Main Report

ENVIRONMENTAL IMPACT ASSESSMENT
Eaglewood Energy

Nama Drill Site – PPL 259 Kiunga, Western Province

July 2014

EAGLEWOOD ENERGY INC.

DOUGLAS ENVIRONMENTAL

Document Control

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Executive Summary

This Environmental Impact Assessment (EIA) was prepared by Douglas Environmental Services (DES) for Eaglewood Energy Inc. in support of the lodging of the Environment Permit Application (EPA) for the Nama Drilling Project for PPL 259 license area with DEC. The EIA follows a series of research and field studies conducted by DES Environment Research Officers on site. The EIA is a supporting document for the overall Environment Permit Application which will be compiled and lodged for Eaglewood Energy Inc. for the proposed drilling project.

The Nama project area is located in PPL 259 located 10 km off the main Kiunga – Ok Tedi road, North Fly, Western Province. Access to the drill site is through Drimgas road. The proposed well site is located 2 km west of Drimgas road and is accessible through an access track.

The Environmental Impact Assessment (EIA) mainly describes the characteristics of the receiving environment, potential environmental impacts and their management control as well as a risk assessment of the proposed drilling project. The EIA was based on researches and field studies conducted in the project area. Individual reports are attached to the appendices of this report.

Acknowledgement

The Environment Impact Assessment (EIA) was made possible through field assessments on site and review of literature and past researches. The authors would like to thank the following people for assisting, one-way or another in the field work as well as the final write-up of this document.

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Table of Contents

List of Tables

List of Figures

List of Plates

Acronyms

ANZECC	Australia and Zealand Environment and Conservation Council
BOD	Biological Oxygen Demand
CA	Community Affairs Officer
CBO	Community Based Organization
CSIRO	Commonwealth Scientific and Industrial Research Organization
DEC	Department of Environment and Conservation
DO	Dissolve Oxygen
DPE	Department of Petroleum Energy
EIA	Environment Impact Assessment
EIS	Environment Impact Statement
EPA	Environment Permit Application
FIMS	Forestry Inventory Mapping System
GIS	Geographic Information System
HOL	Horizon Oil Limited
IFC	International Finance Corporation
ILG	Incorporated Land Group
ISO	International Standard Organization
ITCZ	Inter-tropical Convergence Zone
IUCN	International Union of Conservation Nature
KSB	Kiunga Supply Base
LLG	Local Level Government
LNG	Liquefied Natural Gas
LO	Land Owners
NFDCL	North Fly Development Corporation Limited
NGO	Non Government Organization
NOI	Notification of Intention to Carry-out Preparatory Work
OTML	Ok Tedi Mining Limited
PNG	Papua New Guinea
PNGRIS	Papua New Guinea Remote Information System
PNGSDP	Papua New Guinea Sustainable Development Project
PNGSEL	Papua New Guinea Sustainable Energy Limited
PNGSIL	Papua New Guinea Sustainable Infrastructure Limited
PPE	Personal Protective Equipment
PPL	Petroleum Prospecting License
PRL	Petroleum Retention License
SDA	Seventh Day Adventist
SEIA	Social Economic Impact Assessment
SIA	Social Impact Assessment
SPS	Stanley Production Station
TDS	Total Dissolved Solids
TOC	Total Organic Compound
TPH	Total Petroleum Hydrocarbon
TSS	Total Suspended Solids
WBA	Water Based Mud
WGS	Universal Transverse Mercator
WMA	Wildlife Management Area
WWF	World Wide Fund

1.0 Introduction

Eaglewood Energy Inc. is the operator of PPL 259 and is about to commence drilling of oil and gas at its Nama site located 22 km north-east of Kiunga Town, Western Province, Papua New Guinea. The Nama well will be drilled within the Nama site at co-ordinates 05° 56' 04.15 South and 141° 21' 21.90 East (WGS). **Figure 1 shows the locality map of the project site and the license area. The drilling project is likely to take a period of 3 – 4 months.**

The Nama drill site is accessible through Drimgas road which is 10 km off the main Kiunga – Ok Tedi highway through Gre village. Drimgas road is an unsealed gravel road that runs to Drimgas village which is situated next to the Fly River. The proposed well site is located 2 km west of Drimgas road and is accessible through an access track (**see Figure 1**).

PPL 259 license area is a joint venture between Eaglewood Energy and Horizon Oil (PNG) Ltd covering an area of about 3439.8 m². PPL 259 was granted in 2005 for an initial six year term, and in September 2011, following relinquishment of 50% of its area, the PPL 259 joint venture were award a five year extension. Eaglewood holds a 65% working interest and operatorship of PPL 259; JV partners include Horizon Oil (15% W.I.), Osaka Gas (10% W.I.) and Mega Fortune (10% W.I.).

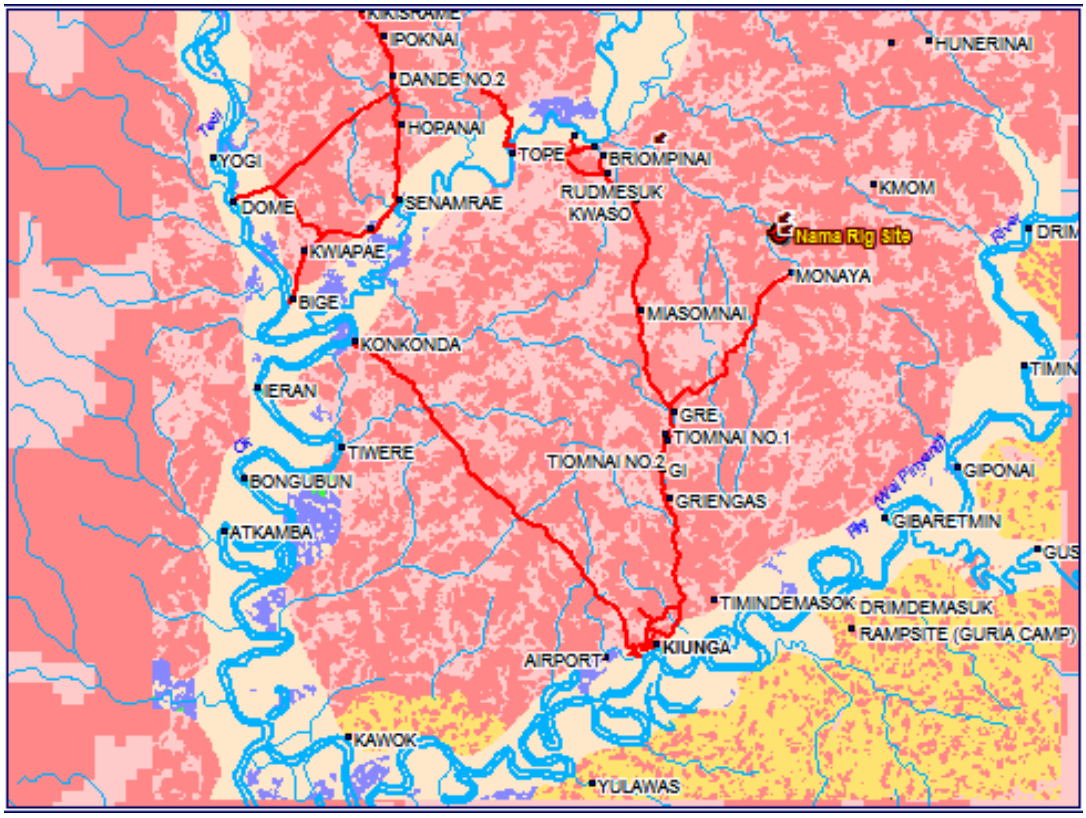

Figure 1: Locality map of Project Area.

1.1 Project Objectives

The objective of the environment impact assessment was to:

- Undertake specific environmental investigations covering physical, biological and socio-economic aspects of project area to assess its environmental characteristics before the commencement of the drilling program;
- Identify potential impacts and issues that are likely to occur as a result of the drilling project;
- Recommend, identify and describe mitigation measures that may be adopted and implemented by the company to manage these identified impacts and issues;

1.2 Proposed Activity

The proposed drilling activity will be conducted in four (4) phases;

i. site clearance,
ii. construction (drilling facilities and accommodation)
iii. drilling operations
iv. site closure

Site clearance activities will involve the removal of trees and vegetation in and around the drill site to cater for the construction of the well pad and drilling facilities. A temporary access road will be constructed linking the drilling site to Drimgas road which will facilitate the movement of workers as well as machinery to and from site. Large trees will be cut down and stumps will be removed from site to allow levelling of the soil where the drilling and temporary camp will be accommodated.

Construction activities will include assembling of the drill and its facilities as well as the generator, water pump, cement casing, mud system, and effluent ponds. The effluent ponds will be used to dispose of rock cuttings and drilling mud. Temporary housing and messing facilities will also be set up on site.

The operational phase will involve the drilling of the well pad using drill and drilling mud. The drilling mud is used for cooling and lubrication, removal of cuttings and maintaining the well under pressure to control ingress of liquid and gas. The cement slurry solidifies around the drill casing and provides support and stability. The mud is than separated through a series of shakers and screens to remove drill cuttings while the reprocessed mud is recycled through the drilling process. The drill cuttings and other wastes are discharged into effluent ponds for storage, dilution and discharge.

The site closure program will commence at the end of the drilling program. This will include the removal of drilling facilities and temporary camp facilities. The waste ponds, incinerators and landfills will be covered and the soil areas that have been contaminated through spills and leaks during storage or handling of chemicals and fuels will be scraped off and taken off site. Empty drums and waste containers will also be removed from site.

2.0 Characteristic of Receiving Environment

This chapter outlines the characteristic of the receiving environment in relation to its physical environment, biological environment and social environment. Data used to identify these traits follow a trend of environmental investigations conducted within the proposed Nama drilling site. The methodologies used to carryout these environmental assessments as well as its results are compiled in individual reports attached to the appendices of this report.

2.1 Physical Environment

This section describes the environment of the project area in relation to the topography, geomorphology, geology, landform, soil, hydrology, air quality, noise, climate and natural disasters. .

2.1.1 Topography

The Nama drill site is located about 22 km north-east of Kiunga Town, North Fly District, Western Province. The drill site is situated on a flat plain with gentle slopes of about 0 – 80 m above sea level. The general area is flat, swampy and rises occasionally to form low mountains and hills. **Figure 2 shows the topographic map of the project area.**

The drill site is situated 2 km west of the Drimgas road situated 10 km off the main Kiung-Tabubil highway. The general vegetation is of natural rainforest with little or no human disturbance. There are no villages located near the well site. Village's located along Drimgas road include Monaya, Gre, Kmom and Drimgas located near the Fly River.

The downstream receiving environment was identified at Tiyo River. The waste discharge from the drill site leads to Tyomgwen seasonal creek located 20 m south of the drill site. The seasonal creek flows through to Tiyo River which eventually joins up with Ok Mart River a further 28 km north-west of the project site.

The general altitude of the project area is from 0-100 m above sea level due to its intricately dissected relicit alluvial plains which are low, closely spaced ridges and narrow swampy valleys. **Figure 3 shows the altitude of the project area.**

2.1.2 Geomorphology, Geology

The general geomorphologic landform of the project area is dominantly off flat, flood plain and swamps. The hydrological processes of flooding and sedimentation are common resulting in formation of Oxbow lakes, flood plains and swampy alluvial soils located along the rivers or low lying valley floors.

Geology of the project area is off sandstone, conglomerate, siltstone, mudstone, minor thin lignite seams, tuff, agglomerate, white sandy clay mostly of former alluvium. Towards the south the parent material is off clastic sediment lignite and alluvium swamp around the Fly and Ok Tedi Rivers. **Figure 4 shows the Geology of the project area.**

2.1.3 Landform

The general landform of the project area is off intricately dissected relicit alluvial plains which are low closely spaced ridges and narrow swampy valleys. Towards the Fly and Ok Tedi Rivers the landform is off meander floodplains on unstable alluvial floodplains. There are patches of back swamps and blocked or drowned valley swamps and lakes and their associated swampy floodplains towards the south-west of the project area. **Figure 5 shows the landform of the project area.**

2.1.4 Soil

A soil assessment of the project area identified general soil types in the project area to be distingusihed mainly by altitude and elevation. The soil assessment was undertaken through soil sampling and profiling. Sampling data was compared to PNGRIS soil data to create a soil map of the project area. **The Soil Assessment Report is attached to the Appendices of this report.**

Results of the soil assessment indicated five (5) soil types which were distinguished by altitude and slope as well as from the influence of the major rivers. Soils on higher altitude and steeper slopes were found to be in the soil order of Paleudults and soils found on gentle slopes or gentle altitudes areas were found to be Dystropepts. The general soils found along the main rivers were identified to be Fluvaquents and Hydraquents. The general soils found south of the Fly River were Plintudults. **Figure 6 shows the different types of soils in the project area.**

2.1.4.1 Paledults

Paleudults are strongly weathered soils and have a horizon containing translocated clay and low base saturation. They are more acidic than base, have a red or yellowish in colour due to the evidence of the accumulation of oxides of iron. Soil profiles 1, 2 4 are good examples of this type of soil.

2.1.4.2 Dystropepts

Dystopepts were found mainly in hilly and mountainous terrain as well as on stable alluvial plains and river terraces where active deposition has ceased. In the project area these soils were mainly associated with Paleudults. Soil profiles 1, 3 and 4 are good examples of this type of soil.

2.1.4.3 Fluvaquents

Fluvaquents are poorly drained soils with their water tables below the surface all year round. They mainly originate almost entirely from sedimentary rock deposition but are possibly modified by organic matter over time. They are mainly common on flood plains, low terraces and weakly developed low levees of major rivers. Soil profiles 2 and 5 are good examples of these types of soil.

2.1.4.4 Hydraquents

Hyrdaquents are permanently saturated and their high water content causes them to be soft underfoot. They are entirely formed from fluvial deposition, and their textures are largely dependent on the velocity of water and nature of the material being eroded from the hinterland. This soil occurs mainly in reduced flood water velocity in swamp back plains which are much clayier in appearance and texture. No profile examples were taken during assessment however according to Figure 6 they can be found closer to the Fly River and smaller tributaries.

2.1.4.5 Plintudults

Plintudults are imperfectly drained, strongly acid soils which occur commonly under low scrub or grassland vegetation. No profile example were taken during soil assessment, however, can be found in the swamps around Kiunga Town.

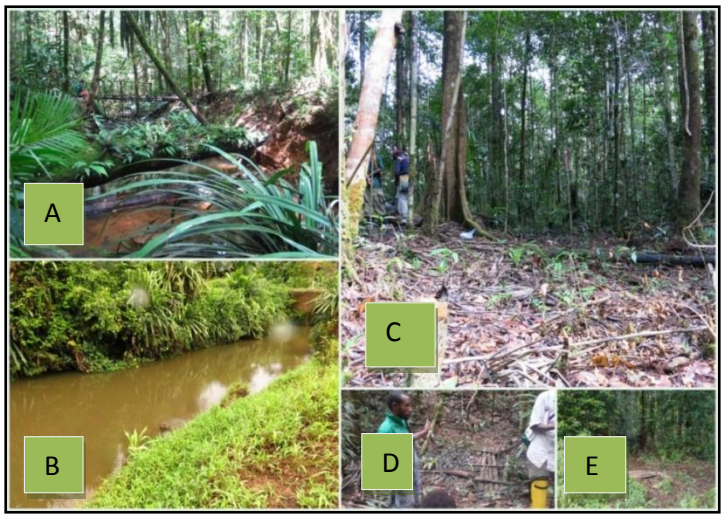

Plate 1: Soil Sampling Sites

Plate 2: Sample 1 – Nama Drill Site

Plate 3: Sample 2 – Tyomgwen Seasonal Creek

Plate 4: Sample 3 – Sum Creek

Plate 5: Sample 4 – Access Track

Plate 6: Sample 5 – Tio River

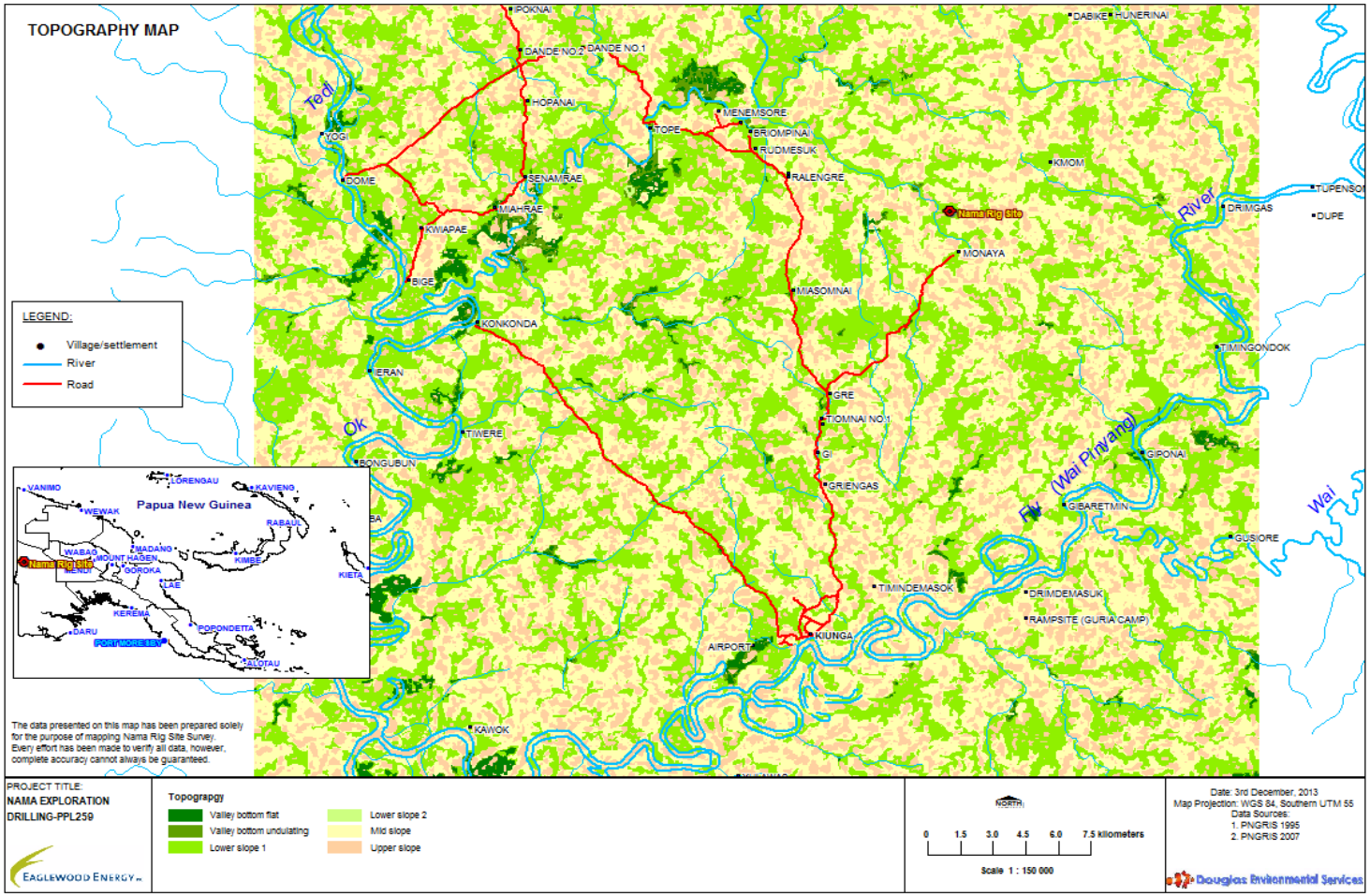

Figure 2: Topography of the Project Area.

