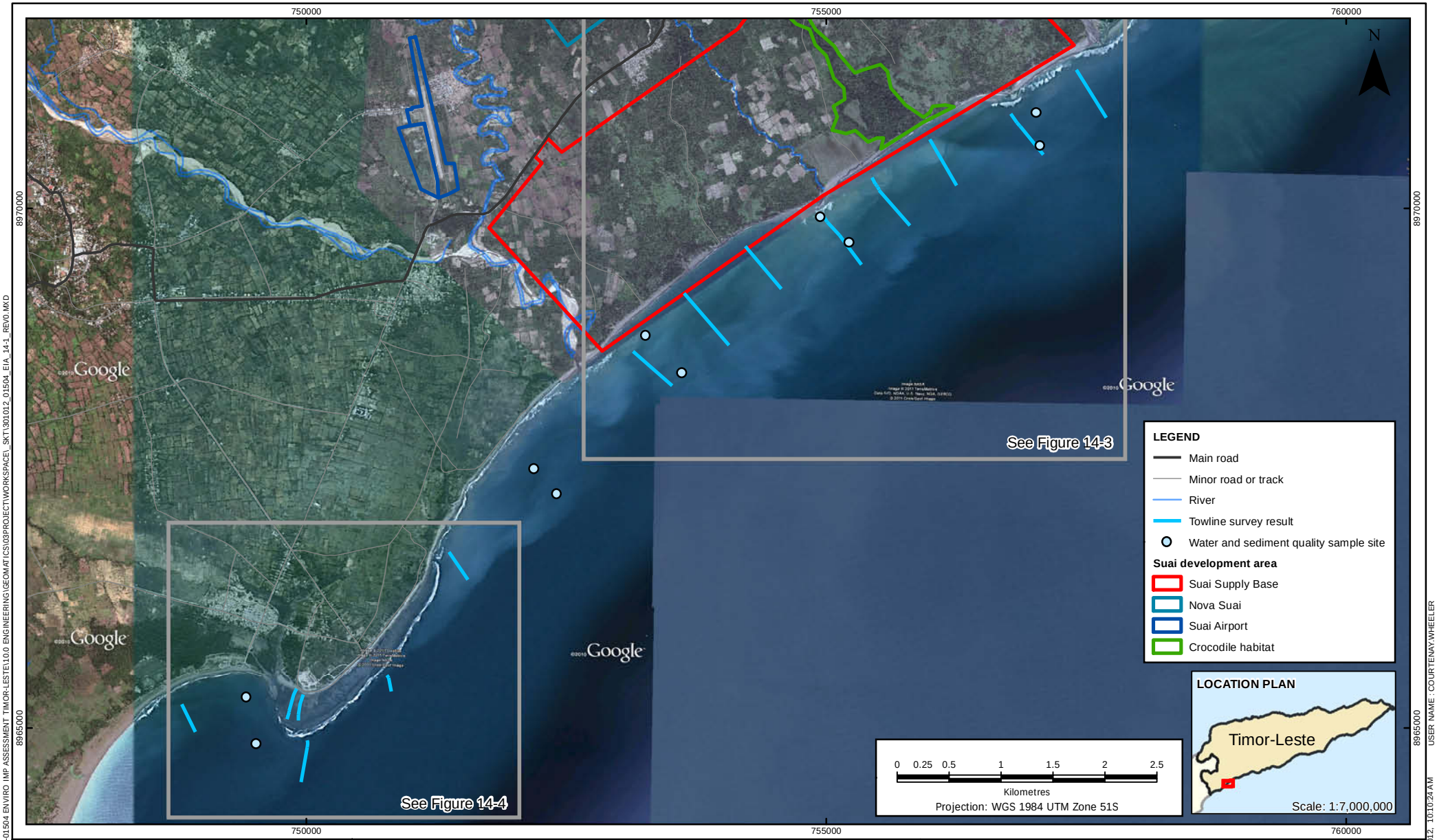
A total of five inshore and five offshore samples were collected at the sites (Figure 14-1). Inshore sites were located between 4 to 8 m depth. Offshore sites were in up to 20 m depth.

14.1.1 Water Quality

A physicochemical water quality profile was obtained by recording measurements at 1 m intervals from the water surface to the seabed at each of the sampling sites. Two depth profiles were recorded at each sampling site.

The following parameters were measured:

- Temperature (°C).
- Salinity (parts per thousand (ppt)).
- pH.
- Conductivity (NS/CM).



NOTES:

This map contains:
1. Imagery: Google Earth (2010)
2. Imagery: DigitalGlobe (2008 - 2011)
3. Rivers: Geographic Information Group TimorLeste (2010)
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Figure 14-1
Suai marine study area and sampling sites

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USER NAME: COURTENAY.WHEELER

- Dissolved Oxygen (DO; % saturation and mg/L).
- Turbidity (nephelometric turbidity units [NTU]).

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

- Total metals [cadmium (Cd), chromium (Cr), copper (Cu), mercury (Hg), lead (Pb), nickel (Ni) and zinc (Zn).
- 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.

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.

14.1.2 Sediment Quality

Surface sediment samples (0 to 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. Each sample was then stored at 4°C and couriered to a NATA accredited laboratory for analysis.

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).
- Particle Size Distribution (PSD).

As no sediment quality guidelines exist for Timor-Leste, the interim sediment quality guideline (ISQG) found in ANZECC/ARMCANZ (2000) was used to assess sediment quality. Laboratory results were collated, concentrations were tabulated and any spatial trends identified. All values were then compared with relevant sediment quality criteria.