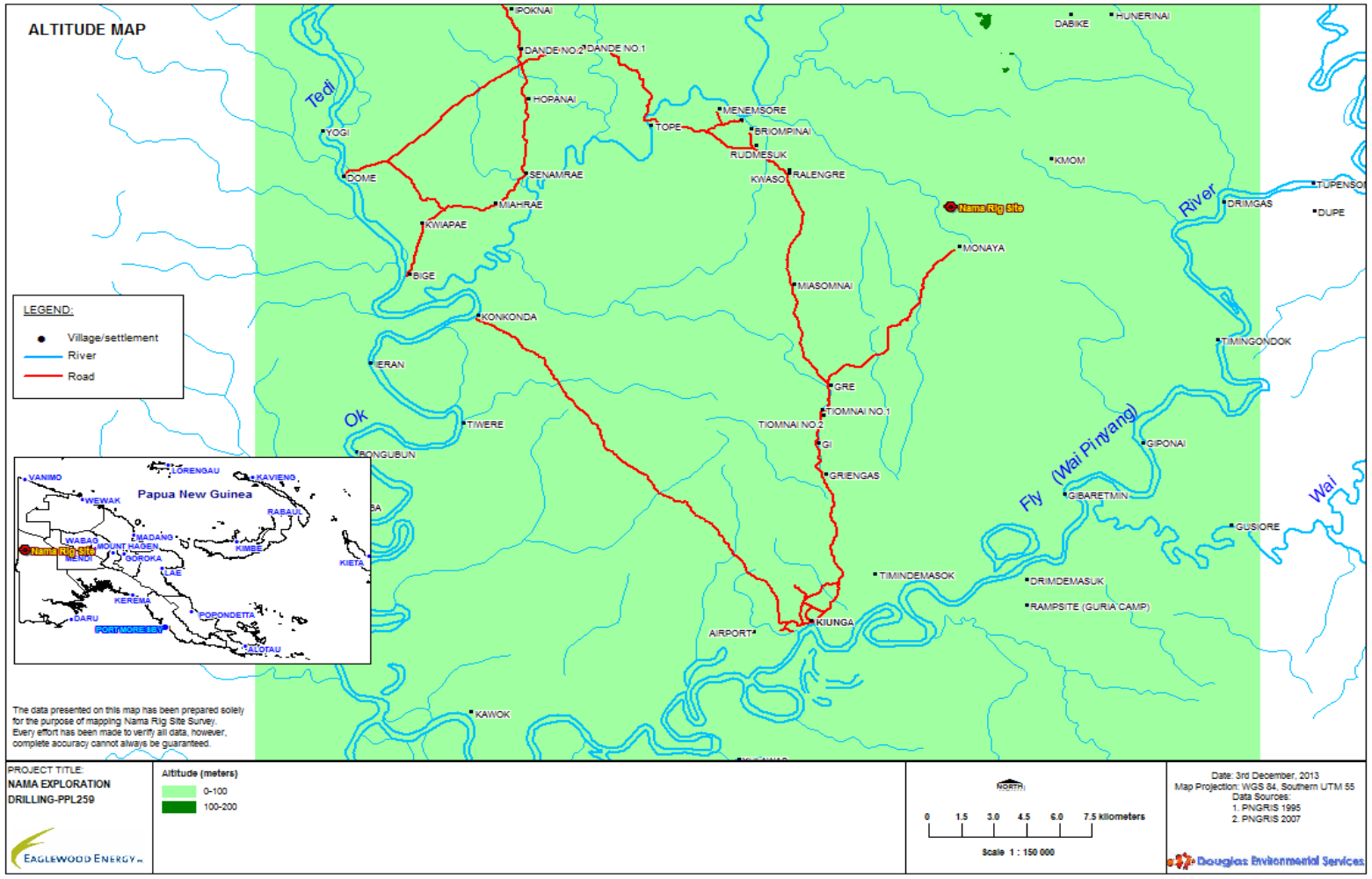

Figure 3: Altitude of project area

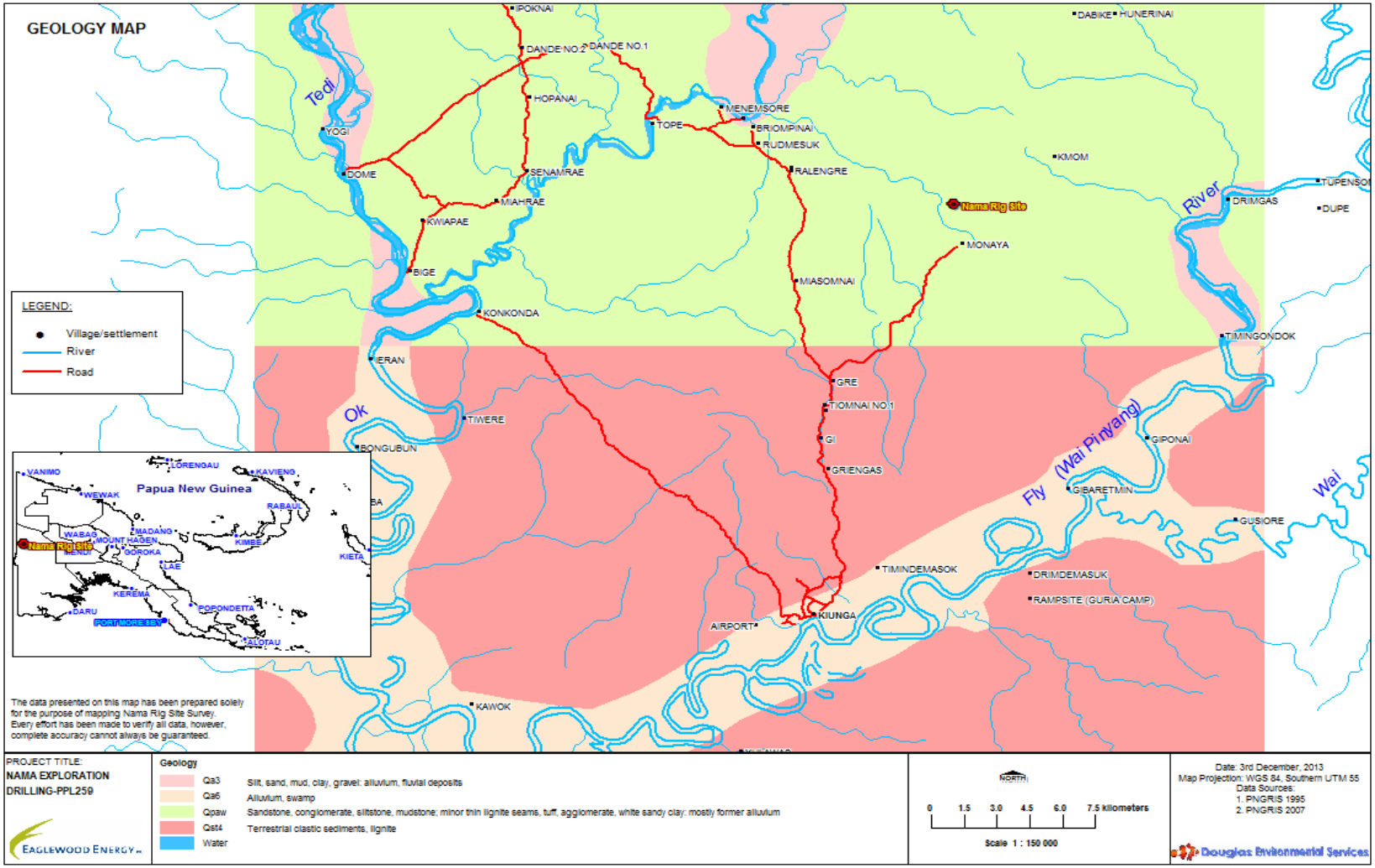

Figure 4: Geology of project area

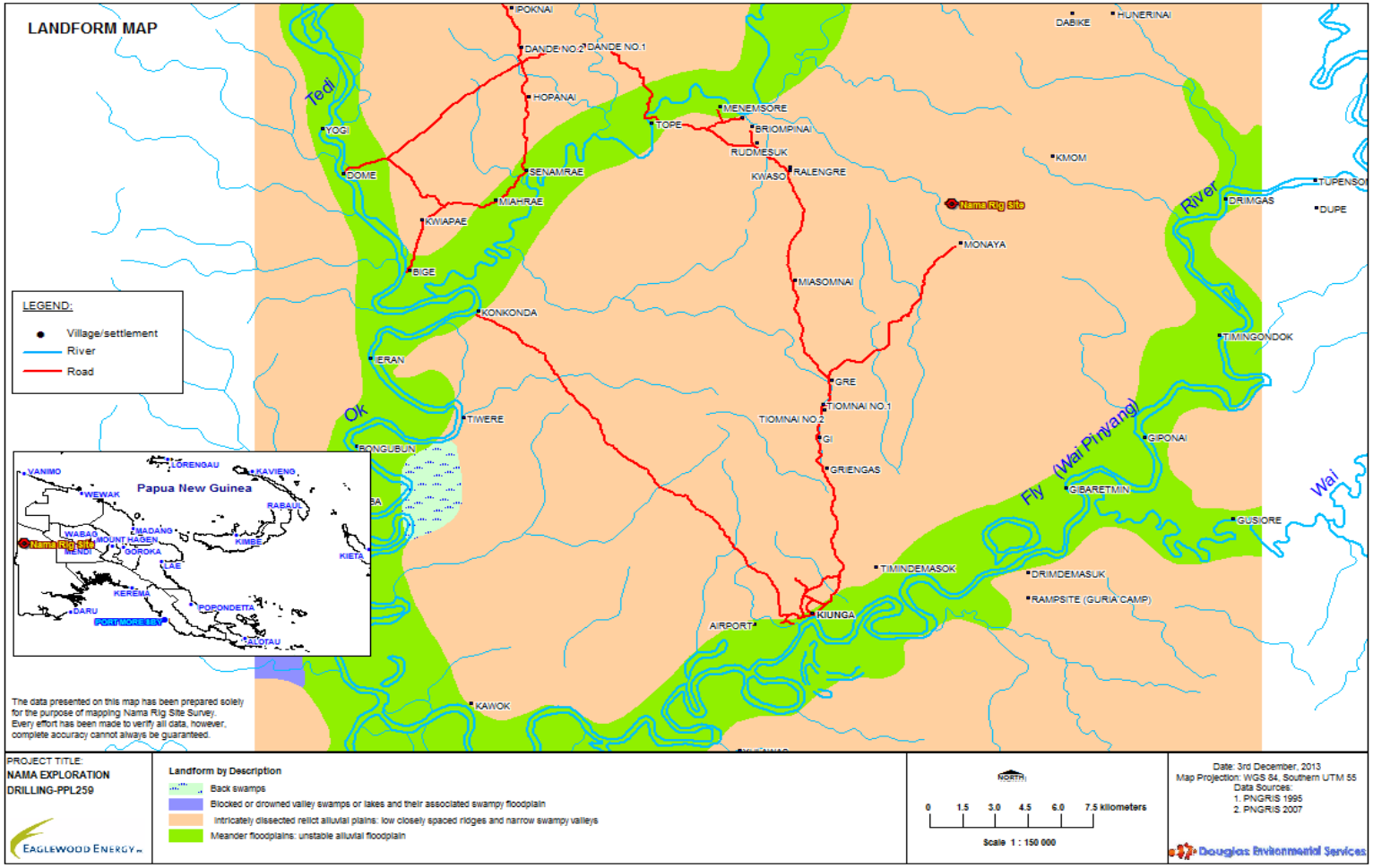

Figure 5: Landform of project area

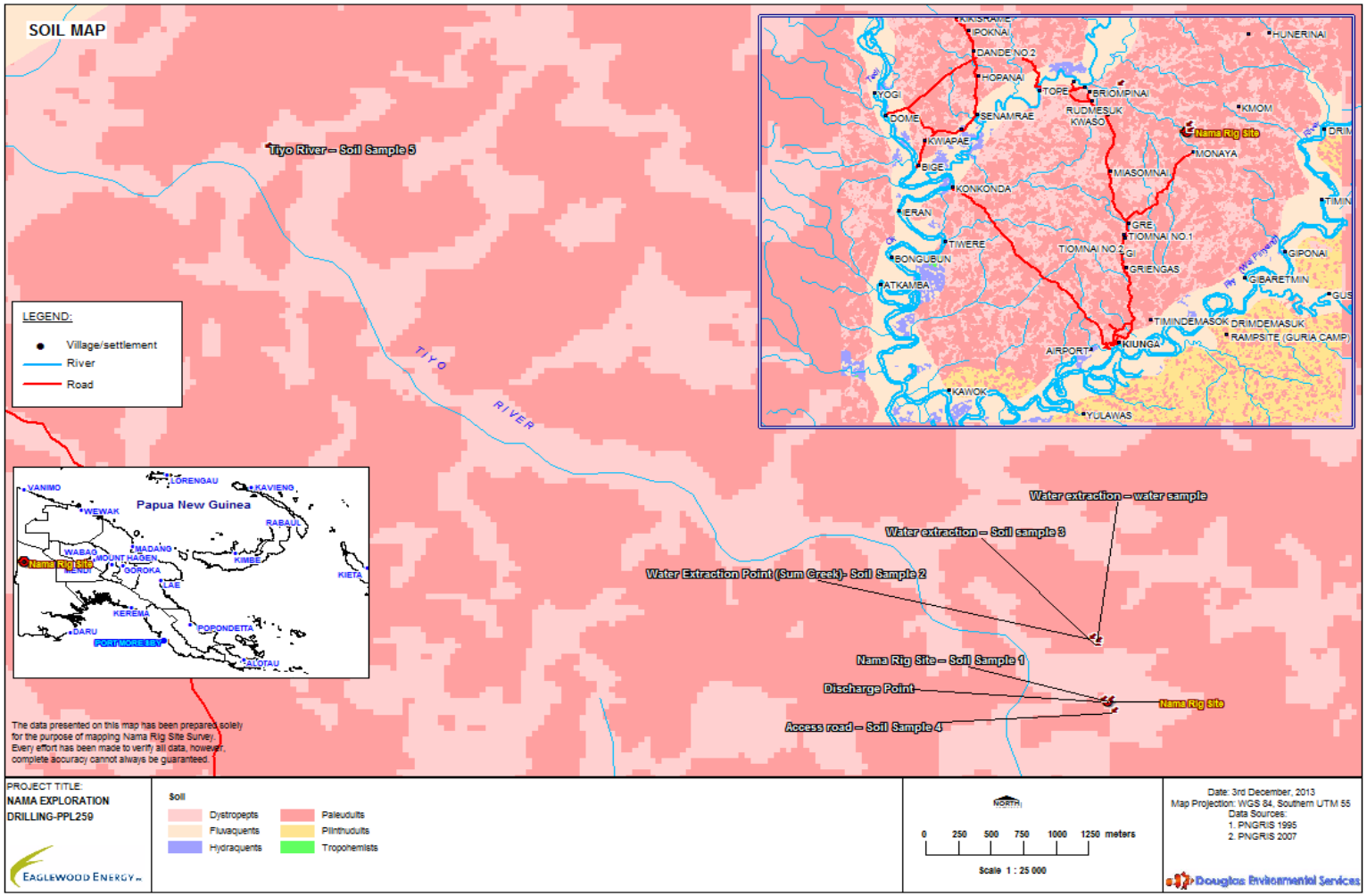

Figure 6: Soils of Project Area

2.1.5 Water Quality

A Water Quality and Hydrology Assessment was conducted and reported as part of the EIA and the main report has been attached to the appendices of this report.

The sampling sites for these assessments were;

- Sum Creek (water source)
- Tiyo River (downstream recipient)
- Seasonal creek (Tyomgwen tributaries) (Mud and waste-water Discharge Point)

2.1.5.1 In-Situ Water Quality Measurements

The in-situ water quality measurements provided the following results;

Table 1: In-Situ Water Quality Measurements

Site	*pH*	*Water Temp.*	*Conductivity*	*Dissolved Oxygen*		*Turbidity*
		^{0} C	µS/cm	mg/L	%	NTU
	6 – 9	<3^0 C increase	150 – 500	Not less than 6	75	<25
Sum Creek	6.29	25.23	13	5.86	71.3	9.5
Tiyo River	6.42	25.1	12	6.47	79.0	3.8
Discharge Point	-	-	-	-	-	-

Most of the measured in-situ readings for all sites were within their acceptable standards. This is to be expected as the water bodies are isolated and away from human influence. Dissolved oxygen for Sum Creek is slightly lower than the standard however this can be attributed to the diurnal fluctuations of oxygen due to the chemical changes producing and using oxygen in the water.

2.1.5.2 Water Quality Results

Samples extracted from Sum creek (Water source) and Taiyo River (downstream of discharge point) was stored just below 0ºC before being transported to the SGS lab within an approximate 74hrs time frame. Parameters that could be tested in the Port Moresby based laboratory provided preliminary results, whilst other parameters that can only be analyzed at their Cairns Lab, Australia, are yet to be received. Hence, the following interpretation of results account only for the interim report.

Preliminary laboratory analyses of water quality samples for the following parameters are given in table 4 below, along with their standards. Parameters which are highlighted in yellow are yet to be received from the Cairns laboratory, Australia.

Table 2: Water Quality Analysis Result

#:	Parameter	Unit	Standards (PNG DEC, IFC/World Bank, ANZECC)	Water Abstraction Point	Downstream Sampling Point	Wastewater and Mud Discharge Point	Comments:
				Sum Creek NAMA – 01	**Tiyo River NAMA – 02**	**Tributary creek**	**Ok = within standards**
1	Oil and Grease	mg/L	10	<0.1	<0.1	x	ok
2	Total Dissolved Solids (TDS)	mg/L	500	<10	<10	x	ok
3	Total Suspended Solids (TSS)	mg/L	50	<5.0	<5.0	x	ok
4	Cyanide	mg/L	0.005	<0.004	<0.004	x	
5	Biochemical Oxygen Demand (BOD)	mg/L	25	10	9.0	x	ok
6	Total Heavy Metals		5			x	
7	Arsenic	mg/L	0.05,[0.1]	<0.10	<0.10	x	ok
8	Barium	mg/L	1	<0.020	<0.020	x	ok
9	Boron	mg/L	1	<0.04	<0.04	x	ok
10	Cadmium	mg/L	0.01, [0.1]	<0.02	<0.02	x	ok
11	Chromium	mg/L	5	<0.02	<0.02	x	ok
12	Copper	mg/L	1	<0.010	<0.010	x	ok
13	Iron	mg/L	1 *(dissolved)*	1.0	1.0	x	ok
14	Lead	mg/L	0.05	<0.20	<0.20	x	slightly above standard
15	Manganese	mg/L	0.5	<0.010	<0.010	x	ok
16	Mercury	mg/L	0.0002	<0.0001	<0.0001	x	ok
17	Nickel	mg/L	1	<0.030	<0.030	x	ok
18	Potassium	mg/L	5	<0.20	<0.20	x	ok
19	Silver	mg/L	0.05	<0.020	<0.020	x	ok
20	Selenium	mg/L	0.1	<0.040	<0.040	x	ok
21	Tin	mg/L	0.5	<0.030	<0.030	x	ok
22	Zinc	mg/L	5	<0.030	<0.030	x	ok
23	Sulphate	mg/L	5	2.0	<2.0	x	ok
24	Fluoride	mg/L	1.5, [20]	0.64	0.46	x	ok
25	Total Phosphorus	mg/L	2	<0.020	<0.020	x	Ok
26	Phenols	mg/L	0.001 or 1	<0.002	<0.002	x	ok
27	Turbidity	NTU	No alteration greater than 25 NTU	4.3	8.4	x	
28	Total Arsenic	mg/L	0.1	<0.10	<0.10	x	ok

Table 3: Hydrocarbon parameter results

Our Reference Your Reference Date Sampled	Standards (PNG DEC, IFC/World Bank, ANZECC)	Units	PG01589 -1 Nama-01 5/22/2014	PG01589 -2 Nama-02 5/23/2014
† Hydrogen Sulfide ^	0.002 mg/L	mg/L	<0.05	<0.05
Total Organic Compounds	1	mg/L	<0.2	<0.2
TRH C6-C10	1000	ug/L	<50	<50
TRH C6-C9	1000	ug/L	<40	<40
Dibromofluormethane (Surogate)	??	%	100	104
d4-1,2-dichloroethane (Surogate)	??	%	81	82
d8-toluene (Sorrogate)	??	%	78	78
Bromofluorobenzene (Surogate)	??	%	89	83
Benzene (F0)	1	µg/L	<0.50	<0.50
TRH C6 - C10 minus BTEX (F1)	1000	µg/L	<50	<50
TRH C10-C14 (µg/L) AN403*	1000	µg/L	<50	<50
TRH C15-C28 (µg/L) AN403*	1000	µg/L	<200	<200
TRH C29-C36 (µg/L) AN403*	1000	µg/L	<200	<200
TRH C37-C40	1000	µg/L	<200	<200
TRH C10-C36	1000	µg/L	<450	<450
TRH C10-C40	1000	µg/L	<650	<650
TRH > C10-C16 (F2)	1000	µg/L	<60	<60
TRH > C16_C34 (F3)	1000	µg/L	<500	<500
TRH > C34-C40 (F4)	1000	µg/L	<500	<500
Nitrite-Nitrogen AN258*	??	mg/L	0.095	<0.005
Nitrate-Nitrogen AN258*	??	mg/L	<0.005	0.012
Kjeldahl Nitrogen	??	mg/L	0.51	0.63
Total Nitrogen	??	mg/L	0.61	0.65

Note:
x – *Water quality in-situ measurements and water quality samples were not sampled. The wastewater and mud discharge point was not sampled as it was too small to be sampled. However, the waste water and mud discharge point will be tested to ensure they meet the required discharge standard before being released into the surface water. If the flow is seen to be adequate for sampling once discharge into the stream is flowing continuous then water quality samples may be taken from the discharge point under monitoring assessments of these aquatic sites. However this discharge point stream will eventually run into the Taiyo River which is near a village (Rarengre village) therefore it was considered necessary to select this as the downstream sampling point. And based on dilution of the discharge this site may be vital to gauge the impacts, if any, of Nama drilling on the water quality.*

2.1.6 Hydrology

The Nama project area has a number of streams, creeks and rivers, which drain into the Ok Mart River located east and the Ok Tedi River to the south joining the Fly River system.

The hydrology of the area around the Nama drill site consists of several springs and ephemeral streams that drain into two big creeks. These ephemeral streams are primarily the result of the high rainfall in Kiunga. The average rainfall per month in Kiunga is about 431.6 mm with an average annual rainfall of 5,179.8 mm.

The two bigger creeks are Sum Creek where water extraction is expected to occur and the much larger Pamo Creek that flows into Tiyo River which eventually drains into the Ok Mart River. **Figure 7 shows the Catchment Area of Tiyo River.**

2.1.7 Creek Discharge and Water Abstraction

The volume of water flowing past a point per second in a creek is said to be the discharge of the creek. Field measurements indicated the discharge or flow for Sum Creek was calculated to be 0.219m^3/s.

Sum Creek is the proposed water source for the Nama drilling site therefore it is necessary to ensure beforehand that the volume of water that is to be extracted does not exceed the base flow of the surface water.

- 0.219 *60*60= 788.4m^3/hour
- 0.219 *60*60*24=18921.6 m^3/day
- 0.219*1000 = 219L/s
- 788.4m^3 *1000 = 788400L/hour
- 18921.6 m^3 *1000 = 18 921 600 L/day

From the data compiled and gathered for water abstraction from the Stanley Drilling site (*HOL, 2013).*

The discharge rate of Sum Creek was calculated to be 788400 litres per hour, and using the average figures from Elevala drilling site, the approximate quantity of water to be abstracted was 8500 litres per hour. This figure amounts to about 1% of the hourly discharge rate of the water source.

Comparison of data indicates that the creek discharge is sufficient to support water abstraction for drilling and camp purposes as well as maintain the ecological state of the environment.

Sum Creek is also a drainage outlet for several ephemeral streams and therefore during periods of high rainfall a much greater discharge is to be expected.

2.1.6.1 Sum Creek

Sum Creek is the proposed water extraction source for the Nama Drilling Project. It is located about 400 meters north of the proposed drill site.

Sum Creek has an average depth of 0.5 m while the average width is about 2 m. The location of the site is in a high rainfall area and the depth of the channel banks give an indication that during heavy rainfall and flooding conditions the water level can rise up to 3 m. The bed (bank) condition of the creek was found to be off fine sand and silt material with thick layer of leaf litter on the surface while aquatic vegetation were found on the streambed.

The discharge or flow for Sum Creek was calculated to be 0.219m^3/s. The discharge rate of Sum Creek was calculated to be 788400 l per hour, and using the average figures from Elevala drilling site (see report), the approximate quantity of water to be abstracted would be around 8500 litres per hour. This figure amounts to about 1% of the hourly discharge rate of the water source.

Comparison of data indicates that the creek discharge is sufficient to support water abstraction for drilling and camp purposes as well as maintain the ecological state of the environment. Sum Creek is also a drainage outlet for several ephemeral streams and therefore during periods of high rainfall a much greater discharge is to be expected.

2.1.6.2 Tiyo River

Tiyo River is located near Rarengre Village just off the Kiunga – Tabubil Highway and has been identified as the location of the waste water discharge sampling point. The waste water discharge will be released into one of several seasonal outlet of Tyomgwen creek.

Tiyo River at time of investigation was moderate in flow rate and was measured to be about 5 m wide and more than 2 m in depth in most parts. Water quality samples were collected at the Tiyo River alongside ***in-situ*** water quality measurements.

2.1.6.3 Tyomgwen Seasonal Creek

The discharge point is proposed to be located at about 20 meters west of the Nama rig site at Tyomgwen Seasonal Creek. Tyomgwen seasonal creek is one of several ephemeral seasonal creeks that eventually make-up Tyomgwen Creek. Tyomgwen Creek flows into and adjoins Pamo Creek which is much larger and eventually flows into the Tiyo River. Pamo creek is further downstream and there is no human settlement within the area. Water quality measurements were not taken during the time off assessment due to its distance. Information gathered from local labourers indicated that the creek itself was remote and rarely visited except for large hunting and fishing expeditions.

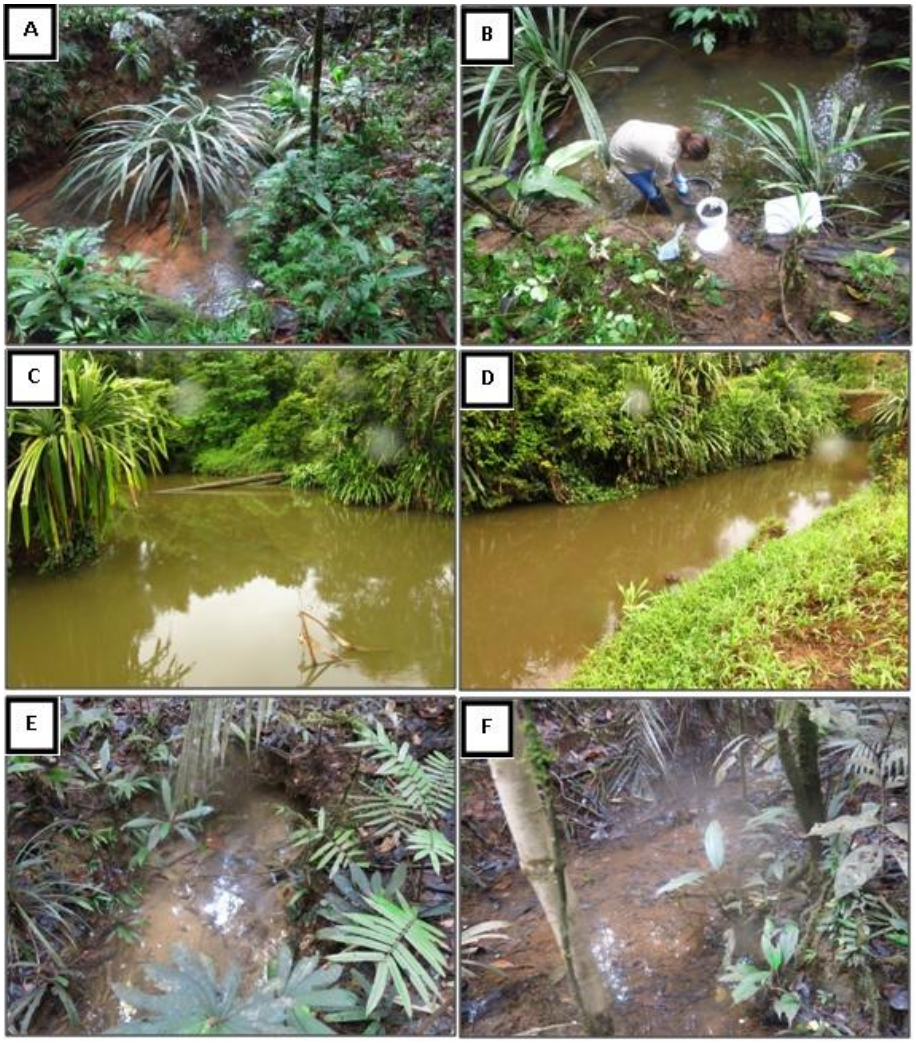

Plate 7 A to F: A – Sum Creek; B – Macro-invertebrate sampling at Sum Creek; C – Tiyo River; D – Tiyo River looking downstream; E, F – Tyomgwen Seasonal Creek.

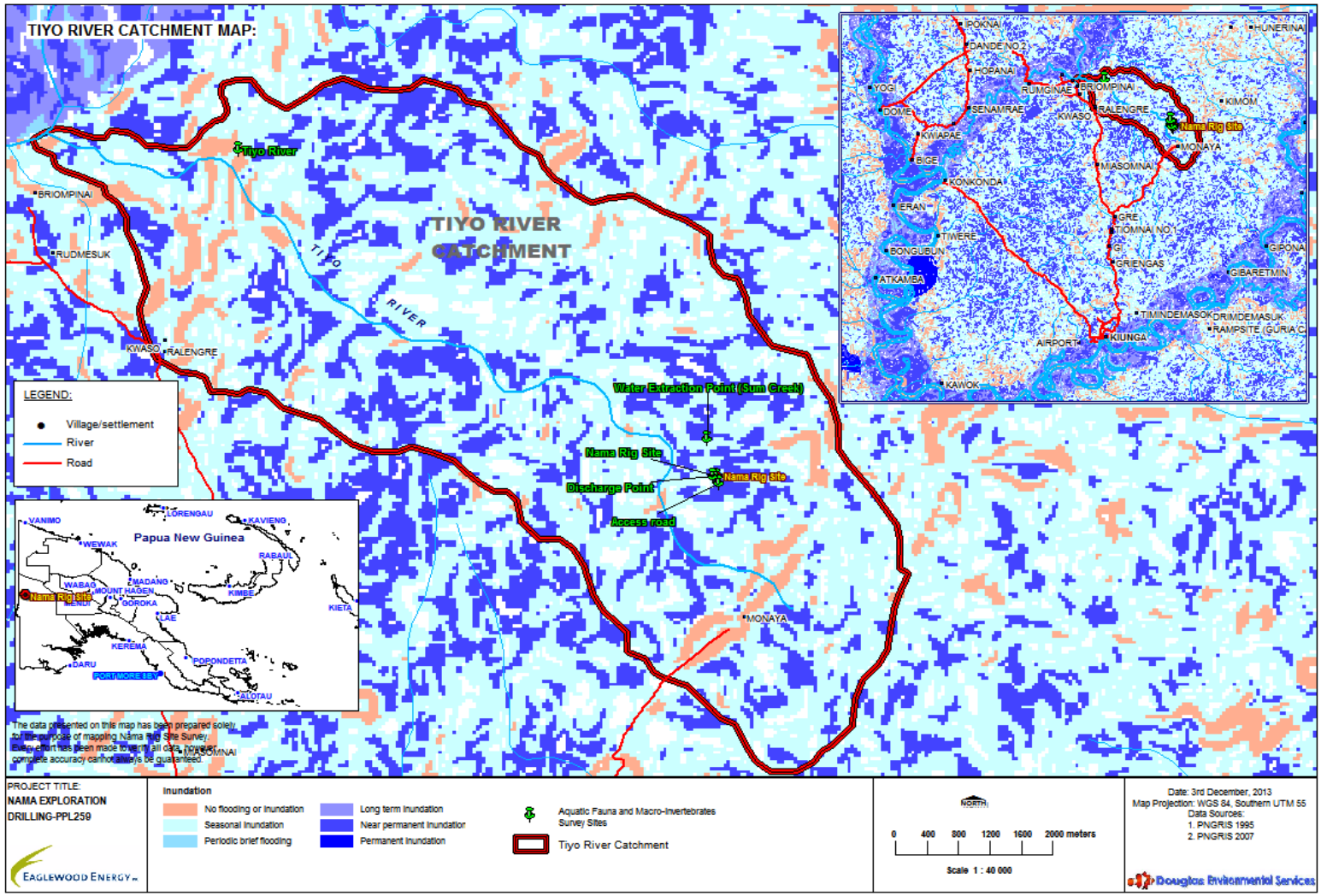

Figure 7: Catchment of Tiyo River.

2.1.8 Air Quality

The Nama drill site is within an area which is remote and consists of undisturbed rainforest vegetation. The air quality is therefore considered pure, clean and free of contamination. There are no gardens within the site and slash and burn are not common agricultural techniques in the area. There are no present activities identified as being liable to adversely affect the existing air quality.

2.1.9 Noise

Current noise levels within the license area are low due to the location being in a remote environment. Agricultural and food gathering land use activities in the area are non-intensive. Forestry activity is minor and only done by villages clearing land for building gardens. Rubber plantations are located along Drimgas road but none on site.

Villages are located far from the Nama drilling site therefore there will be no potential noise disturbance generated during project construction and operation on the human environment.

2.1.10 Climate

The general climate of Kiunga according to the Land Resources of the Morehead-Kiunga Area Territory of Papua and New Guinea (1970), is that of tropical rainforest. The climate is controlled by 2 major surface air masses which are separated by a discontinuous Inter-tropical Convergence Zone (ITCZ). These two air masses are the perturbation belt of westerly-moving vortical circulations to the north, referred to in previous literature as the "north-west season", and the south-east trade wind belt to the south. The latter dominates from June to September and is relatively drier than the air masses of the perturbation belt, the influence of which is greatest from December to March. The south-east trades are associated with surface winds of greater velocity and directional stability. **Figure 8displays the general climate of the Kiunga area with respect to temperature and rainfall.**

2.1.10.1 Rainfall

Generally the area is wet all year round with the average rainfall ranging from 4900 – 5000 mm per year. Annual rainfall increases further north of the project area towards Ok Tedi which is 5200 mm – 5600 mm per year. Towards Kiunga the rainfall decreases from 4400 mm – 4900 mm per year. **Figure 8 shows an example of a typical rainfall pattern of the project area recorded in 2012.**

According to **Figure 8** the highest rainfall recorded in 2012 was in the month of March with a range of 520 mm - 540 mm while the lowest rainfall recorded was in 2012 was in July with a range of 300 mm – 320 mm of rain.

2.1.10.2 Temperature

Mean monthly maximum temperatures in the project are range between 25.2◦C and 32.3 ◦C (max) and 22.0◦C to 27.5◦C (min). According to **Figure 8 the** temperature is stable between 25˚C - 30˚C.

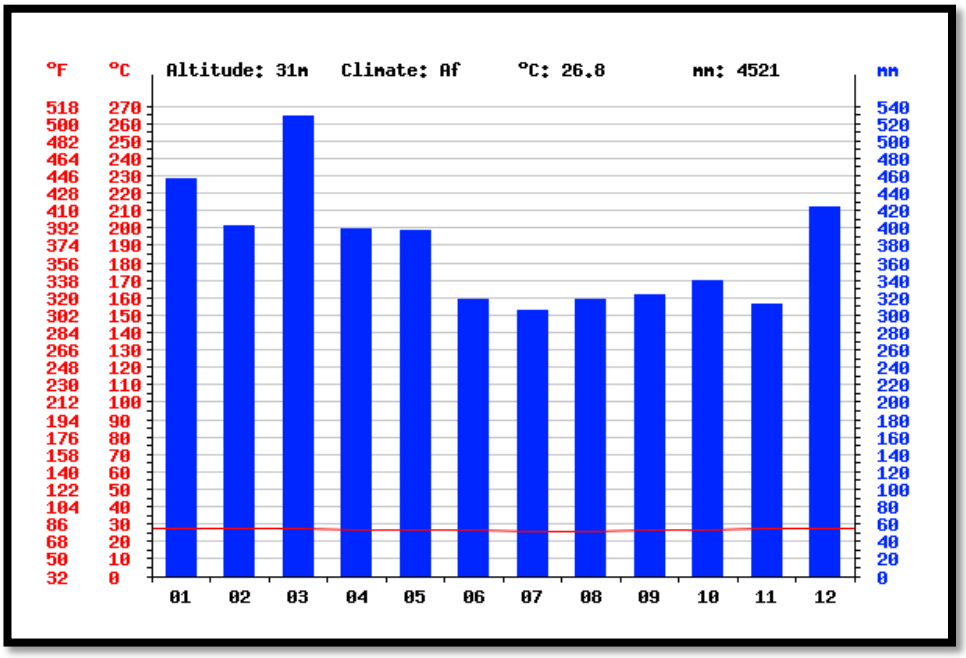

Figure 8: Climate of Kiunga. (Source; retrieved from www.climate-data.org)

2.1.10.3 Humidity

The combination of high temperatures and humidity is an important factor in controlling rates of evaporation. Mean monthly humidity taken for Balimo, which is the closest station to the project area showed relative humidity at its lowest level in the months of June and July, with levels ranging from 100 to 140 % between April and October and reaching its maximum between November and March. With the project area and Balimo having altitudes of less than 600 m, humidity is expected to be similar.

2.1.11 Natural Disasters

Hazards, natural or induced are dangerous conditions or events that can cause injury, loss of life, and/or damage to property, agriculture or the environment. The natural disasters that were found to be a likely event in the project area included floods, drought, fires and climate change.

2.1.11.1 Floods

Heavy storms and irregular rainfall commonly cause flooding within the project area. Apart from endangering human lives, floods can cause extensive environmental disturbance and physical environmental damage to the upstream project area which will eventually end up in the receiving downstream project area. These effects include soil erosion, sedimentation as well as damage to drilling infrastructure.

2.1.11.2 Drought and Fires

Drought hazards are usually associated with long dry spell, and/or El Nino weather patterns. Bushfires, mostly human induced are common during dry seasons, especially for hunting or gardening. Uncontrollable fires can cause destruction to properties, including buildings and may even cause death. Bush fires within the project area are rare due to the high rainfall and humidity all year.

2.1.11.3 Climate change

Climate change is causing an increase in global temperature and also causing irregularities in rainfall causing some areas to have unusually high levels of rainfall and less amount of rain in other areas. Irregularities in rainfall may cause flooding and drought in areas of PNG.

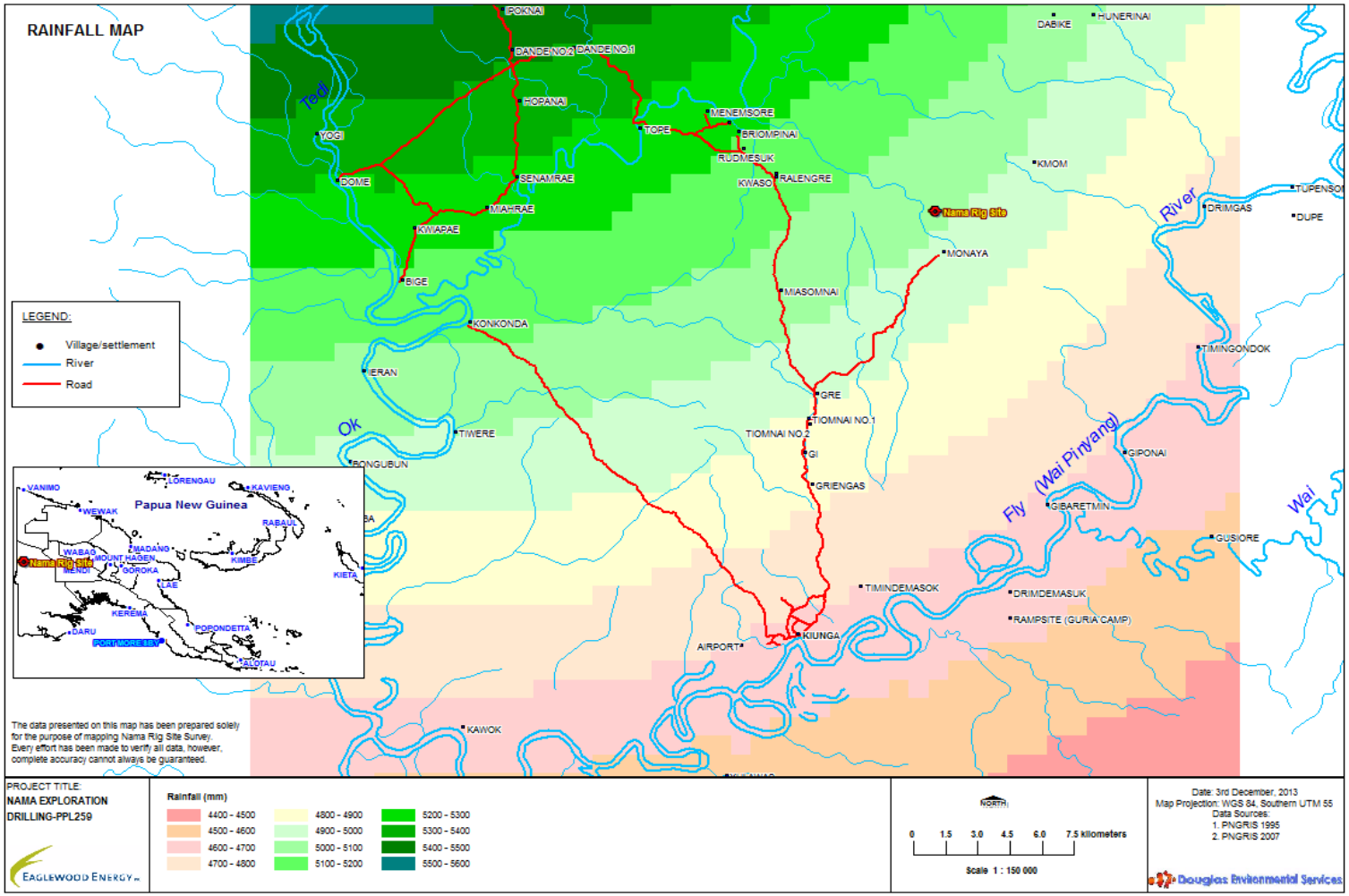

Figure 9: Rainfall of Project Area.

2.2 Biological Environment

This section identifies and describes the biological environment of the project area. The sub-sections have been categorized into the Terrestrial and Aquatic Environment.

2.2.1 Terrestrial Environment

The terrestrial biological environment of the Nama drilling project area in terms of vegetation and flora as well as terrestrial fauna are described further in the following sub-sections. Much of the information used to compile this section was abstracted from extensive researches conducted during the Stanley Development Project due to its close proximity to the Nama drill site, as well as similarities in environment characteristics.

2.2.1.1 Vegetation and Flora

Apart from climate, topography and drainage play a part in determining the character of the vegetation. Vegetation and flora characteristics of the project area are influenced by the ecology, vegetation classification and communities.

I. Ecology

The ecology of the project area is influences by rainfall and the level of human disturbances. In the north, a higher and more evenly distributed rainfall creates an environment suitable for rain forest. For instance, in the Kiunga area the "dry season" rainfall from May to October is only slightly less than half the annual total of 177 in. (5 years of records). This climate results in frequent recordings of tree genera such as *Castanopsis, Lithocarpus, Opocunonia*, *Ericaceous* epiphytes on the rain forest near Kiunga.

Castanopsis and *Lithocarpus,* however, are widespread throughout the hill forest and are dominant in monsoonal or near-monsoonal environment. The establishment of mountain plants in the lowlands is mainly dependent upon open vegetation and infertile, mostly acid-reacting soils. *Sago-Campnosperma* swamp woodland of the flat-bottomed creek valleys and mixed swamp forest along rivers and larger creeks are considered to be a more or less stable edaphic climax, rather than a succession to rain forest.

Dipterocarps are also dominant in these rainforests and are mostly off *Vatica papuana*, *Anisoptera kostermansiana*, and two *Hopea* species. In addition to *Dipterocarps*, *Syzigium spp.* and *Parinaricorymbosa* are also common.

II. Vegetation Classification

The project area comprises of two vegetation types; medium crowned – small crowned and swamp forest. The former type of vegetation covers up to 90 % of the project area while the latter comprises of 10 % of the project area located in patches to the south of the Fly River. **Figure 9 shows the vegetation of the project area.**

III. Vegetation Communities

a) Low-altitude Medium-crowned to Small-crowned Forest

Areas of low-altitude medium-crowned to small-crowned forests that covers 90 % of the project area are made up of closed rain forest. These forests occur on uplands and hills. The dominant flora species are from the genera *Vatica*, *Lithocarpus*, *Canarium*, *Anisoptera*, *Hopea*, and *Syzigium* and understory tree genera *Baccaurea* and *Gnetum*. The lower tree stratum is dense and shrub layer is moderate-minimum due low levels of light entering the forest canopy.

Trees of 1-2 m dbh occur between smaller girthed trees in these forests. Ground cover is made up of seedlings, ferns, *Aracea* (taro) plants, mosses and *Selaginella*. Palms occur in these forests, including rattans are common near waterways. Tree ferns, including tree ferns occur in forest gaps.

b) Open Lowland Forests

Areas of open lowland forests are common towards Kiunga and are made up of secondary forests and open rainforest, along with garden areas form a mosaic in the closed rainforest system. They are found near human habitation and near rivers. Genera found in these forests include *Terminalia*, *Artocarpus*, *Macaranga* in secondary forests. Open rainforests near rivers include the genera *Pometia*, *Octomeles*, *Nauclea*, *Artocarpus*.

Open lowland forests will still hold the genera *Vatica*, *Canarium*, *Syzigium*, *Gnetum*; with a more open canopy, more rattan and a denser herb layer of Aracea. Palm species are also common in these forests.

c) Swamp Forest Complexes

Areas of swamp forest complexes are found along the fly and Ok Mart Rivers and are made up of swamp woodland. Swamp woodlands form a mosaic in the closed rainforests in low-lying areas that are usually inundated. These swamp woodland are commonly of type Sago – *Campnosperma* Swamp Woodland. This type swamp woodland has scattered trees, dominated by *Campnosper mabrevipetiolata*, forming a high open canopy above sago (*Metroxylon sagu*). Other tree genera in these swamp woodland include *Calophyllum*, *Lagerstroemia*, *Elaeocarpus*, *Vatica*, *Terminalia* and *Nauclea*.

Mixed swamp woodland also make up some swamp forest complexes. Common trees in mixed swamp woodland stands are *Syzigium spp.*, *Barringtonia actangula*, *Nauclea orientalis*, *Vatic apapuana*, *Garcinia sp.*, *Carallia brachiata* and *Dillenia alata*. This vegetation is dominant in Kiunga Town and Fly River areas.

d) Areas Dominated by Land Use

Urban and village areas have cultivated trees and plants. Agricultural areas have gardens of bananas *(Musa spp)*, cassava *(Manihot esculenta)* and taro *(Alocassia macrorrhizos)*. Rubber *(Ficus esculenta)* plantations are common. Agricultural areas are established near human habitation and roads. Such areas are common along the Drimgas road and the main Tabubil high-way.

Areas of subsistence gardens, rubber plantations and secondary forests can form mosaics in the closed rainforests, especially near human habitation.

Plate 8: Typical relatively undisturbed disturbance mid-montane rainforest.

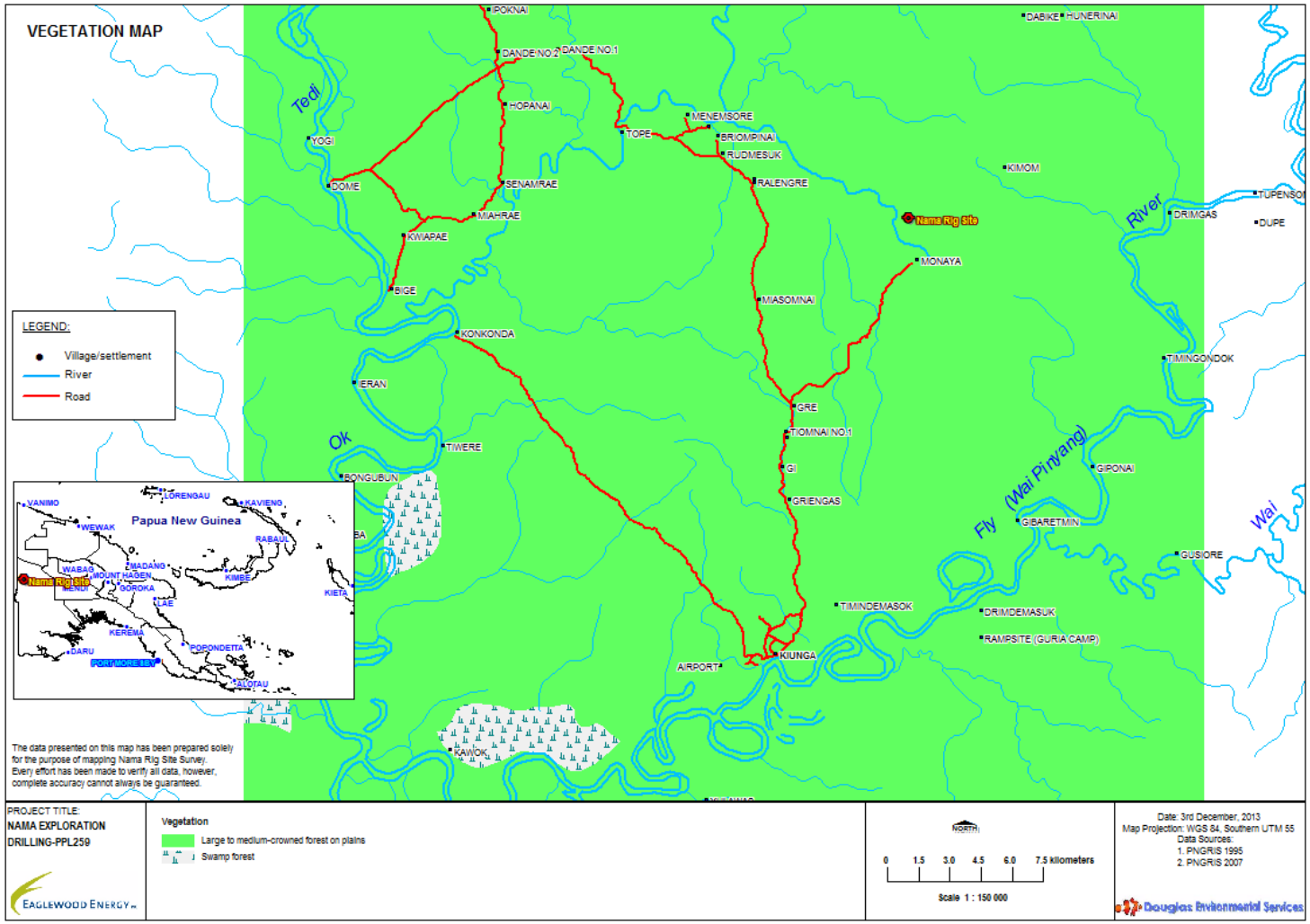

Figure 10: Vegetation of Project Area.

2.2.1.2 Terrestrial Fauna

Extensive researches on terrestrial fauna was undertaken in the project area on the during the Stanley Development Project. The Stanley project area is located 26 km from the Nama drill site. Much of the data covered in this chapter were referenced from the Stanley Development Project EIS. The fauna data was used due to proximity and identical characteristics of topography and vegetation of the Nama project area to that of the Stanley Development Project area.

I. Mammals

A total of about 20 known mammal species were recorded to inhabit the project area. This comprises of 6 marsupials, 6 rodents, two monotremes of one species and the remainder is bats and flying Foxes.

Rodents made up the largest order of mammals, with over 40 percent of mammalian species while bats were the second largest. Bat species account for about 20% of all mammals.

a) Marsupials

A total of 6 species of marsupials were identified and recorded for the project area. This includes; 2 species of cuscus, 3 bandicoots species, and a sugar glider. Cuscus species recorded for this locality were the Common Spotted Cuscus *(Spilocuscus maculates*) from the genus *Spilocuscus* and Silky Cuscus (*Phalanger sericeus*) from the *Phalanger* genus. Other marsupials species recorded were the Stripped Bandicoot (*Microperoryctes kalubu*) from the genus *Microperoryctes*, Long-nosed Echymipera *(Echymipera rufescens*) and Clara's Echymipera (*Echymipera clara)* from the genus *Echymiperinae*. The Sugar Glider (*Petaurus breviceps*) from the genus *Petaurus* was also recorded but was rarely seen.

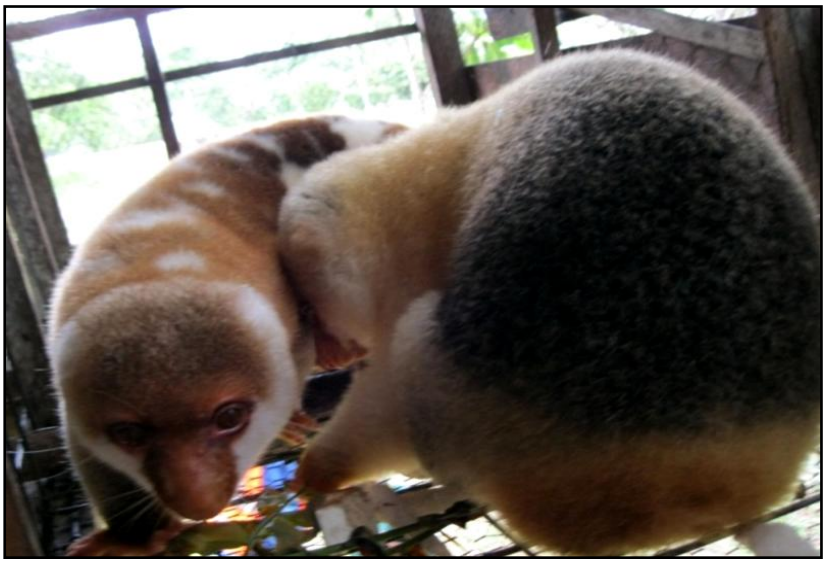

Plate 9: Common Spotted Cuscus Source; Stanley Gas Project (EIS).

b) Rodents

About 6 species were recorded which belonged to 5 genera which were identified as White-bellied Mosaic-tailed Rat (*Melomy sleucogaster),* New Guinea Waterside Rat (*Parahydromy sasper*), Northern Water Rat (*Paraleptomy srufilatus),* Large Tree Mouse (*Pogonomy sloriae),* Polynesian Rat (*Rattus exulan),* and the Spiny rat (*Rattus praetor).* Identifications included rats that were semi aquatic, tree rats, ground rats and rats that lived in the canopies of large trees. All rats are not protected as they are considered to be secure in their habitat.

c) Bats

In the project locality there were 3 species of bats recorded, which included; Little Red Flying-fox (*Pteropus scapulatus*), Fly River Roundleaf Bat (*Hipposideros muscinus*), and Spectacled Flying-fox (*Pteropus conspicillatus*).