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.

14.1.3 Benthic Habitat

Video footage 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 from the shoreline (Figure 14-1). Each transect commenced in a depth of approximately 2.5 m extending out to the 10 m depth contour. A total of eight transects were completed distanced approximately 600 m apart.

For the purpose of generating a habitat map, biota was defined as:

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

14.1.4 Plankton

A plankton net was towed behind a vessel travelling at <1 knot over a 100 m transect at each site. 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.

Following treatment, the entire sample was placed in a 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. The total sample volume was sorted for plankton, fish eggs and fish larvae.

14.1.5 Infauna

Surface sediment samples (0 to 0.3 m) were collected using a Van Veen grab. A total of three replicates were collected per sample location.

Macroinvertebrate samples were processed and fauna identified at Benthic Australia laboratories. The sediment and fauna were placed in a 125 µm sieve. Following washing and sorting, 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.

Statistical analysis of the plankton and marine benthic fauna was conducted using the methods and software packages as outlined in Section 3.5.3 of the Marine Ecology and Fisheries Technical Report (Attachment 2).

14.1.6 Data Assumptions and Limitations

The assessment is based on a draft conceptual layout of the proposed Supply Base. As the layout may be subject to further design amendments, the assessment should be considered preliminary in

nature and subject to further assessment as the design is further developed and additional technical information is collected. As an example, the locations of any dredged channel and dredge spoil disposal sites were not known at the time of assessment.

Data collection is also based on a limited field survey undertaken during the wet season.

14.2 Existing Environment

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 slope steeply to the seabed. In some places along the southern coastline, water depths of 200 m can be found less than 1 km offshore. 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 of the project area show turbid plumes moving from east to west along the coastline.

14.2.1 Water Quality

Results collected during the field investigation between 16 December and 18 December 2011 indicate that marine water quality conditions at Suai are generally 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.

Turbidity recorded at nearshore and offshore sites showed a large variation. Nearshore sites varied between 0.6 NTU and 47.4 NTU while offshore sites ranged between 3.1 NTU to 20.0 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 14-1). Higher values were most likely associated with high rainfall events and the associated run-off.

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. These elevated levels are likely the result of fertiliser use within the predominantly agricultural catchment.

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 (Figure 14-2).

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.

Table 14-1 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

14.2.2 Sediment Quality

Concentrations of total nitrogen and phosphorus were relatively high in coastal sediments. Total nitrogen concentrations observed at all sampling sites were composed of 100% organic nitrogen (TKN) which indicates that nitrogen found in sediments within the study area is organic in origin. The most likely source of organic nitrogen in the study area is agriculture along the Karoulin and Raiketan rivers. Organic nitrogen in natural fertilizer is washed from the catchment before discharging into the sea (Carpenter *et al.*, 1998).

Concentrations of phosphorous were consistent across all sites with no trend apparent.

All metal concentrations in marine sediments were less than the ANZECC/ARMCANZ (2000) sediment quality guidelines except for nickel.

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

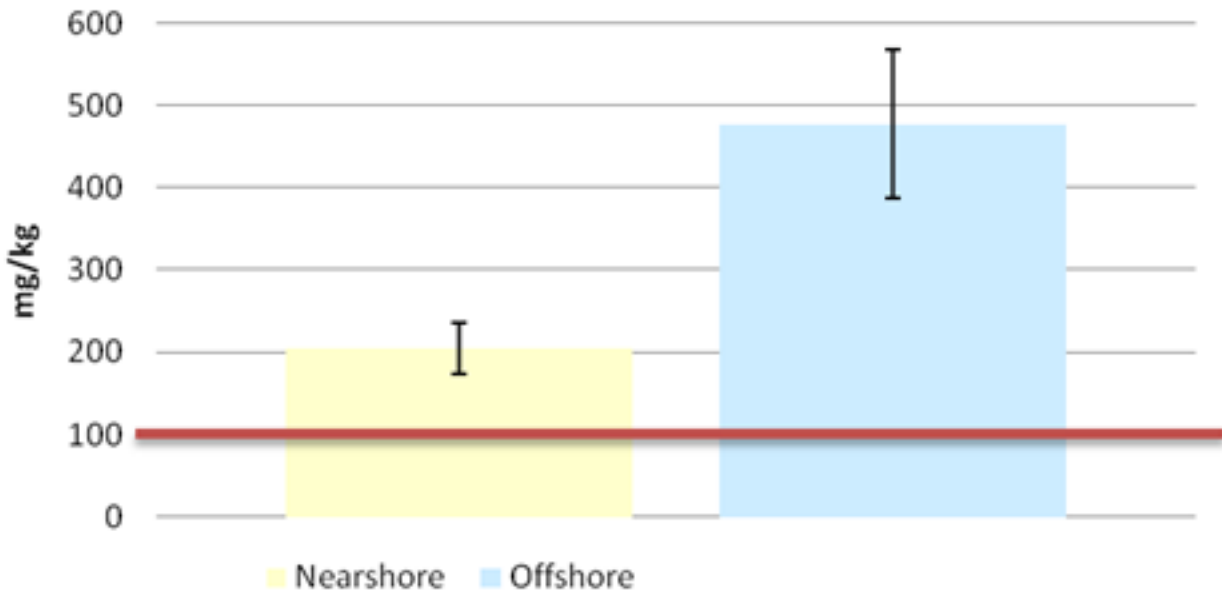

Figure14-2 Mean nitrogen values for nearshore and offshore sediment, with the ANZECC guideline value shown in red

Plate 14-1 Most abundant fauna collected in benthic grab samples. Top left – Hydrozoan; top right – Tellinidae; bottom – Terebellidae (representative photograph only)

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Figure 14-2
Plate 14-1

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14.2.3 Fauna and Habitat Values

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 enhance 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 study area was weathered coastal limestone.