II. Birds

A total of 19 bird species were recorded and a further 23 species were identified in the locality based on the known distributions of these species in Papua New Guinea. Fruit doves, parrots and birds-of-paradise are the most abundant species observed during the time of the survey. Both the lowland and the low-montane bioregions have fewer birds species diversity although the region has a whole is the doorway to seasonal and migratory birds.

Table 4: Birds species recorded for the Stanley Gas Sites in Kiunga, Western Province

Species Name	Common Name
Melilestes megarhynchus	Long-billed Honeyeater
Malurusal boscapulatus	White-Shouldered Fairy-Wren
Rhipidura leucothrax	White-Bellied Thicket-Fantail
Rhipidura rufiventris	Rufous-Backed Fantail
Megapodius freycinet	Common Scrubfowl
Micropsitta pusio	Buff-faced Pygmy-Parrot
Eclectus roratus	Eclectus Parrot
Cyclopsitta gulielmiterti	Orange-breasted Fig-Parrot
Ducula zoeae	Zoe Imperial Pigeon
Henicophaps albifrons	New Guinea Bronzewing
Ptilinopus iozonus	Orange-Bellied Fruit-Dove
Mino dumontii	Orange-faced Grackle
Campochaera sloetii	Golden Cuckoo-Shrike
Cacatua galerita	Sulphur-Crested Cockatoo
Tanysiptera galatea	Paradise Kingfisher
Ptilinopus pulchellus	Beautiful Fruit Dove
Casuarius casuarius	Southern Casoswary
Harpyopsis novaeguineae	New Guinea Happy Eagle

Source; Stanley Gas Project Environment Impact Statement (EIS)

III. Reptiles and Amphibians

A total of 30 reptiles species were recorded which included; ten snake species, 9 are frogs and 11 are lizard's species. Most frequently observed reptiles were lizards, and are from three main genus; *Emoia, Carlia* and *Eumeces* genus. Varanids genus is reported to exist in the locality, but was not sighted during the survey. Frogs detected during the survey are from the genus, *Litoria, Rana* and *bufo* while snake are reported to be present.

Table5: Shows a List of Reptiles for the Project Area.

Taxa	Common Name	Species Name
Snakes	New Guinea Death Adder	*Acanthophi ssp*
	Brown Cat Snake	*Boiga irrrgularis*
	Southern D' Albert's Python	*Leiopython albertisi*
	New Guinea Brown Snake	*Pseudonaja cf. textilis*
	Green Tree Snake	*Morelia viridis*
	Loria Forest Snake	*Toxicoca lamuspreussi*
	New Guinea Ground Boa	*Candoia Aspera*
	Slatey – grey snake	*Stegonotus cucullatus*
	Apodorapapuana	*Papuan Olive Python*
	Common Treesnake,	*Dendrelaphis punctulatus*
Frogs		*Albericus sp*
		Albericus tuberculus
		Austrocha perinaderongo
		Hylophorbu ssp
		Litoria havina
		Litoria cf. gracilentapp
	Green tree frog	*Litoria infrafrenata*
		Ranada emeli
	Cane toad	*Bufo maranus*
Lizards	Coconut Skink	*Cryptoblepharus cf. virgatus*
		Carlia sp
		Emoia caeruleacauda
		Emoia longicauda
		Emoia spp 1
		Emoia spp2
		Eumeces fasciatus
		Eugongylus rufescens
	Spotted Monitor	*Varanus similis*
	Blue tailed Monitor	*Varanus doreanus*

Plate 10: Frog species found in project area.

Top; Green tree frog (Litoria infrafrenata) Ranada emeli (left), Unidentified frog sp(right), Bottom; Cane toad (Bufo Maranus) an introduced frog species (left and right)

Plate 11: Unidentified skink

2.2.1.3 Conservation Areas

There are no conservation areas located within or around the project area however the Tonda WMA is located further downstream away from the main Fly River system. At time of survey there were no terrestrial fauna and flora species within the project area found to be endangered.

2.2.1.4 Aquatic Fauna

Generally, surrounding the Nama project area is the mid montane rainforest which has around 50% - 60% canopy cover that blends into sago swamps where the areas are water logged. The proposed project area offers three types of aquatic habitats that can be categorized into riverine, clear water stream and sago swamps.

In non-turbid rivers (e.g. headwaters and tributaries), aquatic flora are represented by benthic algae, periphytons and diatoms.

For, example, riffles are essentially stones- in- current habitats, where the interstitial spaces (voids) between the stones and the stone surfaces themselves provide microhabitats that are colonized by benthic algae and diatoms (in non-turbid rivers), invertebrates and fish. Fallen trees and exposed root systems, large woody debris,

and other coarse particulate matter provide habitat for numerous fish and macro invertebrate species.
The main channel habitats are characterized by high discharge and high concentrations of suspended sediments and associated turbidity. Within the key habitat types are a suite of microhabitats used by aquatic flora and fauna.

An aquatic fauna survey was undertaken during the environment assessment of the Nama project area (see Appendix). The aquatic fauna survey sites are identified in **Table 5**.

Table 6: Survey Sites and their GPS Co-ordinates

SITE	LONGITUDE	LATITUDE
Sum	141°21□19″	05°55□50″
Pure		**No co-ordinates**
Tiyo River	141°17□52″	05°53□37″

I. Fish Species Distribution and Abundance

A summary of the fish catch data and species distribution is shown in Table 6. The result shows that there is no real relationship in stream size and species richness in the sites that were assessed. Though stream size and fish size are correlated it cannot be conclusive due to the fact that only big size catches were not experienced due to time constrains that did not allow for gill nets to be deployed in Tiyo for example.

Though a site might have high number of catch it does not necessarily mean there are lots more species there.

Table 7: Summary of fish caught from sites assessed.

Site	Family	Species	Length (cm)	Abundance
Sum	Niuguinea Rainbow	*Melanotaenia iris*	5, 2	2
Sum	Kiunga Blue eye	*Kiunga ballochii*	3.4, 3.5, 3, 2.4, 4, 4, 3.4, 3, 2, 2.2, 3, 2	12
Sum	New Guinea blue eye	*Pseudomugil novaeguineae*	4	1
Sum	Ok Tedi rainbow	*Melanotaenia oktediensis*	2, 4	2
Pure	Fresh water crayfish	*Cherax quadricarinatus*	9, 5, 12, 10, 5, 15, 7, 8, 11, 5, 13, 12	12
Pure	Ok Tedi rainbow	*Melanotaenia oktediensis*	8, 4.5, 7	3
Tiyo	Fresh water gar fish	*Zemarchapterus novaeguinea*	12, 16, 8, 10	4
Tiyo	Mouth almighty	*Glossamia sandie*	12	1
Tiyo	fly river rainbow	*Melanotaenia sexlineata*	10, 6, 4	3
Tiyo	Hardy head	*Crateracephalus nouhuysi*	8, 5, 11	3

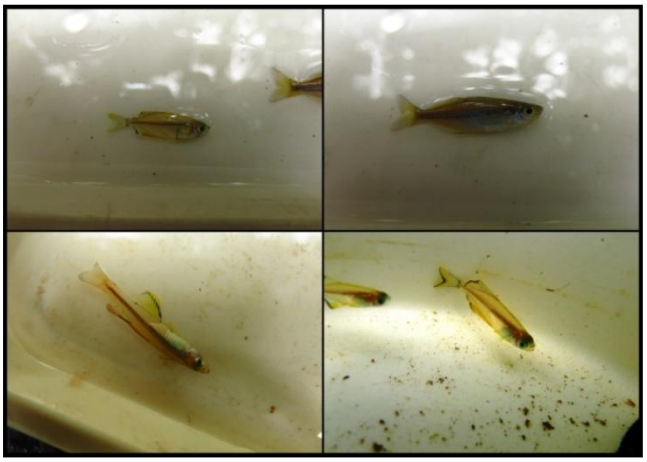

Plate 12: Fish species from Sum creek.

Top; Niugini Rainbow (Melanotaenia iris) Bottom; (left) Niugini Blue-eye (Pseudomugil novaeguineae), (right) (Kiunga Blue Eye (Kiunga ballochii)

Plate 5: Sum Creek looking north-east.

Plate 14: Photos from Pure creek.

Top; Crayish species (Cherax quadricarinatus), Bottom; (Left) Rainbow fish(Melanotaenia oktediensis) , (Right) Pure creek.

Plate 15: Pictures from Tio creek.

Top; Tio River (left), Freshwater Gar fish (Zemarchapterus novaeguinea) , Bottom; Hardy Head fish (Crateracephalus nouhuysi) (left), Mouth Almighty fish (Glossamia sandie)(right).

II. Species of environmental significance

It was evident from the field survey that there are species of environmental significance within and around the Nama project area. In developing the Nama project due diligent must be practiced to minimize adverse detrimental effects to the habitats. These significant species include:

- The Kiunga Blue Eye *(Kiunga ballochii)*
- Ok Tedi rainbow *(Melanotaenia oktediensis)*

a) Kiunga Blue Eye (Kiunga ballochii)

Listed in the IUCN redlist as critically endangered, the Kiunga blue eye is endemic only the upper fly river region. Though no extensive studies have been conducted to clearly defined its geographic ranged it was only discovered in the tributaries of the Ok Smek River in the 1980s by Dr G. Allen.

b) Ok Tedi rainbow (Melanotaenia oktediensis)

The ok Tedi rainbow fish is one of the many species of the rainbow family that is discovered to be occurring in the river systems of the ok Tedi River and Fly River. Listed as vulnerable in the IUCN redlist this species too has in recent times lack the extensive research.

2.2.1.5 Aquatic Flora

An aquatic flora and macro-invertebrate assessment was undertaken in the Nama project area **(See Appendix)**. The objective of survey was to study and assess flora and macro-invertebrate species of the project area. The identification of species of conservation significance and the identification of species with invasive potential

were considered. Hence, findings are expected to detail the existing conditions of the potential impacts from the proposed Nama site. For this particular report, macro-invertebrates sampled as essential water quality indicators are studied along with aquatic plants from the projects water source (Sum creek) and discharge point (Tributary for Tyomgwen).

2.2.1.6 Macro-invertebrate Water Quality Indicators

The identification of Macro-invertebrate communities give a fair understanding of the quality of the water habitat. This is due to the fact that not all different types of invertebrates dwell together because each specie is sensitive towards the different chemical and physical conditions of their aquatic environment which changes due to potential pollutants or change in downstream flow. This mostly affects the macro-invertebrate community. Some macro-invertebrates exist in healthy water bodies and are referred to as intolerable to nutrient pollution and low levels of dissolved oxygen (DO). Other macro-invertebrates exist in both healthy and polluted water bodies and are referred to as tolerable to nutrient pollution and low levels of DO. By identifying the types of macro-invertebrates present in the water body, the quality of water can also be determined according to two categories; intolerant and tolerant species of macro-invertebrates which are assessed against *in-situ* water quality parameters that determine the current physical and chemical components of the concerned aquatic environment.

At time of survey, *In-situ* water quality parameters measured were pH, dissolved oxygen (DO), conductivity, and temperature. Other biological measurements include riparian vegetation, fish, frogs, birds, algae and fecal coliforms (Water and River Commission, 2001). Table 7 and table 8 present water quality parameter measurements and macro-invertebrates sampled upstream at Sum creek and at downstream Tiyo River.

Plate 166: Sampling macro-invertebrates at Sum creek (Water Source)

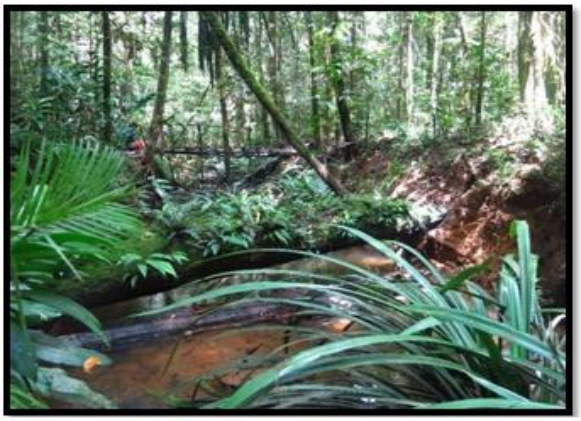

Plate 17: Site 1 Sum creek, proposed water source.

Plate 18: Site 2 Tiyo River, downstream of initial discharge point.

Plate 19: Headwater identified as downstream discharge site. A tributary of Tyomgwen creek.

Table 8: in-situ water quality parameter readings for upstream and downstream of Nama wellhead portion PPL259.

Site Name:	*Sum Creek (Water Source)*	*Tiyo River (Downstream discharge)*
Site ID:	S1-MA PPL-259	S2-MA PPL-259
GPS:	05°55'49'' South 141°21"19'' East	05°53'36'' South 141°17'52'' East
pH:	6.29	6.42
µS/cm:	13.00	12.00
D.O:	5.86 (71.3%)	6.47 (79%)
°C:	25.23	25.1

According to table 7 above, all *in-situ* water quality parameters measured at both upstream and downstream sites fall close to and within the Papua New Guinea water quality standards under the Environment regulation 2002. Hence, indicating that Sum creek and Tiyo River both are healthy capable of sustaining aquatic life. This baseline reading can be used to determine future comparisons to assess possible alterations following construction of the Nama Wellhead.

Table 8 and figure 12 summarizes species composition of macro-invertebrates sampled at Sum creek and Tiyo River. Majority of macro-invertebrates sampled include those that are pollution intolerant and moderately intolerant to organic pollution. Hence, as indicated by *in-situ* readings, the majority of macro-invertebrates sampled being intolerant towards pollution also indicates that both Sum Creek and Tiyo River are healthy enough to sustain aquatic life of fish and aquatic plants.

Table 9: Macro-invertebrates sampled per site (Sum creek and Tiyo River).

Macro-invertebrates				***Sum Creek (Upstream Water Source site)***	***Tiyo River (Downstream discharge)***
Order/class	**Family**	**Common name**	**Pollution Tolerance**	**Count data**	**Count data**
Decapoda	Atyidae	Freshwater shrimp	Pollution Intolerant	8	1
Decapoda	Astacoidea	Crayfish	Moderately Intolerant	1	
Hygrobatiod (Aconopsis)	NA	*water mites	Moderately Intolerant	4	6
Odonata	Zygoptera	Damselfly larvae	Moderately Intolerant	1	
Odonata	Anisoptera	Dragonfly larvae	Moderately Intolerant	0	1
Plecoptera (Order)	Austroperlidae	Stonefly larvae	Pollution Intolerant	1	
Tricoptera	Calamoceratidae (Leaf)	Caddisfly Larvae	Moderately Intolerant	4	3
Tricoptera	Leptoceridae (stick)	Caddisfly Larvae	Moderately Intolerant	3	1

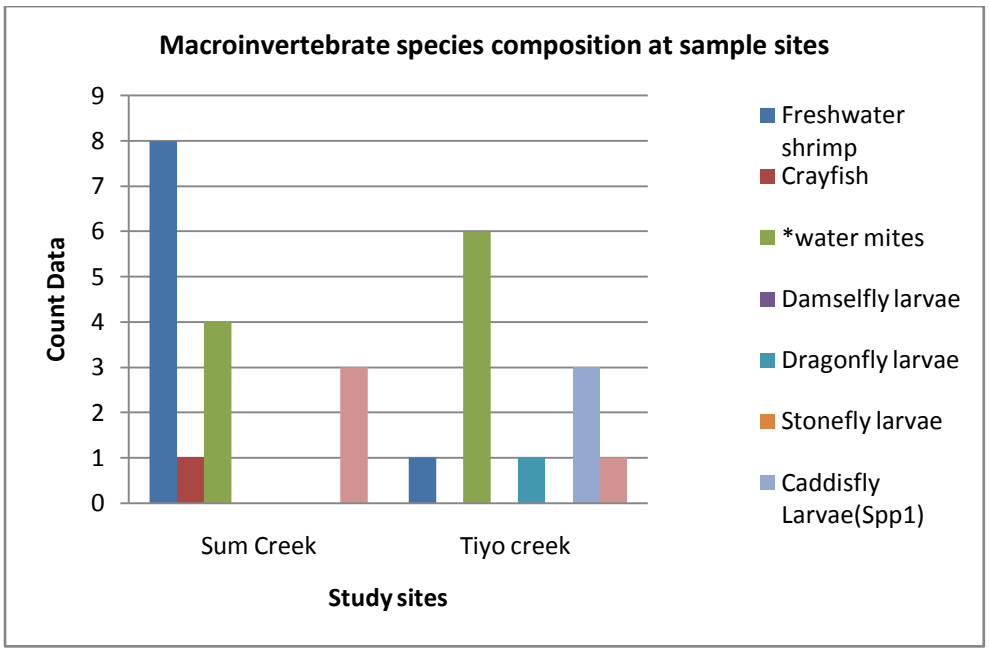

Figure 11: Species composition of macro-invertebrates at Sum creek and Tio River.

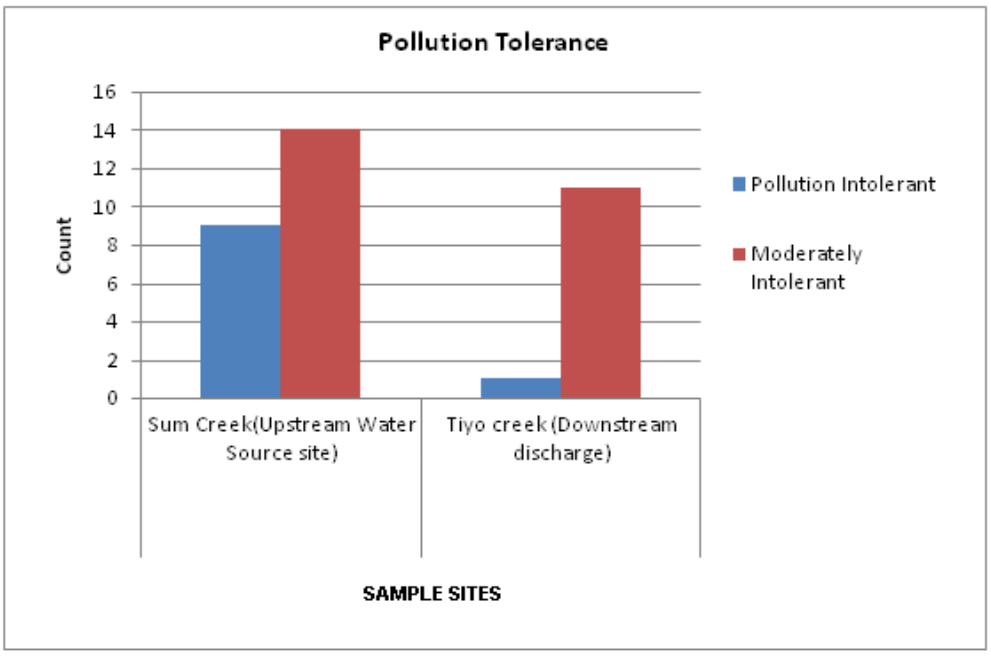

Figure 12: Pollution tolerance of macro-invertebrates samples from Sum creek and Tiyo River

Table 2, figure 1 and figure 2 summarize species composition of macro-invertebrates sampled at Sum creek and Tiyo River and tolerance levels depicted by species identified. Majority of macro-invertebrates sampled include those that are pollution intolerant and moderately intolerant to organic pollution. Hence, as indicated by *in-situ* readings, the majority of macro-invertebrates sampled being intolerant towards pollution also indicate that both Sum Creek and Tiyo River are healthy enough to sustain aquatic life, such as fish and aquatic plants.

I. Aquatic Flora Species

The aquatic flora survey consisted of observations made for Riparian Vegetation growing in and around the upstream creeks (i.e. water source and discharge location) and downstream at Tiyo river where the runoffs from discharging at Nama will eventually end up. Based on morphology, most of the riparian vegetation sighted upstream and downstream included those classified as amphiphytes which are adapted to live both wholly and partially submerged in water.

However, upstream at Nama well site, dominant species of plants were identified from the family *Elatinaceae* which were submerged depending on the depth of creeks surveyed. Most plants appeared wholly submerged within the water with only their flowers blossoming on the surface of the water.

These aquatic flora have adapted to thrive in aquatic environments (i.e. freshwater) and are also referred to as hydrophytes or Macrophytes. These plants require special adaptations for living submerged in water, or at the water's surface. The most common adaptation is aerenchyma, but floating leaves and finely dissected leaves are also common. Aquatic plants can only grow in water or in soil that is permanently saturated with water. They are therefore a common component of wetlands.

The following points describe different types of aquatic flora grouped into their growth adaptation characteristics (Wikipedia, 2014);

- **Amphiphytes:** plants that are adapted to live either submerged or on land;
- **Elodeids:** stem plants that complete their entire life cycle submerged, or with only their flowers above the waterline;
- **Isoetids:** rosette plants that complete their entire life cycle submerged;
- **Helophytes:** plants rooted in the bottom, but with leaves above the waterline;
- **Nymphaeids:** plants rooted in the bottom, but with leaves floating on the water surface;
- **Pleuston:** vascular plants that float freely in the water.

Plate 20: Dominant aquatic plant species.

From the family Elatinaceae sighted upstream at water source (Sum Creek) and discharge site

Plate 21: *Itelophyte* species.

Sighted in patches all along Sum creek, the water source. Acorus spp sighted downstream of discharge point.

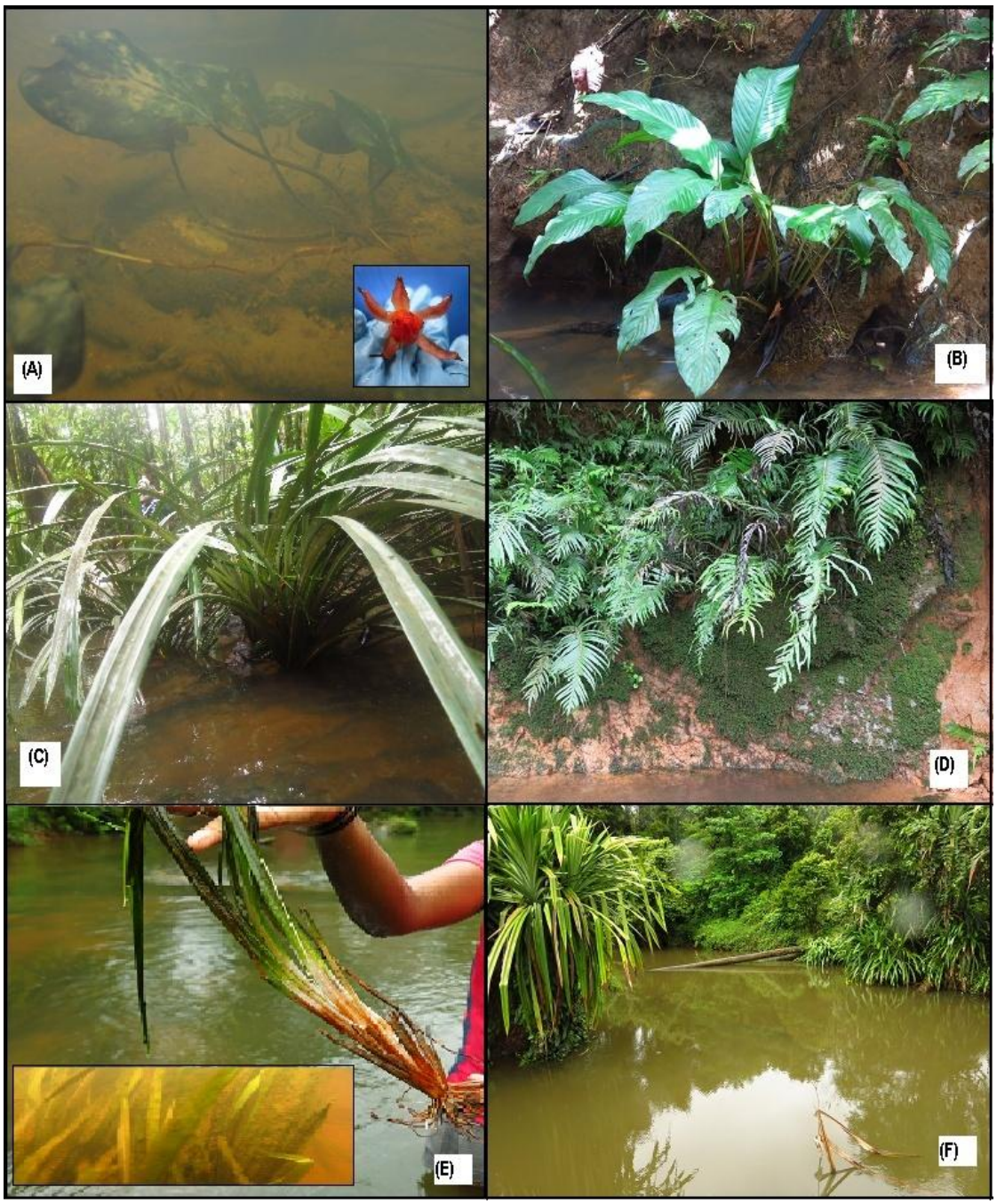

Plate 7: ***Elatinaceae, Hanguanaceae, Acorus, Nephrolepis biserrata, Hydrocharitaceae and Pandanus.***

(a) ***Elatinaceae*** *sighted in abundance upstream at water source, Sum creek (b)* ***Hanguanaceae*** *sighted both upstream and downstream (c)* ***Acorus*** *spp sighted along Sum creek (d) Fern specie* ***Nephrolepis biserrata*** *growing with riparian river moss along the banks of Tiyo river (e) Aquatic grass spp from the family* ***Hydrocharitaceae*** *scientifically identified as* ***Vallisneri aamericana*** *dominating Tiyo River downstream (f)* ***Pandanus*** *trees sighted at Tiyo River and Sum Creek upstream.*

II. Conservational significance and Invasive potential

The conservational significance of a particular species of plant or animal can be determined by the role they play in the overall ecological functioning of an ecosystem. Also their vulnerability to potential environmental changes and their statues of existence in the IUCN red list for endangered species can determine their conservational significance. Thus, conservation is important to maintain ecological balance and biodiversity in areas subject to anthropogenic activities such as the Nama well head exploration at PPL 259.