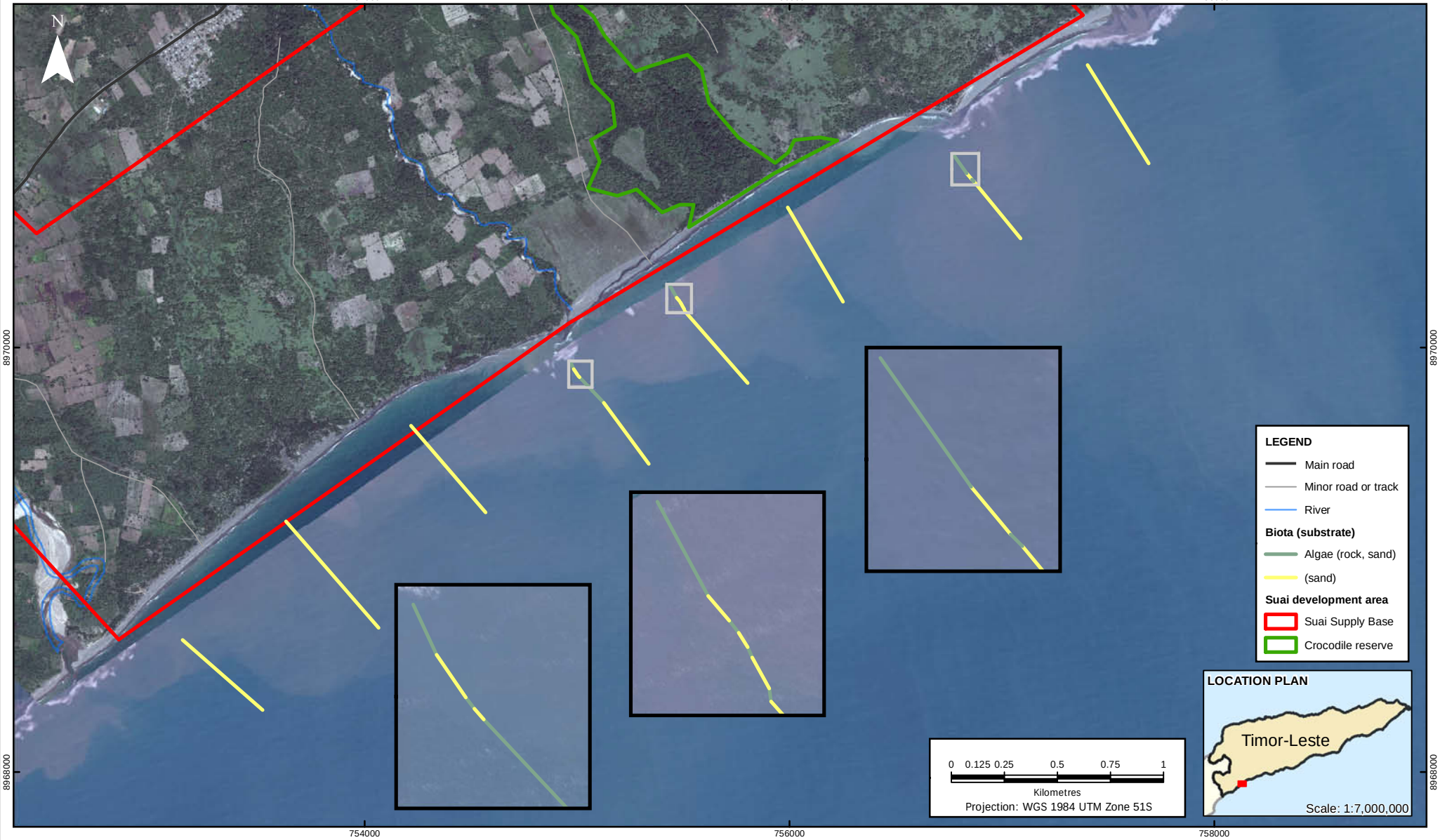
Within the study area, the biotic benthic community was dominated by turfing brown algae. The turf algae was primarily associated with areas of hard substrate and generally had <25% coverage. There is also a fringing coral reef located south west of the main Suai study area (Figure 14-3 and Figure 14-4).

This fringing reef south west of 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 10 m of the surface which then gradually declines below 10 m as depth increases and light diminishes. The band of rich coral growth is very narrow, being approximately 50 m wide.

A high diversity of coral reefs exist in southern Timor-Leste with 301 to 500 species identified (Burke *et al*. 2002). The most extensive coral reefs occur along the northern and far eastern sections of the coastline. Along the southern coastline, small sections of reef occur near Suai, Betano, Beaco and east of Iradarate (Coral Triangle Atlas, 2012).

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 study area. Meadows identified within the study area were generally limited in extent.

The macroinvertebrate communities during the baseline sampling event were species rich in polychaetes (a type of marine worm) and crustaceans, each contributing to 29% of the community fauna (Plate 14-1). 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).