III. Aquatic Flora

All riverine vegetation or riparian zones are valuable because they provide shelter for aquatic and terrestrial fauna; they increase biodiversity and provide wildlife corridors which enable easy access for aquatic and riparian organisms to move along river systems, hence minimizing isolation of communities. The six main aquatic plants identified include two species of *elodeids* (family *'Elatinaceae'* and the *Vallisneria americana*) and the other four as *Itelophyte* riverine vegetation *(Hanguanaceae, Acorus spp*, *Nephrolepis biserrata* and *Pandanus spp*). The wild celery or aquatic grass *'elodeids'(Vallisneria americana)* and the *elodeids* plant from the family *'Elatinaceae'* are fairly tolerant of murky waters and high nutrient loading. Though they can tolerate wave action and are potentially invasive, this species can be used to determine possible negative effects of discharge from the Nama well head upstream as it was only observed downstream at Tiyo River. All other aquatic plants identified as *Itelophytes* are significant in providing shelter and food source for aquatic and riparian organisms.

IV. Macro-invertebrates as water quality indicators

On the other hand, macro-invertebrates identified all have significance in determining water quality statues because they are pollution intolerant. As a result, future monitoring of these macro-invertebrates identified can be used to determine if there are significant changes in the aquatic ecosystems surveyed both at Sum creek (Water source) and Tiyo River (Sampling point for discharge impact).

2.1 Socio-economic Environment

2.1.1 Population and Settlement

The provincial capital is currently Kiunga town in the North Fly District. The population of the province is concentrated in urban and suburban areas or the accessible government service centers. The population of Western province's is changing with improved health, education and basic goods and services mostly concentrated in major service centers like Daru, Kiunga, Tabubil, Balimo and other smaller administrative stations. Majority of land mass in the area is swamp land.

The North Fly District is divided into five (5) LLGs and a total of Eighty-nine (89) LLG Wards (Figure 5). These include These are the most immediate government representatives at the local level and are basically tasked to implement government projects and provide leading roles in project negotiations/mediations between stakeholders in any development I efforts in the local communities.

Population

		Male (%)	*Female (%)*
Total	50914	53.1	46.9
< 15 years	21209	52.5	47.5
15-64 years	29146	53.5	46.5
> 65 years	559	53.0	47.0
Citizen households	7284		

Area and population density

Area (km²)	21846
Occupied area (km²)	5438
Population per km²	2.3
Population per km² of occupied area	9.4

Figure 13 Polulation of North Fly District.

Western's total population is 3% of national population and average annual growth of 2.2%. The *2000 Census* for Western Province counted total of 25,744 Households and 153,304 Persons (79,240 Males and 74,064 females) distributed among three districts. North Fly district is the next most populous region of Western Province (33%), South Fly (30%) and Middle Fly (37%) (Table 1 and Figure 6).The Nama Exploration Drilling site is located in the *North Fly district.*

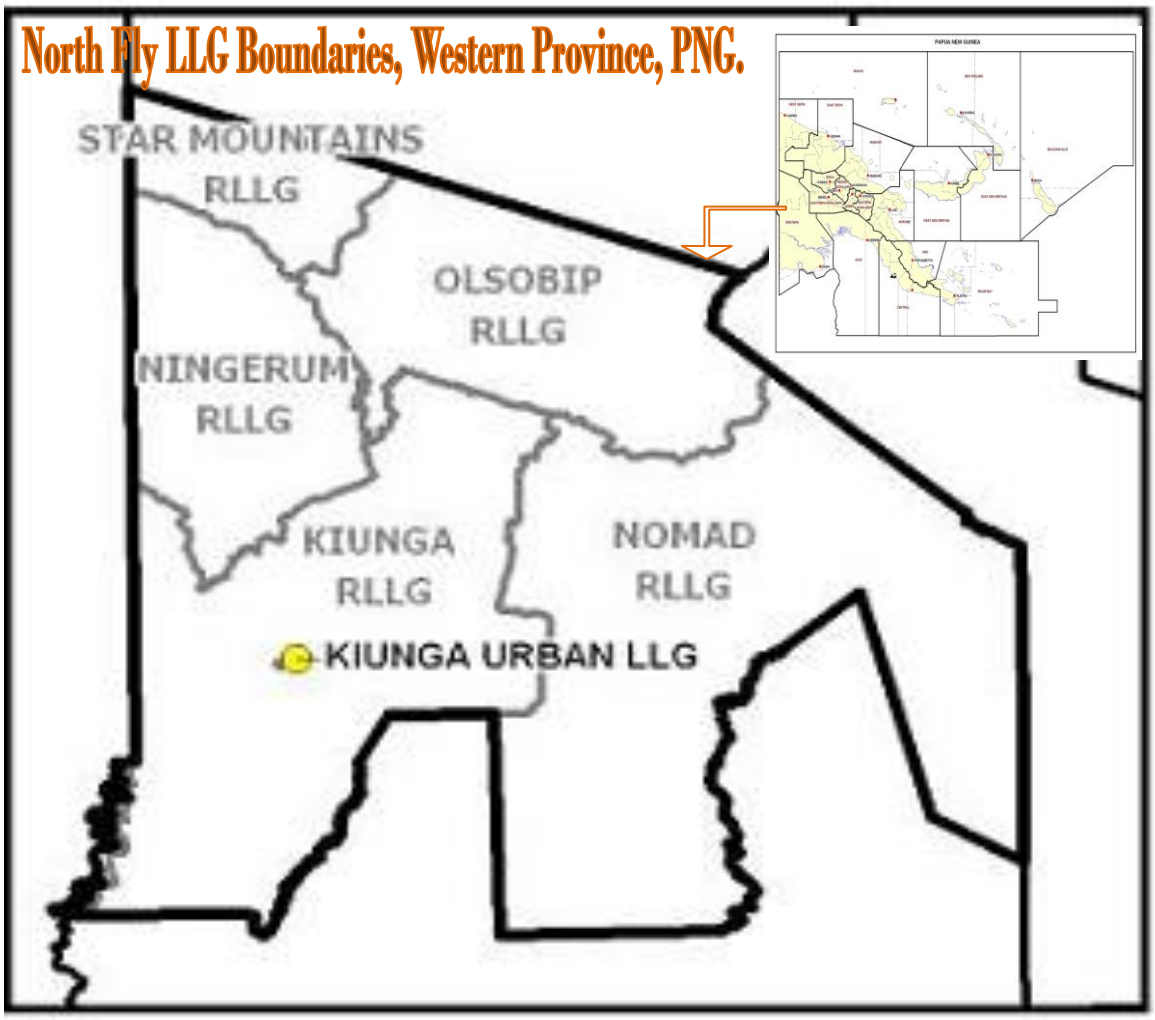

Figure 14: North Fly District LLG Boundaries in Western Province of Papua New Guinea.

The 2000 Census data indicate majority of the population lives in rural areas. There were more males than females at the 2000 Census. Figure 5 general provides the birth place of people in Western province enumerated in 2000 National Census.

Western Province experiences in-migration of people from other provinces. In North Fly District and the Nama Drilling Project area is well represented as "PNG[1] ". Net migration by province (census 2000); *Pipol, kaikai na mani*: Agriculture in Papua New Guinea (ANU 2008) identifies Western Province in the category of having significant number of Households who are migrants based on place of birth and residence of household heads.

1 Implies North Fly District is well represented by people from all over PNG; Interview with NFDC staff(2010).

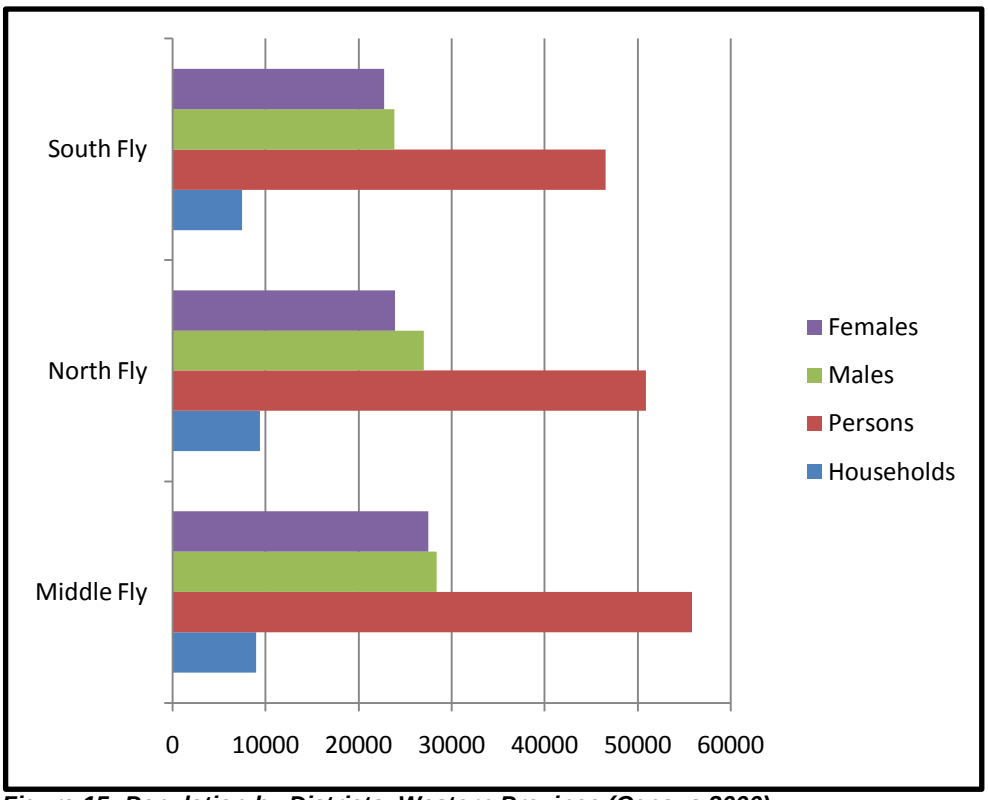

Figure 15: Population by Districts, Western Province (Census 2000).

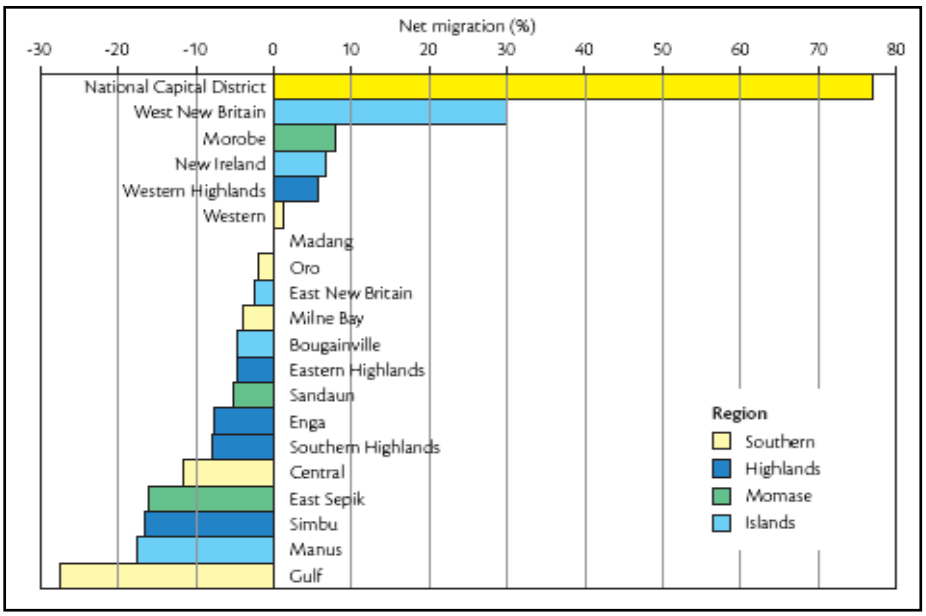

Figure 16: Place of Birth and Residence of Household heads (2000 Census).

2.1.2 Origins

The people from the project area migrated from the west, from the present-day West Papua. Warfare and sorcery are seen as the major factors that drove the Awin people to their present location. Sorcery is still a major concern of the Awin people.

Work on the archaeology and the prehistory of the proposed project area were conducted by Herman Mandui of the Papua New Guinea National Museum (February 1997). In his work, he covered areas relating to settlement patterns, burial sites and prehistoric site of wasted axes and flake sites.

2.1.3 Archeology, Historical and Religious Features

There are no archaeological, historical and religious features found in the project area however, extensive researches conducted during the Stanley Development Project identified 8 types of archaological sites which include 'significant places', 'spirit places', 'burial places', 'artifact sites', 'old village sites', 'old agricultural sites', 'ossuaries', and 'caves and rock shelters'. The definition and dscription of these archeological sites are further elaborated in the Social Impact Assessment (SIA) (See Appendices).

2.1.4 Culture and Tradition

The SIA identified that the people in the area were off Arwin orgin. The Arwin were once the original inhabitants of the river side area and their *tangible* and *intangible* culture was reflective of the natural ecosystems and associated resources of the habitats. Like other areas of PNG, traditional subsistence activities include gardening, sago processing, hunting and fishing.

The Awins follow a patrilineal kinship system through which inheritance of property and natural resources are passed on. Important decisions in the community are made by the elders and area respected by all. Marriages in the Awin are arranged while most socio-cultural activities are celebrated in clans.

The nature of specific deaths in the village always requires explanation and is often blamed on sorcery. The dead are buried close to the village and each site is respected. There are certain places and food that are restricted from women and children- for example; women cannot bath at specific locations of the creeks while certain foods are forbidden to children or pregnant mothers.

2.1.5 Resource and Land Use

In Papua New Guinea people value, name, and use, modify, and enjoy the local environment. Because of this they seek to manage and to conserve, or to exploit their environment. Cultural resources are the result of humanity's interaction with or intervention in the natural world or its natural resources. This includes all the manifestations of humanity: buildings, landscapes, artifacts, literature, language, art,

music, folkways and cultural institutions are all cultural resources. It also refers to only those parts of the cultural heritage, those manifestations of humanity, physically represented in the landscape by “places” (that is cultural resources which occur on, or are an integral part of, land or landscape).

A proportion of places will have characteristics that might indicate that they are or may be culturally significant, of importance to the community, and therefore need to be investigated further. Often this indication of potential significance has been used as the basis for *conservation.*

Natural subsistence resources are those materials that are obtained from the natural environment in order to support the existence of rural people who, in Papua New Guinea; account for over 80% of the population.

Special sites used by the bird of Paradise for dancing/mating were found in the area however none were found within the drill site.

Several lakes and creeks used as spiritual sites or “*ples masalai”* were known around the area however none were found within the drill site or license area.

Galip tree, and Bamboos are known to be story trees/ plants in the area. Some tress were planted by local people (ancestors) while ‘eels, ducks, water birds, crocodile inhabit local lakes and the creeks in which viller’s regularly use for swiming, canoeing, laundry, etc.

Plate 23: Stream Used for Bathing and Laundry by Kmom Villagers, 2014.

Plate 24: Typical Vegetable Crop Gardens observed within the Nama Impact Communities, 2014.

Plate 25: Some food crops grown in vegetable gardens by Nama Impact Communities, 2014.

Plate 26: A Tree Sap (locally called Twan) used as Source of light by Nama Impact Communities, 2014.

2.1.6 Languages

The landowning communities of Western Province are identified based on the tribal and language groups in each geophysical region including the Ari Waruna, Awol, Bamu-Kiwai, Biami, Bimin, Bine, Boazi, Faiwol, Gidra, Gogodala, Idi, Lewanda, Nambu, Ningerum, Nomad, Pa, Southern Kiwai, Suki, Tonda, Waia, Wabuda and Zimakani languages

The predominant group of people or the Awin people and speak the Awin (Aekiyom) language. Two other groups that who are culturally distinct from the Awins are the Yonggoms and the Ningerum. Although there are some social interaction with the other language groups, Awin (Aekiyom) is the predominant tongue that is spoken in the study area with very little influence from the other lingua groupings.

2.1.7 Employment and Income

'At the provincial level, subsistence employment was most common for both males and females, accounting for 67% and 84% of total employment, respectively. This was followed by wage jobs for males (20%) and females (5%). These provincial aggregates mark the different activity patterns that exist in the urban and rural sectors. In urban areas, wage jobs were most common for males, accounting for 70% of urban employment. Subsistence activity was important for females (42%) but less so for males (15%). In the rural sector, 79% of male employment and 89% of female employment was subsistence activity. This was followed by wage job, 9% for

male and the gardening and fishing for money, 5% for male and 4% for females respectively'.[2]

During the questionnaire survey, a total of 37 sample surveys were undertaken, which 10 participants had formal fortnightly employment. Hence, 27% of the sample participants were the direct sources of villagers' income generation and contribution to the communities' cash flow on a fortnightly basis.

These participants provided basic community services, especially education services of teaching in Primary, and elementary schools found in the three (3) Nama Project impact communities.

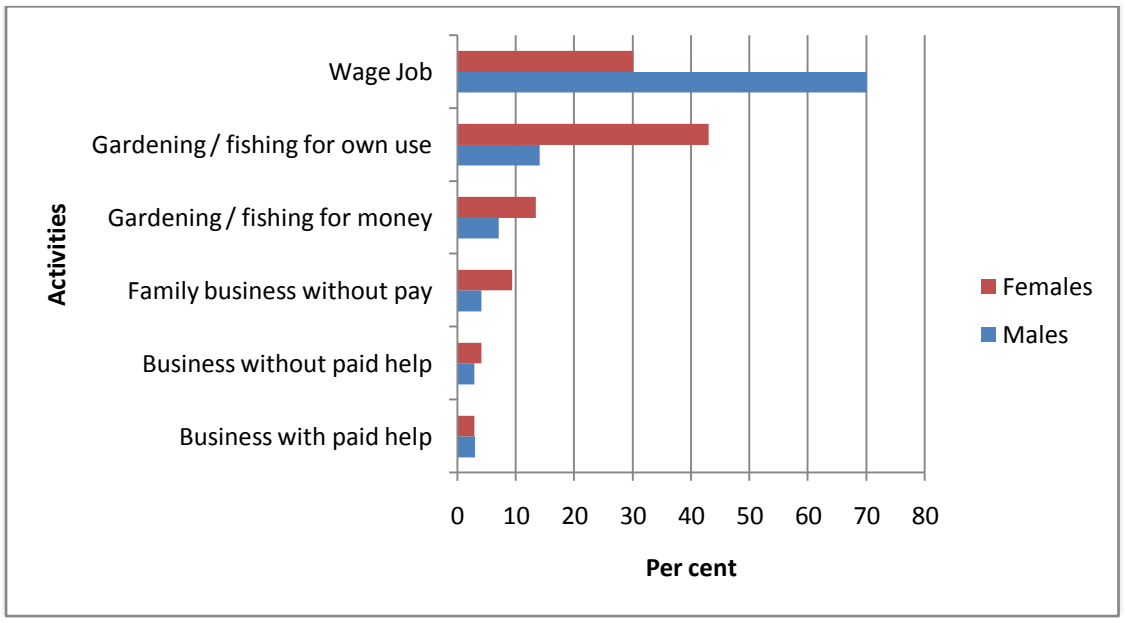

Figure 14: Type of urban employment by Sex, Western _ 2000 Census.

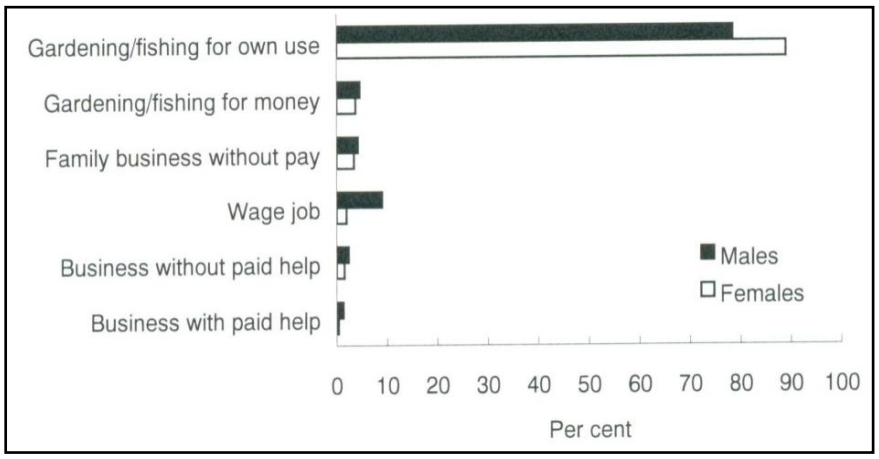

Figure 15: Type of rural employment by Sex, Western _ 2000 Census.

Plate 23: Kiunga Vegetable Market – Dried Fish and Vegetables are Villagers sources of income.

2.1.8 Community Assets and Access to Government Services

Kiunga Town is the main area of business and infrastructure. Kiunga Airport is the main link to outside provinces in PNG and is located 2 km away from Kiunga town. The airport caters for flights travelling from Tabubil, Daru and Port Moresby at the same time accommodates helicopters and smaller planes operated by companies currently occupying the KSB area. Smaller planes lead travel to very remote areas of Western Province.

Kiunga Port is the largest port service in the area which assists in the provision of goods and services to the community. The port also accommodates the OTML downstream port services which enable the export off gold internationally.

2.1.9 Health

Kiunga hospital is the main health service provider in the North Fly District while there are also other health centres located in the rural areas, including the Ningerium health Centre and the Gre Aid post which are well within the vicinity of the Nama Project impact communities.

The Health centres in the North Fly district of Western Province benefit from multi-million kina health Programme funded by OTML. Other partners in the Programme implementation include JTA International, Western Government, Catholic Health Services and the Evangelical Church of PNG (ECPNG).

Locals are treated for common disease such as malaria, fever, diahhorrea and other common illnesses. The Health Center's/Aid Posts enable villagers to have access to general health facilities for medical treatments and supply materials such as mosquito nets and detergents to prevent the spread of common illnesses.

2.1.10 Education

The level of educational attainment of the population is an important determinant of its capacity to be economically independent. Increasing levels of education indicate development progress both at an individual and societal level.

According to Stanley SEIA Survey by ERM in 2012, more than half of the people in both urban and rural areas had received some method of education. The proportions of males and females attending school were 25% each in urban sector. In rural sector, proportionally more males than females were attending school, 24% and 21% as shown in table 3. The next table summarizes school establishment in western Province.

In the Nama project area impact villages there were two primary and two elementary schools identified which were funded by the Provincial Government. These schools were located in Gre and Kmom Villages, respectively. Issues identified during the SIA survey included qualification of teachers and transport.

Plate 24: Typical Pit Toilet and Classrooms at Kmom Village.

A. A typical Pit Toilet observed in Gre Village. B. Students and their Classrooms at Kmom Village, 2014.

2.1.11 Law and Order

Western Province shares two international boundaries and 5 Provincial boundaries and is the largest province in terms of land area. The high migration of people into the project area has resulted in the increase in Law and Order problems.

Law and Order is maintained in the Province through the presence of the main Police Station in Kiunga Town. Police ensures law and order is maintained through patrol posts. The main means of patrolling is through government funded vehicles and boats. Additional security is maintained through private security firms operating in the area.

The local people within the Nama project area have reported no serious law and order problems. In addition, minor family related problems are solved amongst themselves with occasionall assistance from the local pastors.

Similar studies in the past identified the following law and order issues common in the remote rural communities:[3]

- Attempted murder/murder
- child abuse-under age marriage
- rape
- drugs
- domestic violence
- break and enter
- firearms

Village court hearings are conducted in all villages and serious cases are referred to the court house in Kiunga.

2.1.12 Administration and Political Representation

Western Province is administratively divided into three electorates (Districts), namely the North Fly, Middle Fly and the South Fly District. The province shares International boundaries with Australia to the South and Indonesia to the West. Western Province has a 480 Km border with Irian Jaya to the West. The border with Australia in Torres Strait comes within 4 Km of the South Coast.