NOTES:
This map contains:
1. Imagery: DigitalGlobe (2008-2011)
2. Rivers: Geographic Information Group TimorLeste (2010)
3. Roads: DivaGIS (2010)
4. Biota and substrate: WorleyParsons (2012)

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Figure 14-3
Suai benthic habitat tow paths

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NOTES:
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2. Imagery: DigitalGlobe (2008 - 2011)
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Figure 14-4
Suai reef area benthic habitat tow paths

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14.3 Environmental Impacts

Activities associated with construction and operation of the Suai Supply Base that have the potential to adversely affect the marine environment include:

- Construction and physical presence of new marine structures within the marine environment.
- Dredging and reclamation activities.
- Operation of the desalination plant.
- Operation of the wastewater treatment plant.
- Construction and operational aspects associated with spills, discharges and runoff.

The activities outlined have the potential to impact marine communities through the following:

- Changes to local hydrodynamic and coastal processes.
- Changes to water quality.
- Changes to sediment quality.
- Direct and indirect changes to benthic habitats and infaunal communities.
- Changes to fisheries resources.

14.3.1 Water Quality

Suspension of Sediments

Many aspects of the construction process will disturb and resuspend benthic sediments, including:

- Rock placement for breakwater construction.
- Land reclamation and shore protection.
- Pile driving for jetties.
- Pipeline installation for discharge outlets.
- Dredging.
- Dumping of dredge spoil.
- Other in-water construction activities.

During port operation, ship wash (waves) and propeller turbulence in shallow water can erode the shore and stir bottom sediments, re-suspending sediments. Areas with intense vessel traffic e.g., the harbour entrance and vessel turning basins will be more heavily affected.

Dredging may be required to achieve a safe navigation depth into the Suai Supply Base. The volume, type of dredged material and dredging method have not yet been defined but, will require further consideration to ensure that potential impacts are kept as low as reasonably practicable.

Impacts from dredging are primarily related to sedimentation and turbidity effects on benthic primary producers e.g., corals and seagrass, which can lead to indirect impacts on other species reliant on these habitat types for food, shelter and breeding. Ambient levels of turbidity and sedimentation are

likely to be high along the Suai coastline, particularly during the wet season and will require further consideration in defining water quality trigger levels for dredging.

Maintenance dredging is expected to be required, although the frequency and volume are yet to be determined as they are dependent on the rate of sediment accumulation within the harbour. The resuspension of sediments can arise due to seabed excavation, loss from the dredger whilst loading, loss of material during transport and the disposal of dredged materials. The intensity and extent of impact will depend on the frequency and volume of dredging and the method of dredging and material disposal.

The resuspension of sediments in the water column reduces water quality due to:

- Increased concentration of suspended solids.
- Reduced light penetration.
- Increased nutrient concentration through the mobilisation of organic material, biologically available nitrogen and phosphates from the sediment.
- Increased concentrations of toxicants including heavy metals and organic compounds from sediments.

These changes in water quality can have physical, chemical and behavioural effects on marine biota (Anchor Environmental C.A. L.P., 2003), including:

- Changes in respiration and clogging of respiratory structures.
- Changes in feeding rates and clogging of feeding structures in suspension feeding organisms.
- Reduced growth rates and reproductive success due to sediment loading.
- Increased growth due to higher nutrient availability.
- Contamination and poisoning from the accumulation of heavy metals and organic compounds.
- Slowed photosynthesis and primary production due to reduced light penetration in the water column.
- Altered behaviour, such as avoidance, altered schooling behaviour, cover abandonment, or attraction (as a potential food source or cover).

Sediments within the study area are generally uncontaminated, with the levels of cadmium, chromium, copper, lead, zinc and mercury all well below ANZECC trigger values for sediment quality (ANZECC/ARMCANZ (2000). No impacts from mobilised contaminants are expected.

Sediments within the study area have relatively high concentrations of nitrogen (100 to 840 mg/kg) and phosphorus (400 to 600 mg/kg). The mobilisation of nutrients may cause a rapid increase in phytoplankton abundance leading to depleted dissolved oxygen. In open waters, currents will rapidly replenish oxygen and any impacts will likely be short-lived. In areas of low water movement, as may be created within the harbour, mobilisation of nutrients may lead to eutrophication.

Discharges, Spills and Runoff

Discharges, spills and runoff can all reduce water quality. During construction, discharges or spills may occur from construction vessels and runoff from land-based construction areas. During operation vessels, cargo handling and waterfront industry are sources of runoff, discharges and spills into the marine environment. Most reported oil spills occur within port and harbour areas, most are small and result from normal operations such as loading and refuelling (e.g., WA EPA, 2007b). They often arise due to faulty equipment, poor procedures and accidental or intentional discharges of wastes.

Discharges may include oily bilge and ballast water, sewage and other wastes. Spills may include lubricants, hydraulic oils, fuels and paints. Site runoff during construction would typically be sediment-laden water but, may also be contaminated with concrete, paints and oils. Operational site runoff may be contaminated by spilt fuel, bulk product, paint residues and sediment.

Spills and discharges can cause adverse impacts on water quality and marine ecosystems. Spilt oils initially float, forming a thin surface layer that can quickly spread over a large area. Oils and other substances can be acutely toxic to marine biota and may contaminate fisheries resources. Repeated small spills and discharges lead to the accumulation of hydrocarbons in surface waters and sediments. Repeated small spills can have chronic effects on marine biota, including reduced growth and reproduction, ultimately reducing population viability (e.g. Dicks *et al*, 1982; Guzmánand Holst, 1993).The biodegradation of oil consumes dissolve oxygen from the water further reducing water quality and this can have additional impacts on marine biota.