To the North, Western Province has borders with both East and West Sepik Province. Western Province also borders with Enga Province and Southern Highlands Province towards North-East, and the Gulf Province in the East.

Provincial Government is made up of Governor, Parliamentary members representing South Fly, Middle Fly and North Fly. The current members of parliament included Mr Attia Wobiro representing Western Provincial, Mr. Boka Kondra representing North Fly Open, Mr. Aide Ganasi representing South Fly Open and Mr. Roy Biama representing Middle Fly Open with the Chairman of each LLG.

The provincial Administrator is Dr. Moduwa Gumoi and his Deputy DA: Mr. Gul Gorgom while Mr. Moses Ase is the District Secretary. Kiunga Local Level Government Manager is Mr. Richard Alphonse while the LLG president for North Fly is Mr. James Donald and Mr. Awoke Yanai (Vice president).

The three (3) LLG Ward to be impacted by the Nama Exploration Drilling Campaign are:

1) Ward#: Six (6), Councilor is Mr. Dickson Owen,
2) Ward#: Twenty Six (26), Councilor is Mr. Awoke Yanai,
3) Ward#: Two (2), Councilor is Mr. Joel Krondu.

[3] Douglas Environmental Services (2oo8) - EIS; Inter Oil Elk/Antelope Project.

Table 4: Representatives elected in the 2012 National Election.

District	Political Representative
North Fly	Hon. Kondra BoKa
Middle Fly	Hon. Roy Biyama
South Fly	Hon. Aide Ganasi
Provincial	Hon. Atti Wobiro (Governor)

Table 5: Western Province LLG Administration Areas.

Code Number	Districts	Local Level Governments	Wards	Census Units
01	Middle Fly	5	121	256
02	North Fly	5	83	241
03	South Fly	4	71	221

The Nama Exploration Drilling project is located within the Kiunga Rural LLG and has three (3) wards to be impacted. The ward councilors representing the impact communities are as listed in the table below (**table 7**).

Table 6: LLG Ward Councilors Representing the Nama Drilling Impact Communities.

Village	Ward LLG	Ward Councilor
1. Kmom	Ward # 26 (Dabike)	Mr. Awoke Yanai
2. Monaya	Wards # 2 (Tmindmesuk)	Mr. Joel Kronduo
3. Gre	Ward # 6 (Gre)	Mr. Dickson Owen

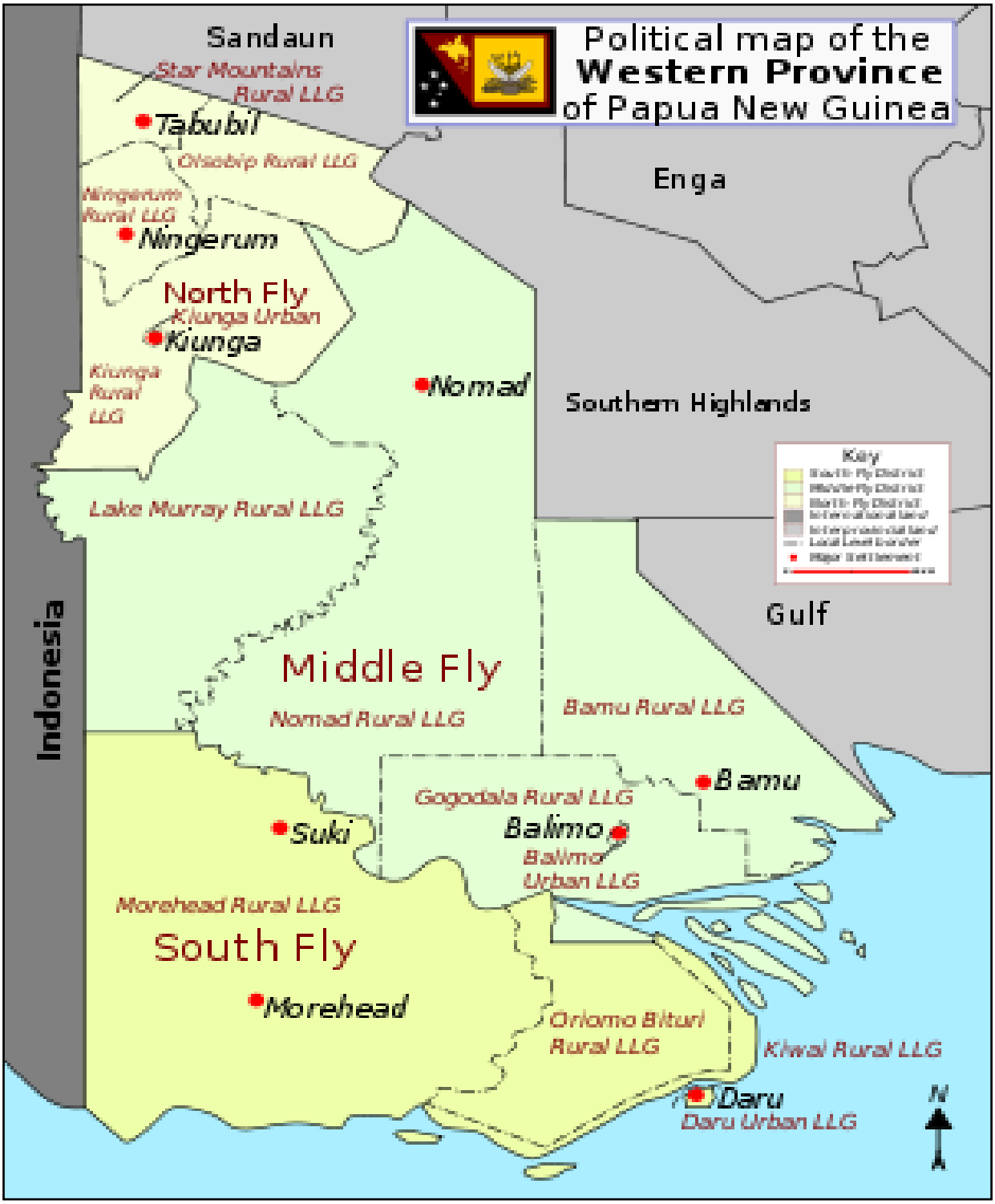

Figure 16: Political and Government's Administrative Boundaries of Western province, PNG.

2.1.13 NGO and Church Services

Information on religious affiliation is important as an indicator of social awareness as well as for policy and planning by religious and other non-government organizations. The majority (95%) of the people in Western Province in 2000 were Christians.

The Evangelical Church of Papua New Guinea (ECPNG) is dominant in the project area. However the Catholics and Seventh Day Adventist (SDA) have recently had converts in the project area. Similar studies by Douglas Environmental Services in Western Province concerning church affiliations in the Gogodala district of the Middle Fly region confirm ECPNG is dominant in Western Province (more than 50%).

Non-Governmental Organizations (NGO) refers to any recognized groups outside of government that are formed for a common purpose or goal. In a community setting, such organizations are referred to as Community Based Organizations (CBO's). These groups can be a women's group, youth groups, church groups, etc. These groups are non-profit organizations and differ from organized groups such as Cooperative Society, Business Groups, and etcetera.

There are no CBO's or other non-profit organizations operating in the area, except the various churches in the area and PNGSDP. However, these churches are not involved in any activities. This can be demonstrated by the fact that there are few churches with buildings. Although most of the villagers indicated belonging to certain denomination, attendance and participation in church activities is non-existent. The Rumgenai hospital is managed by ECPNG.

Plate 25: ECPNG Church in Gre Village.

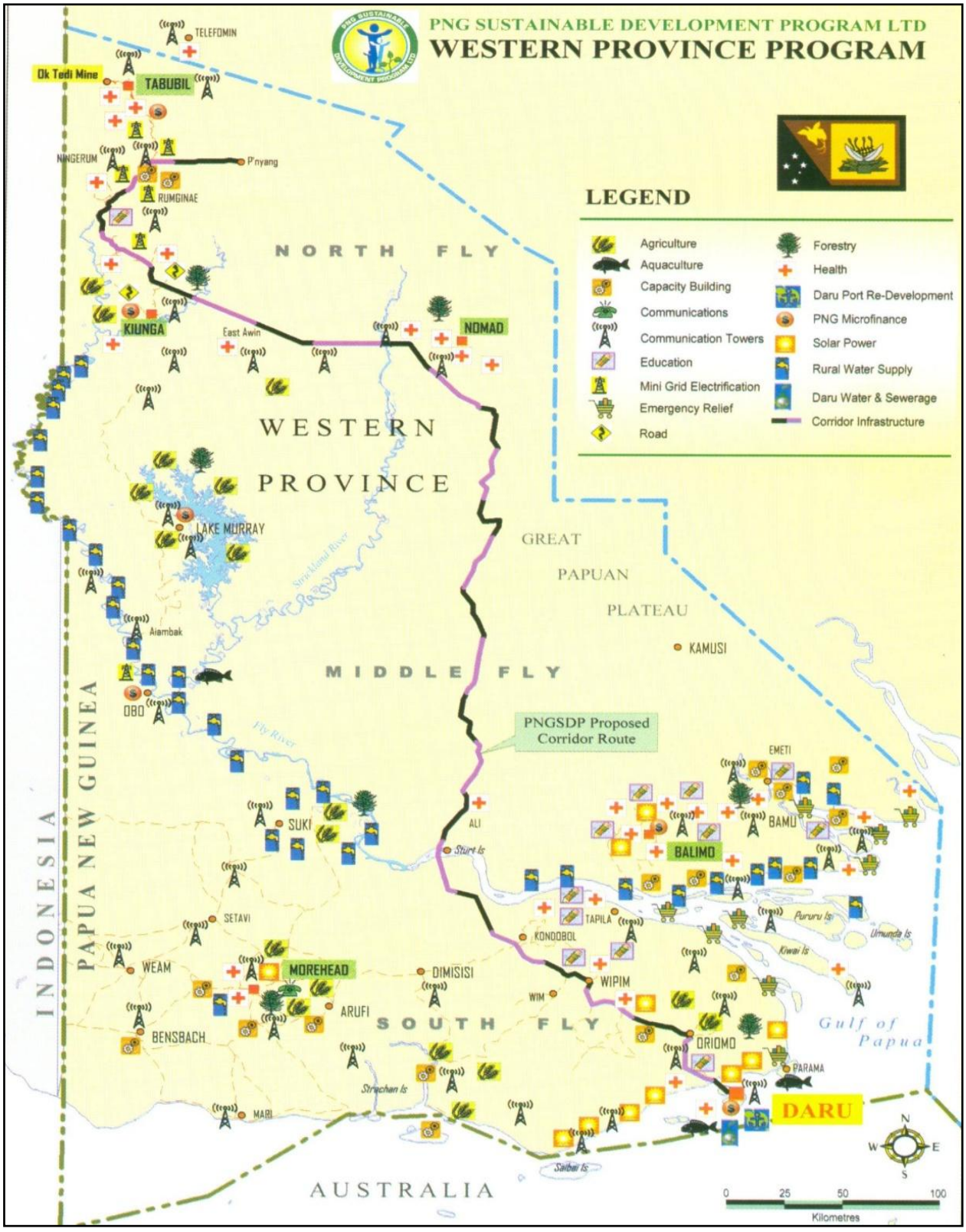

Figure 17: PNGSDP Development Program in Western Province, PNG.

2.1.14 Transport and Communication Infrastructure

The Nama project site is linked through Drimgas road which links to Kiunga town, Gre - Monaya -Kmom – Drimgas village located along the Fly River system. Hence, site can also be access via Drimgas using boat through the Fly River and via Gre-Drimgas road.

Plate 26: Places along Gre to Drimgas Road.

A. Gre to Drimgas Road and Bridge conditions to access Nama Exploration Drilling Site, 2014. B. PMV 15 Sitter Bus at Gre Village Loading Passengers to Kiunga Town, 2014. C. Kiunga Town over looking from Lobire Guest House towards Provincial Government Office Building (Maroon & Yellow colored).

2.3.14 Nama Project Area Communities.

The following subsections provide the general features of the impact communities of the Namadrilling project. The villages to be impact by the Nama Exploration Drilling activities are; Gre, Monaya, and Kmom with Drimgas, to certain extent on the end of the access road. Each villages constitutes of several clans however the 3 landowning clans for the Nama project area identified by the SIA were the Huseke Gre and Sore clan.

2.3.14.1 Gre Community

Gre village is located along the Kiunga-Tabubil road at the junction of the Gre-Drimgas road.The village is within LLG Ward # six (6) with councilor Mr Dickson Owen. At time of study, the village had a population of 492 members.

The dominant clan identified wasGre clan while there were eleven (11) other clans identified in the village. The Huseke Clan which were a minorityclan in Gre village were identified as the land owner clan in the Nama project area.The village had primary and elementary school, as well as an Aid Post.

The village is organized in such that village houses are in a linear alignment along the main road/highway on both sides of the road. Houses are mostly built of bush materials, with timber of mixed tree species and walling from black palm with roofing of Iron sheets and black palm leaves/kunai grass. All houses were generally observed to be in very good condition (**Plate 29,** one of the houses in Gre Village). Most villagers source water for drinking and cooking from privatewells while creek/streams were used for bathing and laundry purposes.

Gre villagers mostly speak local language known as Awin (Aekyom), while English, Tok Pisin and occasionally Motu as business languages.

The three (3) dominant churches in the village were ECPNG, CRC, and Revival. The village had two village court magistrates responsible for attending to minor law and order issues while major crimes were referred to Kiunga District Courts. The Highway patrol of the police is effective as part of Ok Tedi Tabubil security measures.

Plate 27: A. Chief of Gre Clan, B. Nama Project Land Boundary.

A. Chief Kwani Yaku on Left (grey shirt) of Huseke Gre Clan in Gre Village.

B. Nama Drilling Project Land boundary along the

Access road marked by Huseke Gre and Sore Clans.

Plate 28: Gre Community during Community Consultation and SEIA Study, 2014.

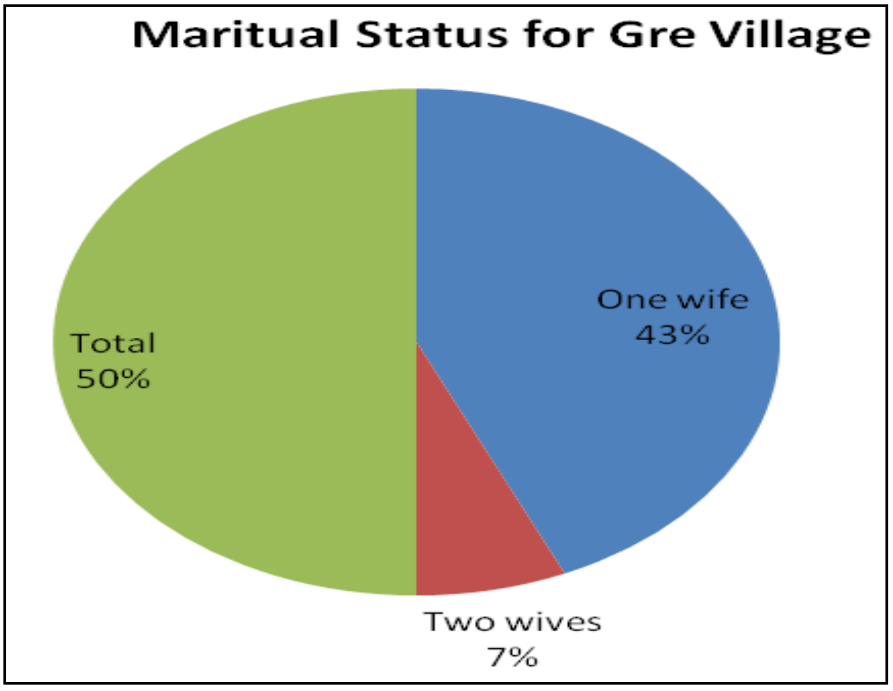

Figure 18: **Maritual Status (number of Wives) for Gre Villagers.**

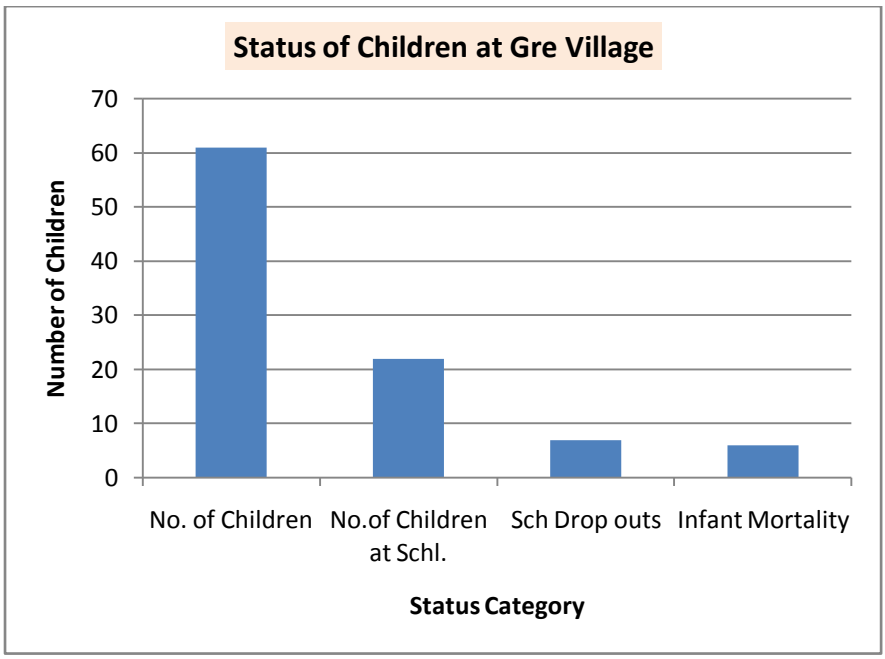

Figure 19: Status of Children in Gre Village.

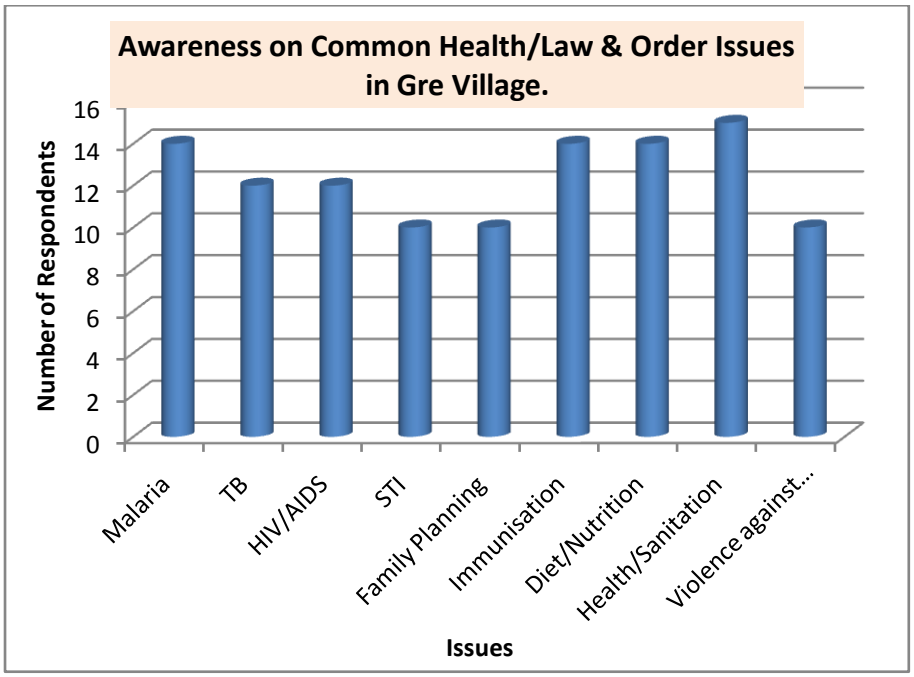

Figure 20: Gre Villagers' Level of Community Awareness on Common Health Issues.

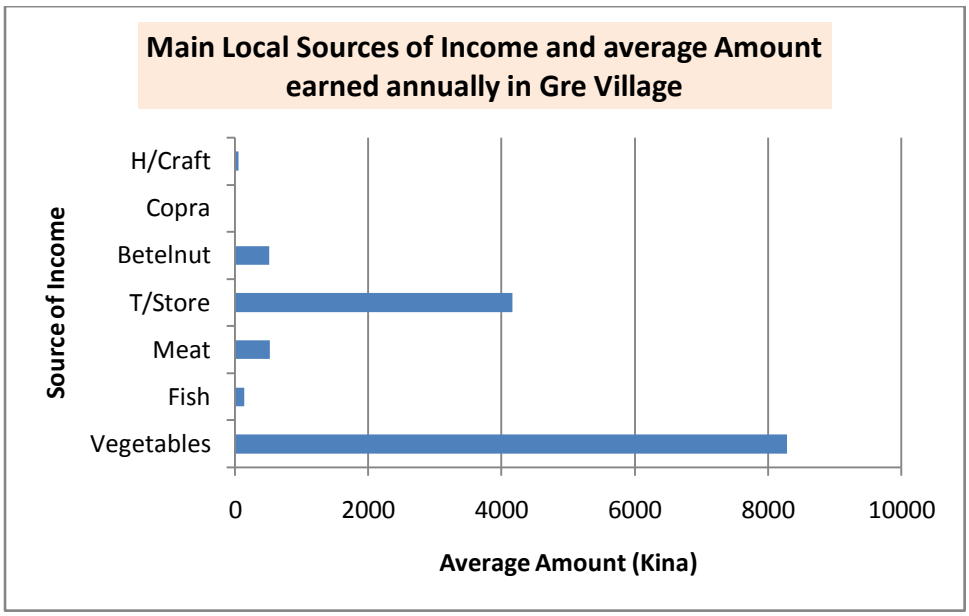

Figure 21: Annual Local Source of Income and Average Amount earned by Gre Villagers.

Plate 29: Photographs of Gre Village.

A. Aid Post and Medical Officer at Gre Village, 2014. B. Pigs are domesticated for both meat and cultural ceremonies. C. Road side betelnut market at Gre Village and Vendors being interviewed by Nama SEIA team.D. Bow and Arrows/Spears used by Gre Villager for hunting wild animals.

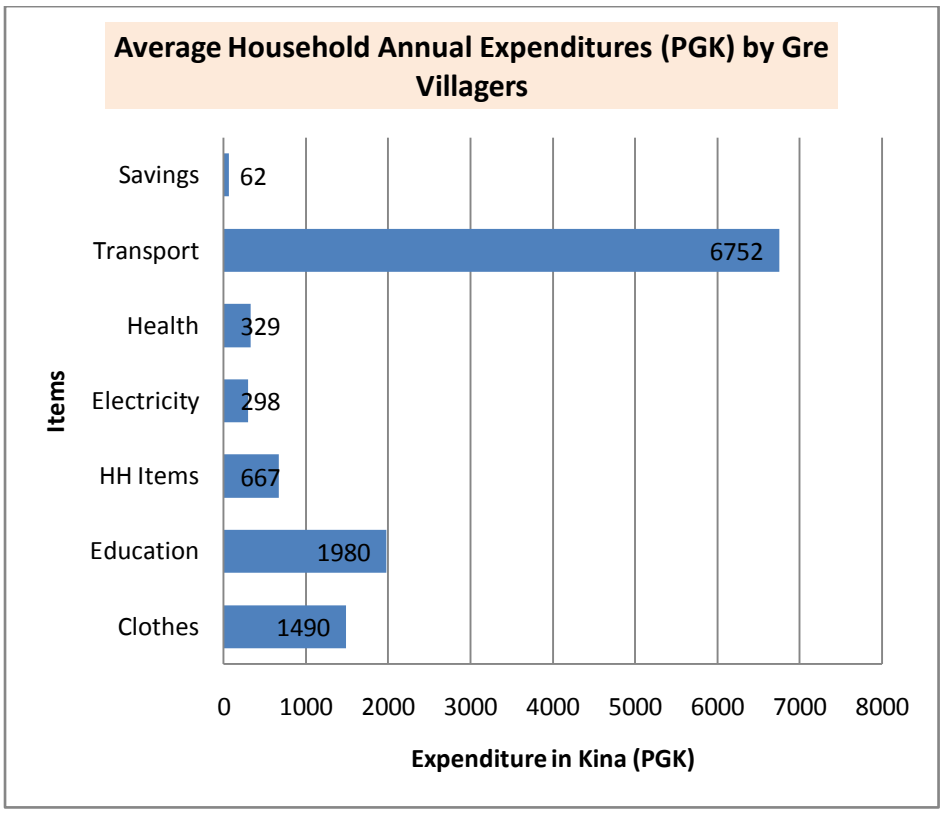

Figure 22: Average Household Annual Expenditures (Kina) by Gre Villagers.

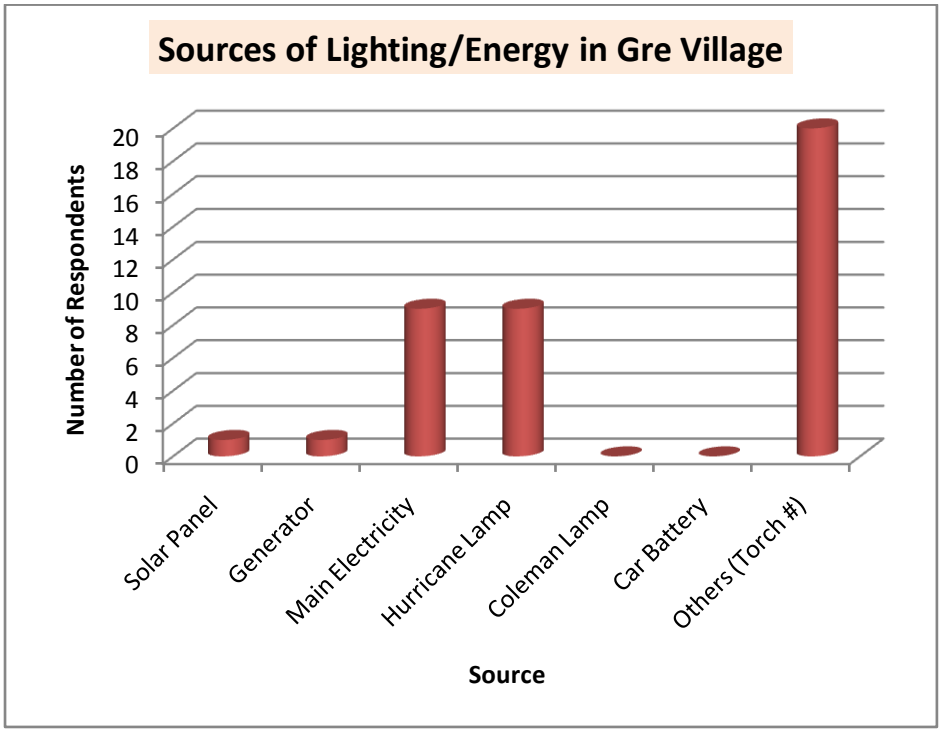

Figure 23: Main Sources of Lighting/Energy used by Gre Villagers.

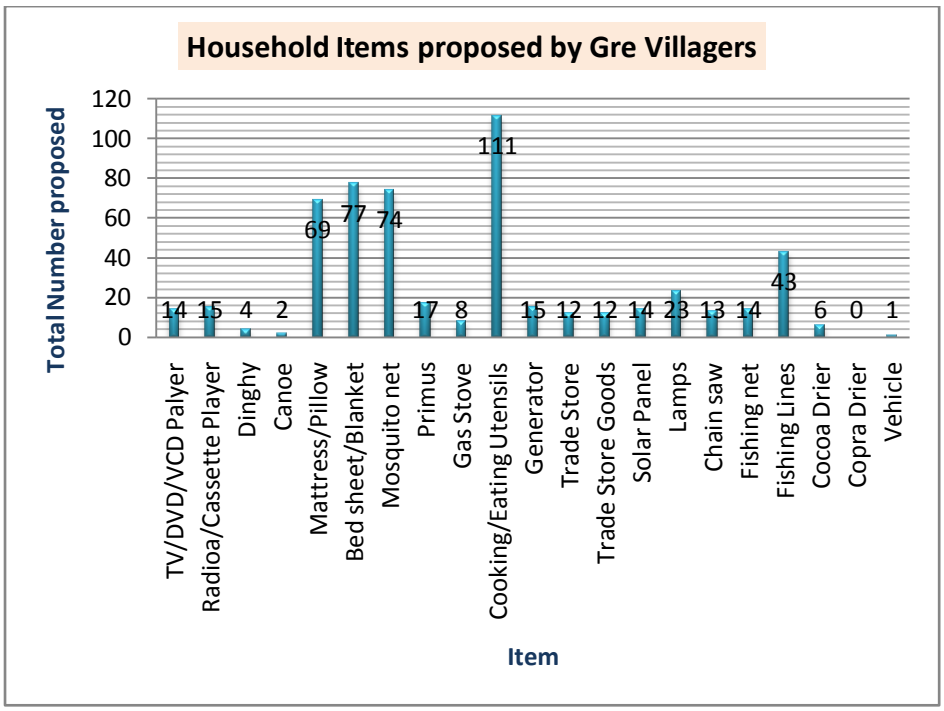

Figure 24: Household Items desires and proposed to purchase by Gre Villagers, 2014.

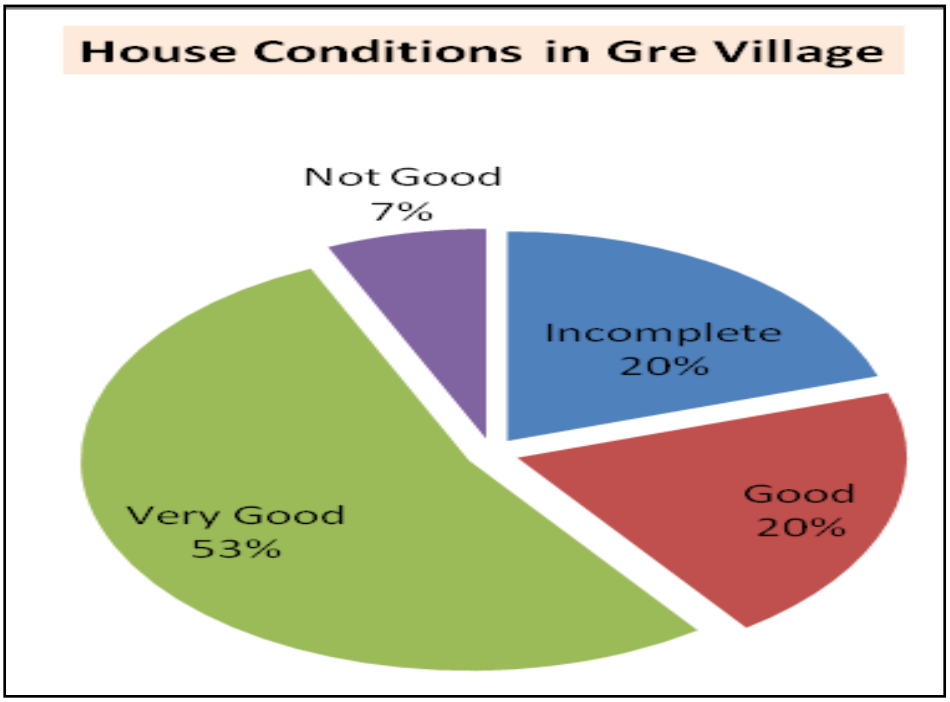

Figure 25: Condition of Houses observed in Gre Village, 2014.

Plate 30: Gre Village A. Western Power and B. Typical Good Condition House.

A. Western Power Generator House for Gre Village Electricity Supply, 2014.

B. Typical Condition of Houses observed as Very Good in Gre Village, 2014.

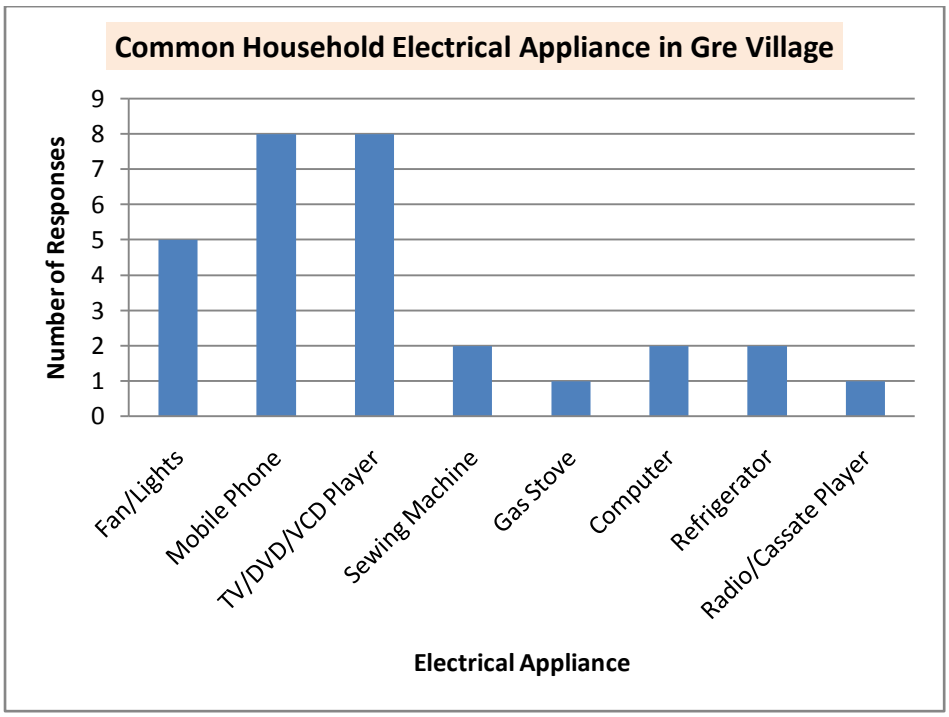

Figure 26: Common Household Electrical Items recorded in Gre Village,2014.

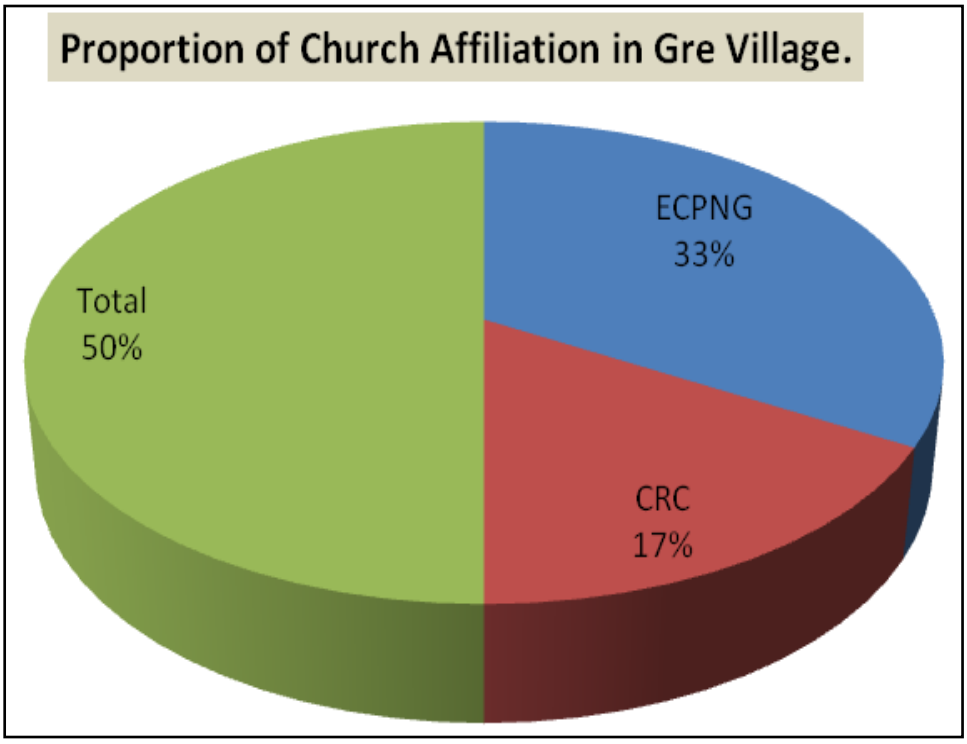

Figure 27: Religious (Church) Affiliations of Gre Villagers, 2014.

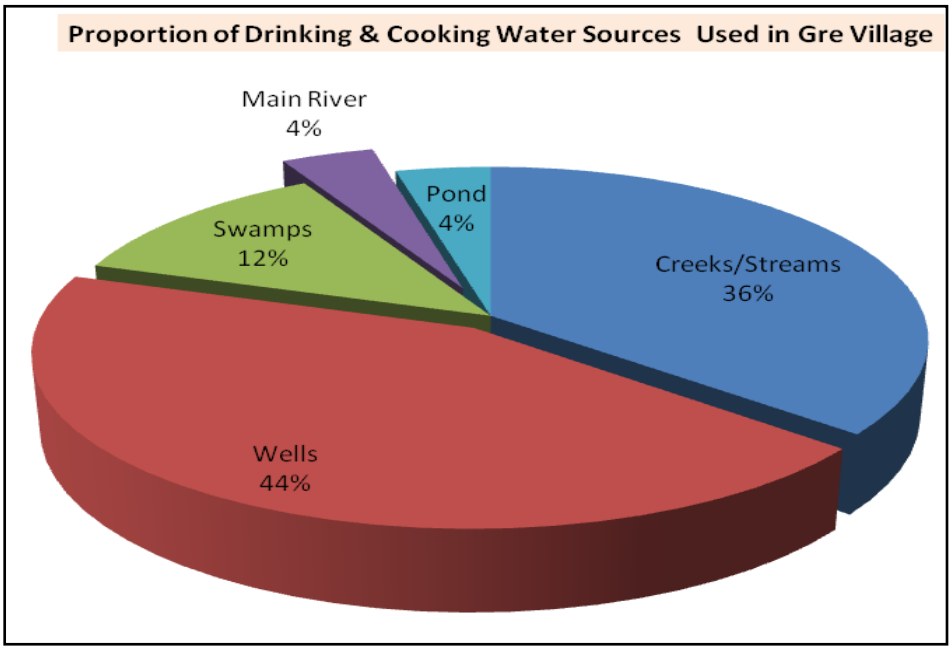

Figure 282: Proportion of Gre Villagers use of Drinking and Cooking Water Sources.

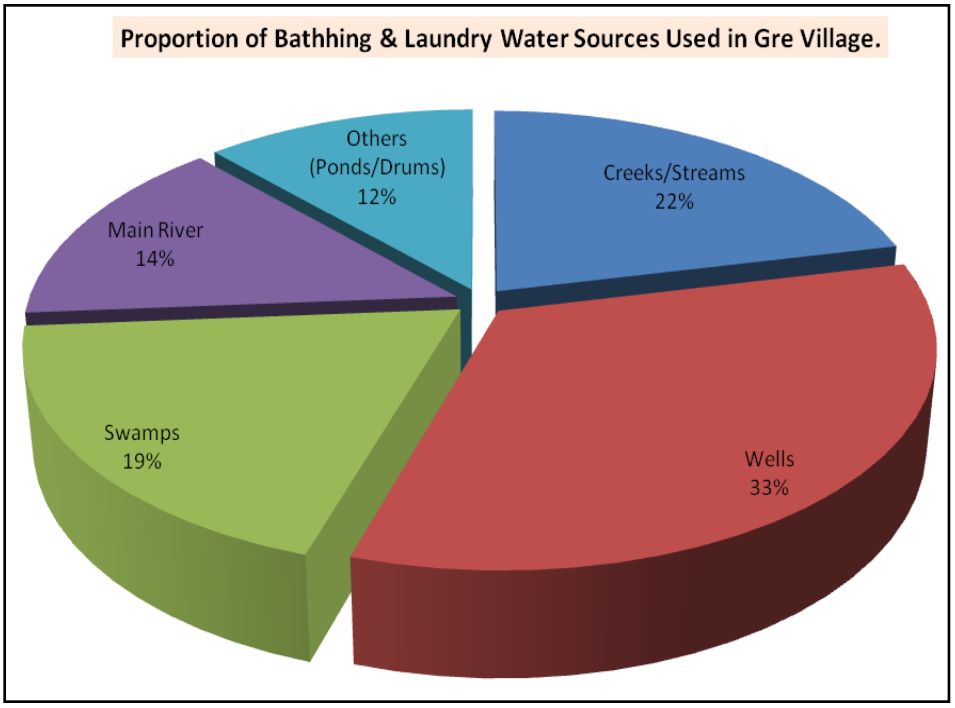

Figure 29: Proportion of Gre Villagers use of Bathing and Washing Water Sources, 2014.

2.3.14.2 Monaya Community

Monaya village is located immediately at the junction of the access road to the proposed Nama exploration Drilling site. At time of survey, the village was found to be deserted due to relocation of the villagers by the local level government to Tmindemasukto enable accessibility of basic government services.

Monaya village has a population of 399 with a village recorder assigned to collect village data in terms of population basic issues encountered by the community members. The village recorders work alongside leaders and report issues to responsible Local Level government representatives.

Common languages used in the village was Awin (Aekiyom), English and Tok Pisin as business languages.

Monaya village has its members who affiliate to Three (3) churches known as CCN (Community Church Network), Catholic and Lutheran however the churches are all located at Temindemasuk village.

In Monaya village houses are arranged in a linear alignment along the main Gre – Drimgas road on both sides of the road. Houses are mostly built of bush materials, with timber of mixed tree species and walling from black palm with roofing of black palm leaves/kunai grass. All houses were generally observed to be in very good condition. Most villagers source water for drinking and cooking from wells while creek/streams are used for bathing and laundry purposes.

There were eight households interviewed in Monaya village. All of the interviewees processed were males. The village in used for gardening, hunting and leisure seasonal camping as the villagers reside at Temindemasuk village nearer to government basic services and accessibility to modern goods at Kiunga town.

As can be seen from the graph (**figures 24 & 25** above) there were total of 35 children recorded from the eight (8) households interviewed. The questionnaire survey results for Monaya village indicate infant mortality recorded 23 % of children, 46 % students and average of 8 drop outs from school.

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As can be seen from the graph (**figures 24 & 25** above) there were total of 35 children recorded from the eight (8) households interviewed. The questionnaire survey results for Monaya village indicate infant mortality recorded 23 % of children, 46 % students and average of 8 drop outs from school.

Plate 31: A & B; Photographs of Monaya Community leaders and Villagers.

A. Monaya Community leaders during SEIA Community Consultation, 2014.

B. Men at Monaya Village pointing towards the Proposed Nama Exploration Drilling Site, 2014.

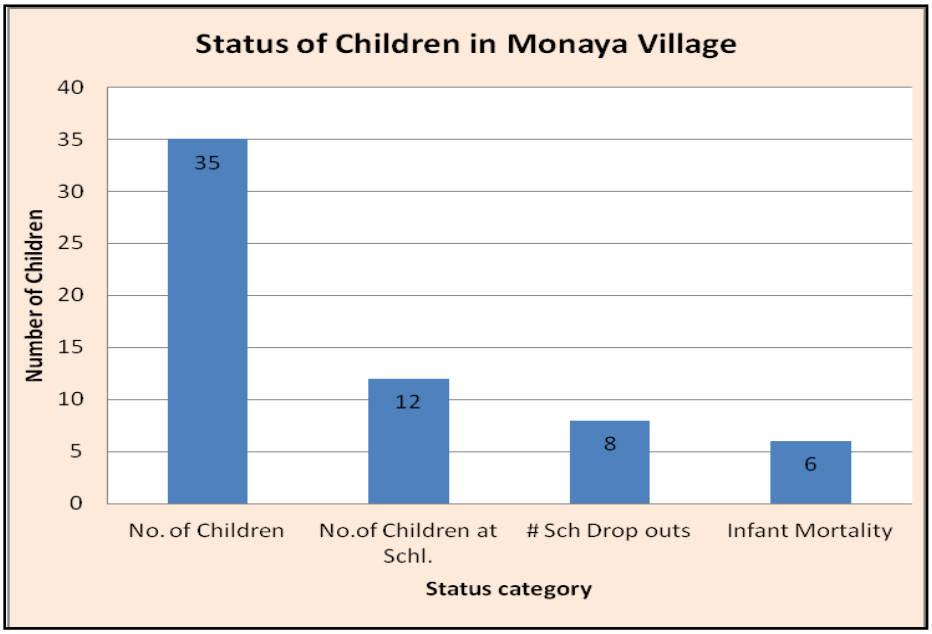

Figure 30: Status of Children in Monaya Village, 2014.

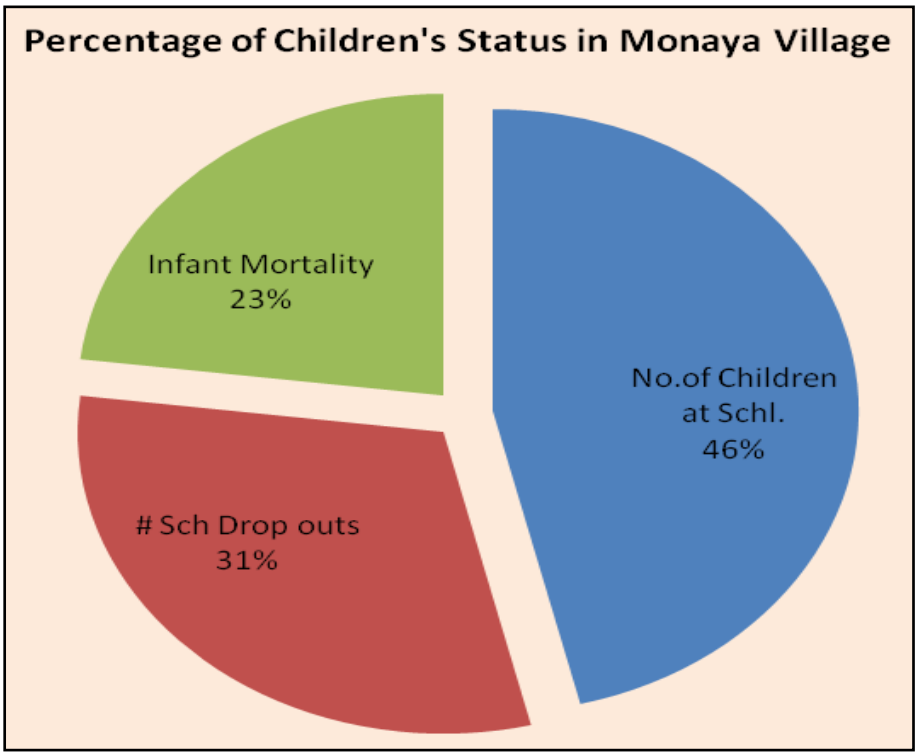

Figure 31: Percentage of Children's Status in Monaya Village, 2014.

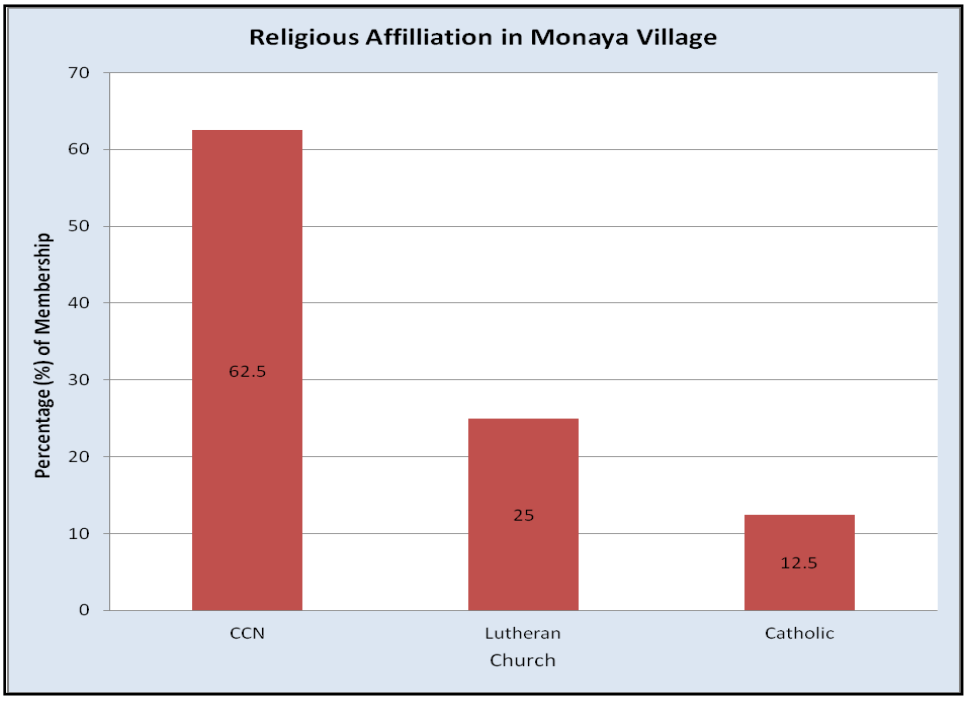

Figure 32: Religious Affiliation of Household Heads Interviewed Monaya Villagers, 2014.