Desalination Plant Operation

The potential environmental effects of reverse-osmosis (RO) desalination plants have been widely studied and summarised (see Tularam and Ilahee, 2007; RPS, 2009). Impacts on water quality and marine ecosystems are primarily related to the discharge. The Suai Supply Base RO plant is a small plant, producing 15 kl per hour. Assuming a typical recovery of 40%, this plant's discharge volume is expected to be relatively small, at approximately 22.5 kl per hour.

Brine discharged by RO plants typically has a salt concentration twice that of seawater. The discharge may also have a slightly elevated temperature (<2°C above ambient) and contain traces of anti-scalants, flocculants, biocides and cleaning chemicals used in the plant. The brine is denser than seawater and generally sinks from the point of discharge. Consequently, any impact on water quality and marine life is more likely to occur in bottom waters and on the seabed. The long-term effects of the discharge of trace chemicals are largely unknown; however, elevated salinity is generally considered the primary environmental stressor. High salinity may be acutely toxic, causing dieback of marine biota at the outlet. Exposure to slightly elevated salinity in the area adjacent to the outlet may have chronic effects on marine biota, leading to a gradual shift in community structure.

The intensity and extent of impact from the discharge are highly dependent on the volume and concentration the discharge, and the rate of dilution. The rate of dilution is in turn dependent on the situation and design of the outlet, and turbulence in receiving water caused by currents, waves and tides. Rapid dilution reduces the risk of intense impact but, increases the area of low risk.

When discharges are released to a well-flushed environment, the impacts of even large desalination plant discharges tend to be minor (Roberts *et al*, In Press). The planned small RO plant, with low

volume discharge, is unlikely to have any acute salt toxicity or chronic exposure effects, provided there is adequate dilution and dispersal of the discharge.

Wastewater Treatment Plant Discharge

Water quality may be impacted by the long-term discharge of pathogens, nutrients and toxicants in treated wastewater.

Effluent from wastewater treatment plants typically contains viruses, bacteria and other microorganisms and its discharge may lead to unsanitary water quality. The magnitude of contamination depends on the level of treatment employed. Primary treated effluent can have a bacterial load of up to 10 million colony forming units (cfu) per milliliter. Secondary treated sewage typically contains 1000 to 10 000 cfu/ml. With an active disinfection process, this can be reduced further to less than 100 cfu/ml. This level of treatment is suitable for subsurface irrigation (EPA VIC, 2002) but in the marine environment may pose a threat of disease transmission through primary contact recreation and the contamination of shellfish fisheries.

The primary impact of the discharge on marine biodiversity is likely to be through increased nutrient loading. Treated wastewater contains nitrogen and phosphorus. Increased nutrient concentrations can cause increases in phytoplankton biomass, changes in species composition and impact other marine biota.

If chlorination is used as a means of effluent disinfection, residual chlorine may be acutely toxic to marine life at concentrations as low as 0.01 mg/L (DEH, 1991). The use of chlorine can also lead to the formation of toxic chlorinated organic compounds which will potentially bioaccumulate in the environment.

The treated wastewater is likely to contain low concentrations of toxicants such as heavy metals, organochlorines and hydrocarbons. The long-term discharge may lead to reduced water quality, contamination of fisheries resources and the accumulation of toxicants in sediments.

14.3.2 Sediment Transport and Quality

Changed Hydrodynamics and Sedimentation Regime

The presence of coastal breakwaters to enclose the Suai Supply Base has the potential to interrupt sediment transport patterns along the coastline caused by alteration of the nearshore wave regime. The shoreline in the vicinity of Suai is predominantly sand and further consideration of longshore transport of sediment will be required to determine whether impacts on intertidal habitats will be significant. Potential impacts to the significant area of coral reef that occurs to the south-west of the Suai development footprint will also require further assessment.

The construction of breakwaters will change local current patterns, focusing currents around the outside of the wall and stagnating water behind the wall. This may cause accelerated sediment deposition, the deposition of finer sediments and the accumulation of organic material. The biodegradation of organic material consumes dissolved oxygen and can lead to hypoxic conditions in bottom waters and sediments. This can result in changes to the chemical composition of the sediment, the formation of hydrogen sulphide and the mobilisation of heavy metals and other harmful

substances. Alteration of sediment composition and chemistry may result in shifts in sediment community composition within these areas.

Discharges, Spills and Runoff

As discussed previously, spills, discharges and contaminated runoff may occur during construction and operation of the port. These may reduce sediment quality as well as water quality. Major spills, repeated small spills and ongoing discharges can lead to the accumulation of contaminants such as petroleum hydrocarbons, metals, organochlorines and organic materials in sediments. These substances can contaminate fisheries resources and have toxic effects on marine biota, including slowed growth and poor reproductive success of individuals (e.g., Dicks *et al*, 1982; Guzmánand Holst, 1993). Infaunal assemblages in contaminated sediments typically have lower species richness and diversity (Johnston and Roberts, 2009).

Antifoulant Contamination of Sediments

Antifouling coatings are used to prevent biofouling on vessels and some marine structures. These coatings are usually toxic to marine biota in very low concentrations and also have implications for human health. Vessel cleaning and the application or removal of antifouling coatings either in maintenance facilities or in-water can lead to the contamination of sediments and fisheries resources, and have lasting effects on marine ecosystems.

A widely used antifoulant; organotin or tributylin (TBT), was recently banned, and the use of some other toxic antifoulants restricted, in countries that adopted the *International Convention on the Control of Harmful Anti-fouling Systems on Ships* (IMO, 2001). However, these chemicals may still persist on older vessels and those originating from non-signatory countries. TBT causes deformation and imposex in marine gastropods and has been linked to mortality in higher order predators (Daffron *et al*, 2011).

14.3.3 Benthic Habitat

The construction of the Supply Base will disturb areas of seabed through the following activities;

- Construction of rock breakwaters.
- Construction of shipping berths and jetties.
- Land reclamation for construction of hardstand areas.
- Dredging.

There will be a permanent loss of marine habitat associated with infilling and reclamation works. Construction of breakwaters and other maritime structures will also result in the loss of soft bottom habitat; however, the presence of the jetty, berths and pilings provide new hard substrate for the settlement and colonization of marine organisms.

Most of the construction activities, including dredging, will cause localised direct impacts to a combination of soft bottom benthic communities and rock pavement habitat both of which presently occur in the intertidal and shallow subtidal zones of the project area. Disturbed areas will be

recolonised by a combination of locally occurring marine species, although the recolonizing communities on the inside of the enclosed harbour will be significantly different to those that occur on the outside. This is largely due to the changes to hydrodynamic processes, affecting circulation and wave propagation caused by construction of the breakwaters.

The sandy benthic habitat in the project area will be unavoidably altered by the construction process. GIS analysis indicates that Phase 1 construction of breakwaters alone will cover approximately 200,000 m^2 of the seabed with rock. Expansions of the breakwaters in phases 2 and 3 will cover a further 65,000 m^2 and 60,000 m^2 respectively. These breakwaters will replace soft sediment habitat with shallower rocky substratum, removing some areas from the marine environment altogether.

Land reclamation along the shore will remove further habitat from the marine environment. The construction of ramps, shore protection and dredging in the vicinity of the LCT ramp will alter depth profiles, alter substratum composition and remove further biota. Previously identified changes in hydrodynamics, water quality and sediment quality would also modify benthic habitat characteristics.

Recolonisation of altered habitats will inevitably occur from surrounding populations; however, it is likely to include a different suite of species leading to altered community composition.

14.3.4 Infauna

The loss and alteration of sandy benthic habitat discussed above will result in loss or change of infauna assemblages in the affected areas.

Depth, water quality, sediment quality and sedimentation rates are important determinants of infaunal community structure. Changes in these parameters may result in altered community composition, as different groups of taxa are more suited to different environmental conditions. For example, bivalves are generally less abundant in high sediment-suspension/deposition environments, while some crustacea and polychaete worms are more prevalent (Anderson *et al*., 2004).

Within the study area, waters are naturally turbid due to the discharge of nearby rivers. Seasonal storms, cyclones and monsoonal flooding are common. The communities inhabiting the area will be suited to this environment and are likely to be relatively tolerant of elevated turbidity. Benthic infauna communities subject to frequent natural disturbances are likely to recover relatively quickly from a disturbance event (Dernie *et al*, 2003). Provided impacts on water and sediment quality are comparable to natural disturbance events, community responses will follow natural recovery processes and ecological impacts will be minimal. If impacts on water and sediment quality are long-term or exceed natural levels (frequency, intensity or duration), there may be a shift in community composition or even a loss of the community and subsequent colonisation by a different suite of species (Miller *et al*, 2002).

14.3.5 Fisheries

The commercial fishing industry in Timor-Leste has recently undergone major redevelopment and expansion; however, the industry is predominantly concentrated on the north coast and the presence of any commercial operations in the study area is not currently known. Subsistence fishing occurs in the vicinity of the study area.

Fishing will be permanently excluded from the area by construction and operation of the Supply Base. The loss of fishing area is assessed as approximately 250 ha. This is unlikely to have a noticeable effect on regional fish catches but, will displace some local fishers. Affected fishers are likely to relocate to adjacent fishing grounds, and this may increase fishing pressure in these areas.

There is potential for impacts on sediment and water quality to adversely affect fisheries resources, although any affects are unlikely to extend much beyond the project footprint. Increase suspended sediments or eutrophication could reduce local productivity, cause population dieback or displace fisheries resources. Heavy metals, petrochemicals, chlorinated hydrocarbons and wastewater pathogens bioaccumulate in fish and shellfish, and may exceed levels safe for human consumption. Sediments and water in the study area are presently uncontaminated. Provided water and sediment quality impacts are managed appropriately, contamination of fisheries resources by project activities is unlikely.

14.3.6 Colonisation by Invasive Marine Species

As previously discussed, construction activities will disturb and in places remove existing biota within the project area. Disturbed and stressed communities are particularly susceptible to invasive marine species for a number of reasons (Hutchings *et al*. 2002). Disturbed areas and new structures provide vacant space for colonization by opportunistic species. Disturbance can reduce biodiversity within a community and low biodiversity may reduce the community's resilience to invasion. The disturbance may also create environmental conditions in which the invasive species has a competitive advantage over indigenous species (e.g., low light climate, low water movement, or high concentration of suspended solids).

The construction of the Suai Supply Base will likely include the use of floating plant, such as barges and dredges, from other domestic or international ports. These vessels have spaces and structures where marine species can attach and they are often slow moving, so antifouling is less critical to vessel performance and may not be well maintained (GISP 2008). These vessels typically have long residency times in ports and work sites. These factors increase the chance of becoming infected by a potentially invasive marine species and of infecting a new site. Consequently, dredges and barges are considered to be a particularly high-risk vector for the translocation of invasive marine species (e.g., GISP 2008; Wells *et al*. 2009).

During operation the Supply Base will receive a high volume of commercial vessels. These vessels are a vector for the translocation and introduction of invasive marine species. Petroleum industry vessels are usually well maintained and antifouled, and spend minimal time in port, so they are considered lower risk than dredgers and barges. However, due to the high traffic volume and their frequent transits between ports where invasive marine species are present, these vessels still pose a moderate risk (e.g. GISP 2008; Wells *et al.* 2009; API 2010). The risk is higher where vessels are moving between ports with similar environmental characteristics.

14.4 Avoidance, Management and Mitigation Measures

14.4.1 Resuspension of Sediments

Construction and operational activities will unavoidably disturb and resuspend some sediment. The impact of this was reduced by avoiding sensitive and high conservation value habitats when selecting the development location. Breakwaters will be constructed first and these will limit the extent of impact of subsequent construction, as they will largely contain the dispersal of suspended sediments.

The limitation of vessel speeds within the port and the designation of specific vessel turning areas will reduce the intensity and extent of impact. Shore protection structures will prevent erosion.

The requirement for maintenance dredging is uncertain. Its frequency and volume will depend on the rate of sediment accumulation within the harbour. If/when maintenance dredging is required, careful dredging practice will be employed to minimise impacts, including:

- Timing of dredging and disposal operations to avoid coincidence with key lifecycle stages for local biota.
- Selection of appropriate dredger and dredging methods for the dredge volume required, including utilization of suspension reduction technologies where practicable.
- Implementation of a ‘No Overflow’ policy during dredge loading.
- Minimisation of dredging volume though careful planning and avoidance of excessive deepening.
- Careful selection of disposal sites and methods. Disposal of sediments within the adjacent area allows the natural dynamics of the system to be maintained, and also minimizes the costs transporting materials to remote disposal sites. Dredged sediments may be used for beneficial beach renourishment where appropriate.
- Record keeping.

Dredging protocols will be developed and incorporated into an environmental management system for the Suai Supply Base.

14.4.2 Discharges, Spills and Runoff

Policies and procedures will be developed for construction works, bunkering, cargo transfer and waste management that eliminate intentional discharges to water and minimise the risk of accidental discharge or spillage. These procedures will be incorporated into an environmental management system for the Suai Supply Base. Other measures will include:

- Adequate reception facilities will be provided to receive ship wastes.
- A spill detection, reporting and response system will be developed to ensure prompt control and clean-up of any spills.
- Spill containment equipment will be maintained on site.

- Site runoff from the tank farm will be controlled with a containment bund.

14.4.3 Desalination Plant Operation

The location of the plant outlet is critical for the minimisation of impacts from the discharge. The outlet will be situated in an area of high turbulence and water movement to optimise dilution and dispersal of the discharge. The outlet design will include a diffuser to further accelerate dilution. With adequate dilution of the discharge, impacts on water quality and marine biota are expected to be minimal.

14.4.4 Wastewater Treatment Plant Discharge

In order to reduce the environmental impact of wastewater discharge on the marine environment, treated wastewater will be retained on land for re-use or recycling wherever practicable and environmentally beneficial.

As there is a low risk to human health for the discharge of pathogens, primary contact recreation will be excluded within 100 m of the outlet and shellfish collection excluded within 500 m.

The design of the wastewater treatment plant is not defined. Secondary treatment of wastewater and subsequent disinfection by microfiltration, UV irradiation or ozone treatment would have the lowest impacts on the marine environment but, may not be practicable. If a chlorination disinfection process is used, de-chlorination and toxicity monitoring of the discharge is recommended.

14.4.5 Changed Hydrodynamics and Sedimentation Regime

The alteration of hydrodynamics and sedimentation in the project area is a likely and unavoidable consequence of the construction of the breakwaters. The impact of these alterations can be minimised by avoiding sensitive and high conservation value habitats when selecting the development location.

14.4.6 Antifouling Contamination of Sediments

The contamination of port sediments by antifoulants will be minimized by controlling the application, maintenance, removal and disposal of antifouling coatings within the project area. The Australian government has developed *Antifouling and In-water Cleaning Guidelines* (DAFF, 2011) that provide a practical approach for management of antifouling. Recommendations in these guidelines include:

- The prohibition or control of certain antifoulant coatings.
- The containment and controlled disposal of all antifoulant residues and waste.
- The removal of vessels and movable structures from the water for cleaning and maintenance wherever practicable.

14.4.7 Benthic Habitat

Construction and operational activities will unavoidably alter benthic habitats within the project area. The impact of this was reduced by avoiding sensitive and high conservation value habitats when selecting the development location.

The constructed breakwalls will provide substantial artificial reef habitat. When mature, artificial reefs can have fish and benthic communities that are comparable to natural reefs in terms of abundance and diversity (Lincoln-Smith *et al*, 1994) and reef building corals have been known to establish on breakwalls (Burt *et al*,2009). Artificial reefs are increasingly cited as mitigation for impacts on rocky reef communities. However, development of the Suai Supply Base is not expected to impact rocky reef habitats and the mitigation of impacts on one habitat type with the construction of a different habitat is problematic.

14.4.8 Infauna

Construction will unavoidably remove some areas of benthic soft-sediment habitat and the infaunal communities they contain. Further impacts on infauna will be limited through the control of impacts on sediment and water quality.

14.4.9 Conservation Significant Fauna

Whilst the use of the development area by conservation significant marine species was not assessed as part of this study, it is recognised that several fauna species may frequent the area. Of these species, sea turtles including the Flatback, Olive, Hawksbill, Leatherback and particularly the Loggerhead turtle and the Green turtle may have breeding sites on the south coast of Timor-Leste where the appropriate conditions exist. The importance of the Suai development site as a breeding area should be determined, which will influence the extent of mitigation measures required.

Light emissions from construction and operation of the supply base at Suai have the potential to impact on turtles by disrupting visual cues and affecting nesting behavior. These impacts may be significant where the site is important for nesting and foraging individuals. Potential impacts can be managed and mitigated by implementing various lighting controls during both the construction and operational phase of the project. A suite of management options are available including the use of downward facing lights, reducing illumination of beach areas, use of acceptable lighting types, minimizing light spill and shrouding to reduce light intensity.

14.4.10 Fisheries

Construction and operational of the Supply Base will unavoidably displace some fishers from the project area. The exclusion of fishing from the base may, to some extent, protect the fisheries resources contained within, and in the long-term these may act as breeding stocks that contribute to fisheries in nearby waters. Although this may have some positive effect, it is likely to be relatively minor.

While not implemented specifically to mitigate for the loss of fishing grounds, construction of the extensive breakwaters will provide reef habitat in an area where there is limited natural reef. Where

fisheries populations are habitat limited, artificial reefs have been shown to increase productivity and augment local fisheries resources (Pickering and Whitmarsh, 1997; Pondella *et al*, 2002).

14.4.11 Colonisation by Invasive Marine Species

The primary vectors for invasive marine species are vessel ballast water and biofouling.

The *International Convention for the Control and Management of Ships' Ballast Water and Sediments* (IMO 2004) provides technical standards and requirements for the control of marine pest translocation in ships' ballast.

At present there are no international conventions for the management of biofouling; however, the Australian government has developed a *National System for the Prevention and Management of Marine Pest Incursions*, including:

- *National biofouling management guidelines for commercial vessels* (NSPMMPI, 2009a).
- *National biofouling management guidelines for non-trading vessels* (NSPMMPI, 2009b).
- *National biofouling management guidelines for the petroleum production and exploration industry* (NSPMMPI, 2009c).

14.5 Residual Impacts

Construction will unavoidably disturb and alter habitats in some areas of the site. The consequence of these changes are likely to be confined within the breakwaters and were minimised by locating the development site in an area where habitats are likely to have a relatively high tolerance to turbidity and disturbance and, are generally of low conservation value.

There remains a small risk of eutrophication within the harbour caused by stagnation of water and mobilization of nutrients from the sediment.

Operation of the desalination plant is not expected to have any noticeable impacts.

The risks of spills, antifoulant contamination and marine pest incursions will be greatly reduced through the implementation of specific management plans as part an environmental management system.

14.6 Monitoring and Reporting

Water quality monitoring within the harbour area is recommended to determine if stagnation and eutrophication is occurring. Measurements should include the levels of dissolved oxygen and nutrients (particularly organic nitrogen and phosphorus compounds). Monitoring may also include phytoplankton sampling.

Monitoring of water quality and benthic communities in the vicinity of the wastewater treatment and desalination plant outlets is recommended to verify predicted impacts and inform management decisions. The monitoring programs would ideally follow an MBACI design, including multiple baseline surveys and sampling at multiple impact and reference locations.

14.7 Further Work

At present, the assessment of marine biodiversity impacts is generalised, as the extent and intensity of effects from project activities are uncertain. The development of a hydrodynamic model for the project area would allow:

- Prediction of dispersal and settlement patterns for sediments suspended by construction and operational activities.
- Prediction of sediment accumulation within the harbour, allowing the assessment of maintenance dredging requirements.
- Modelling of residence times inside the harbour to assess the risk of eutrophication.
- The identification of the optimal location for the desalination plant and wastewater treatment plant outlets and the predication of discharge dilution and dispersal patterns.

A coastal processes study is also required to quantify the interruption to sediment movement along the coast from construction of breakwaters and the risk of erosion or deposition on adjacent intertidal habitat. Siltation of the harbour entrance may also occur.

The coastal process study would define the existing wave and current climate and existing sediment transport pathways. Numerical modelling would then be used to assess the impact of the proposed development on coastal processes and predict areas of morphologic change (erosion and accretion). Different breakwater configurations may be tested in the model to optimise the structures for wave penetration into the harbour, minimise sedimentation and maintenance dredging, and minimise the impact on adjacent coastal areas.

At present the design of the wastewater treatment plant has not been defined. The level of treatment and type of disinfection process used (if any) will have significant bearing on the facility's impact on the marine environment. Completion of the design would enable a more comprehensive assessment of impacts.

Chapter 18 describes the environmental management systems for the Suai Supply Base. With respect to the marine environment these will include:

- Procedures for construction works, bunkering, cargo transfer and waste management that eliminate intentional discharges to water and minimize the risk of accidental discharge, spillage and runoff.
- A process for spill detection, reporting and response.
- Protocols for the management of antifouling.
- A marine pest management plan.
- Protocols for dredging operations and dredged material disposal.

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