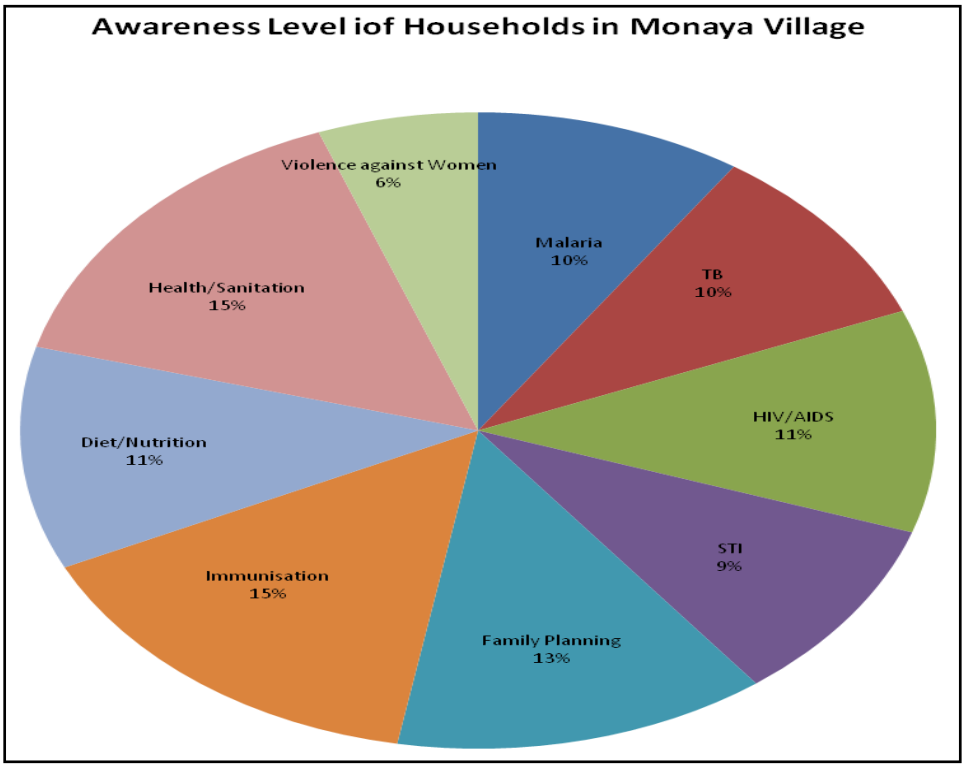

Figure 33: Proportion of Awareness Level of Households Heads interviewed in Monaya Village.

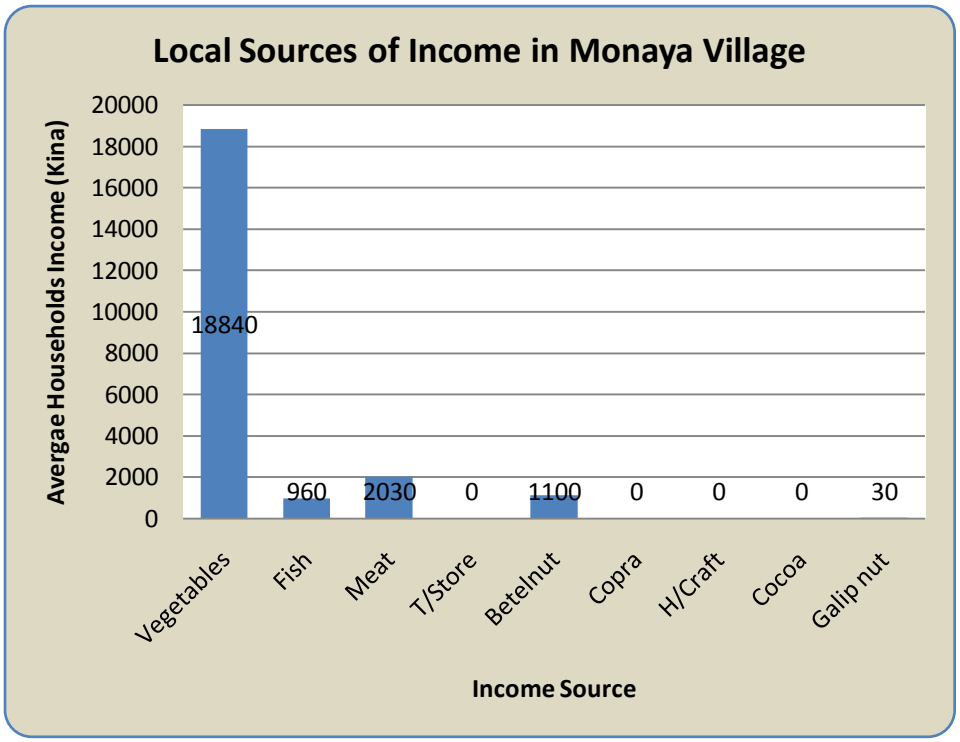

Figure 34: Local Income Sources and annual Average Amount (Kina) in Monaya Village.

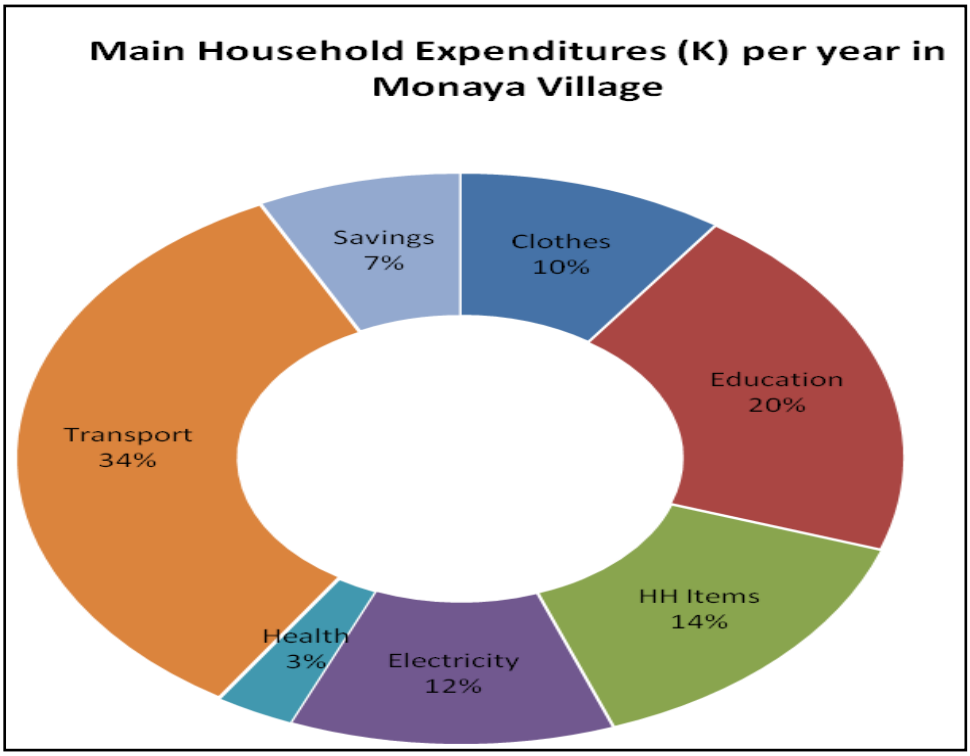

Figure 35: Proportion of Annual Household Expenditure by Monaya Villagers.

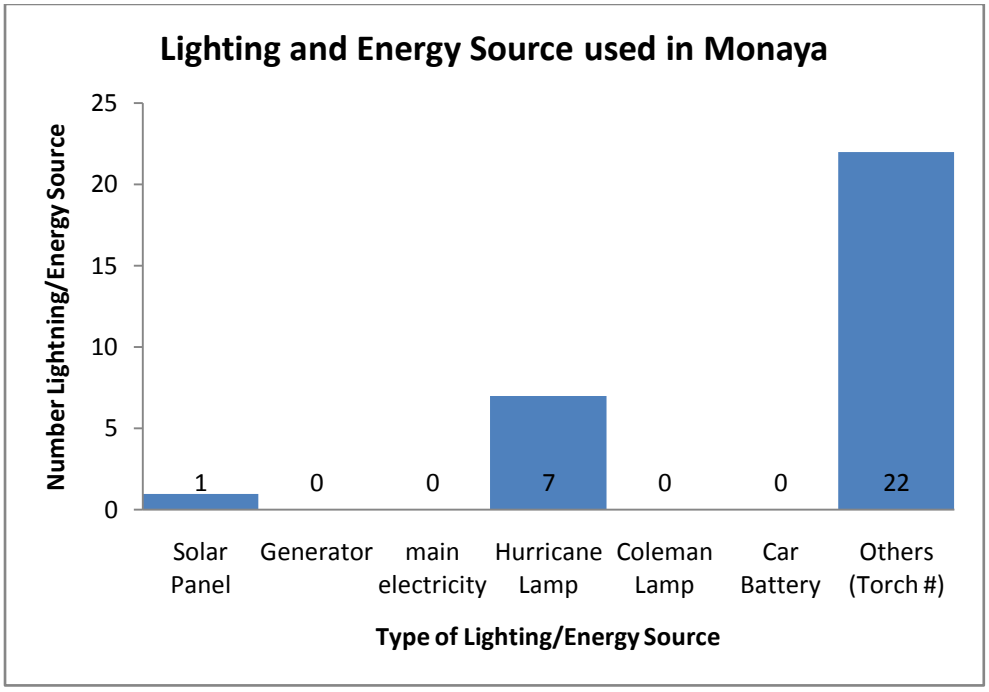

Figure 363: Sources of Lighting/Energy used by Household Heads Interviewed in Monaya.

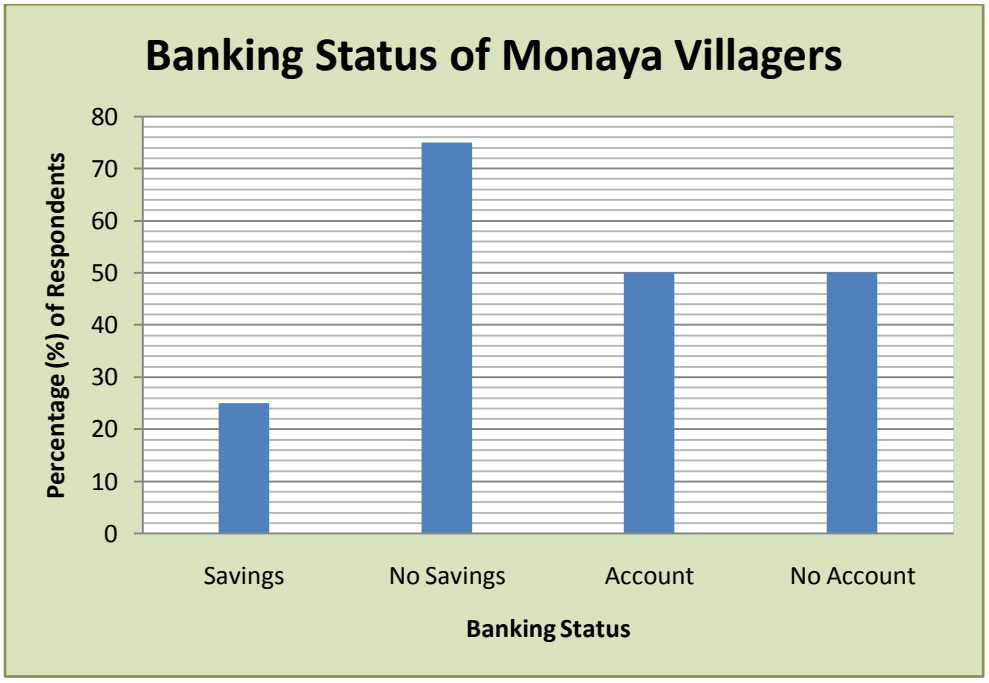

Figure 37: Banking Status of Monaya Villagers interviewed.

2.3.14.3 Kmom Community

Kmom village is within Ward (LLG) #: Twenty (26) of the Kiunga Rural LLG. There were no landowner clans identified in this village.

Languages mostly spoken by Kmom villagers are Awin (Aekyom), while English, Motu and Tok Pisin are used as business languages.Churches in which the villagers affiliate are Three (3) churches including CRC, ECPNG and Revival.

In Kmom village the houses are mostly built of bush materials, with timber of mixed tree species and walling from black palm with roofing of black palm leaves/kunai grass. All houses were generally observed to be in very good condition. Most villagers source water for drinking and cooking from wells while creek/streams are used for bathing and laundry purposes.

Plate 328: Kmom Primary School Students Assemble to attend to Nama SEIA team, 2014.

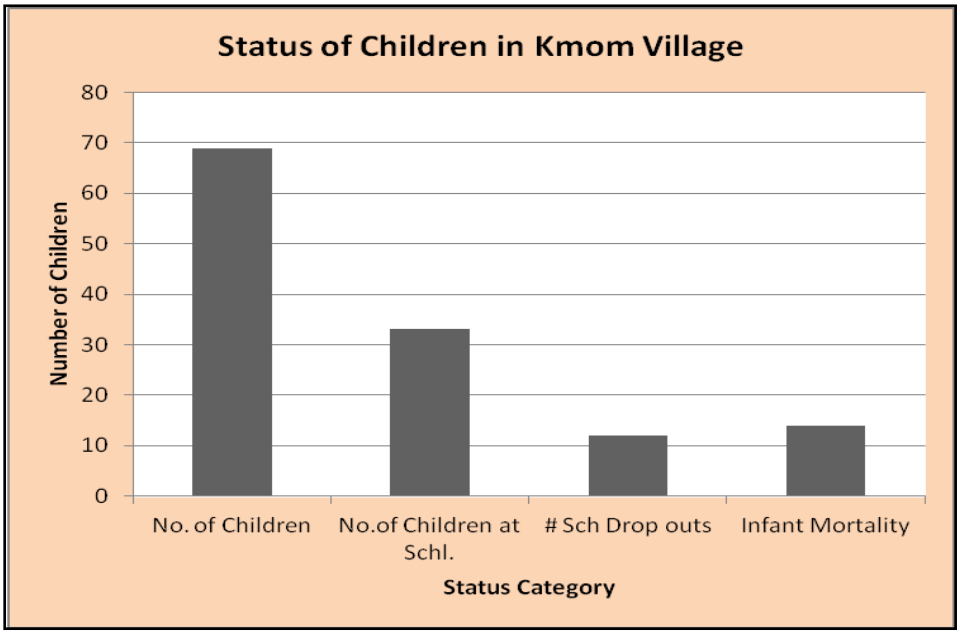

Figure 38: Status of Children in Kmom Village.

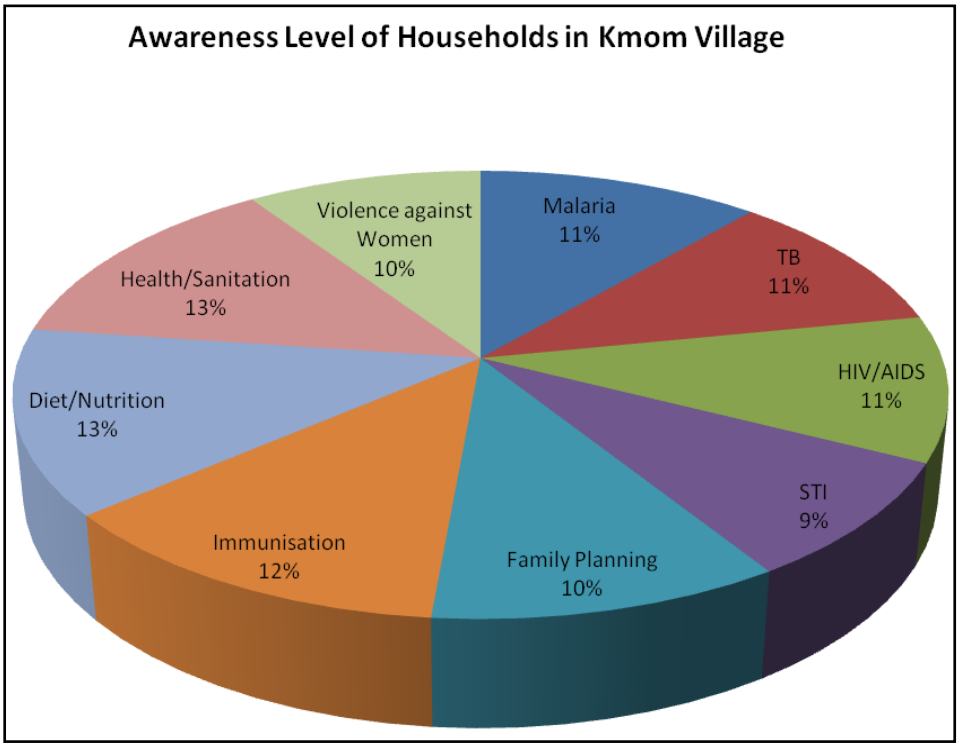

Figure 394: Health and Law & Order Issues Awareness Level for Households Interviewed in Kmom Village.

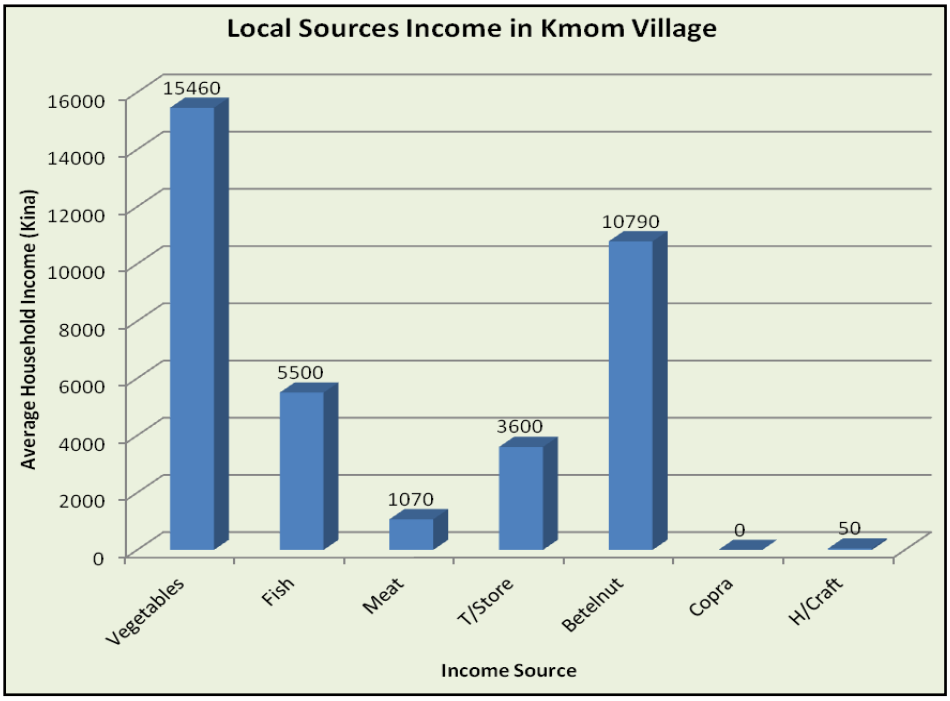

Figure 40: Local Income Sources and Average amount (Kina) earned by Kmom Villagers.

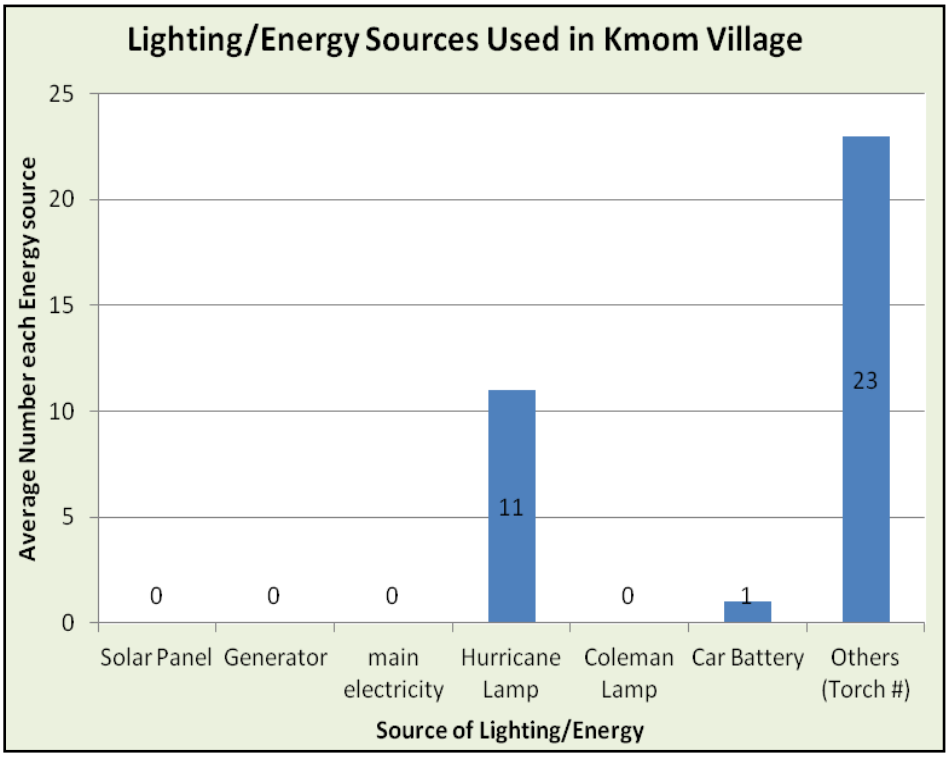

Figure 41: Lighting/Energy Sources used by Kmom Villagers.

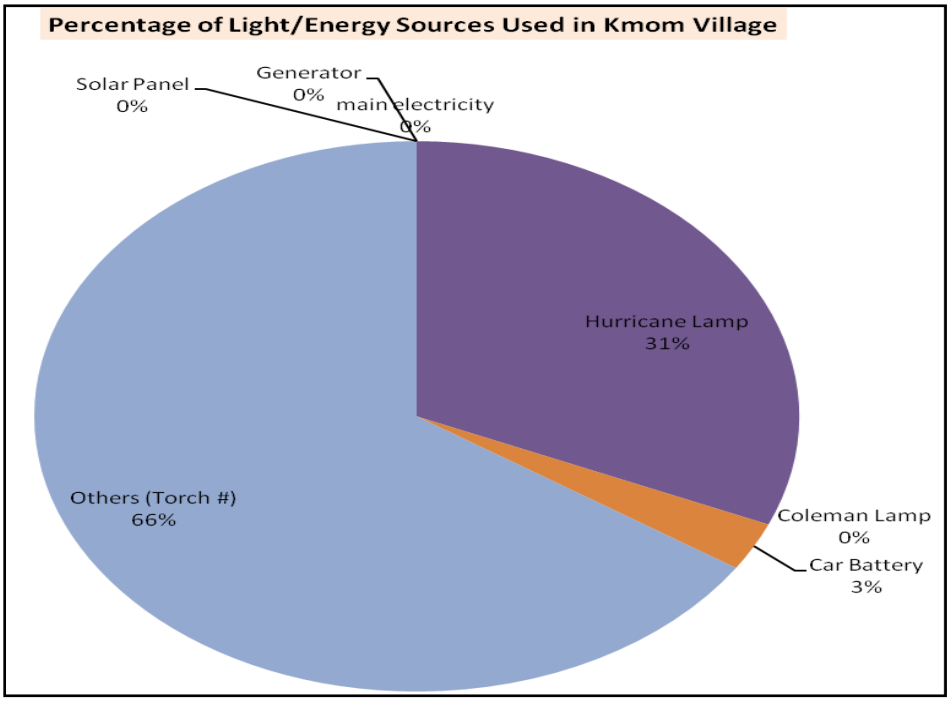

Figure 425: Proportion of Light/Energy Sources used in Kmom Village.

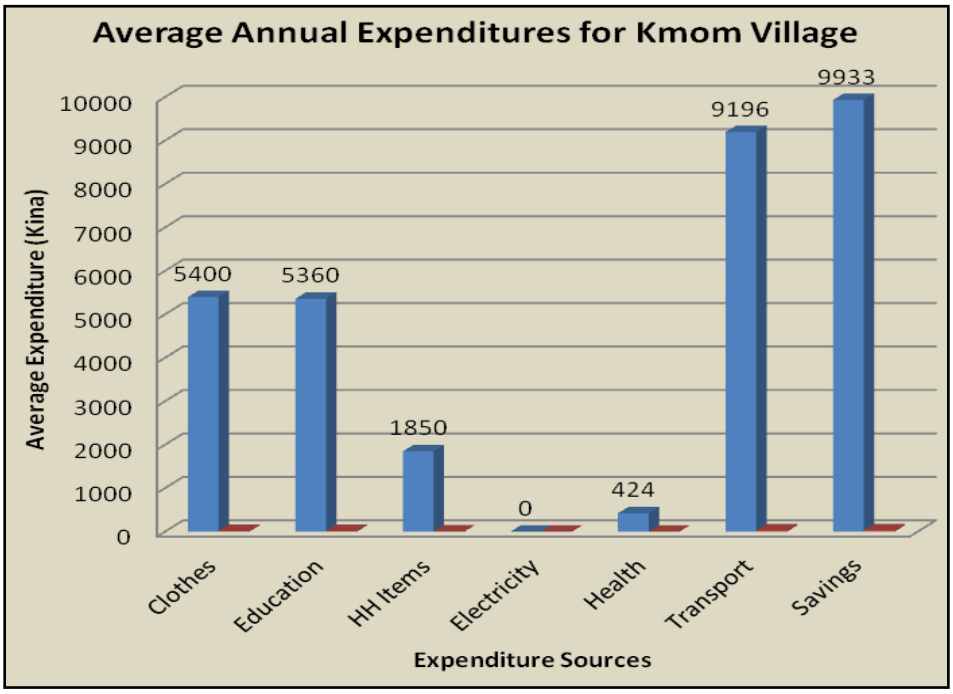

Figure 43: Annual Average Household Expenditures by Kmom Villagers.

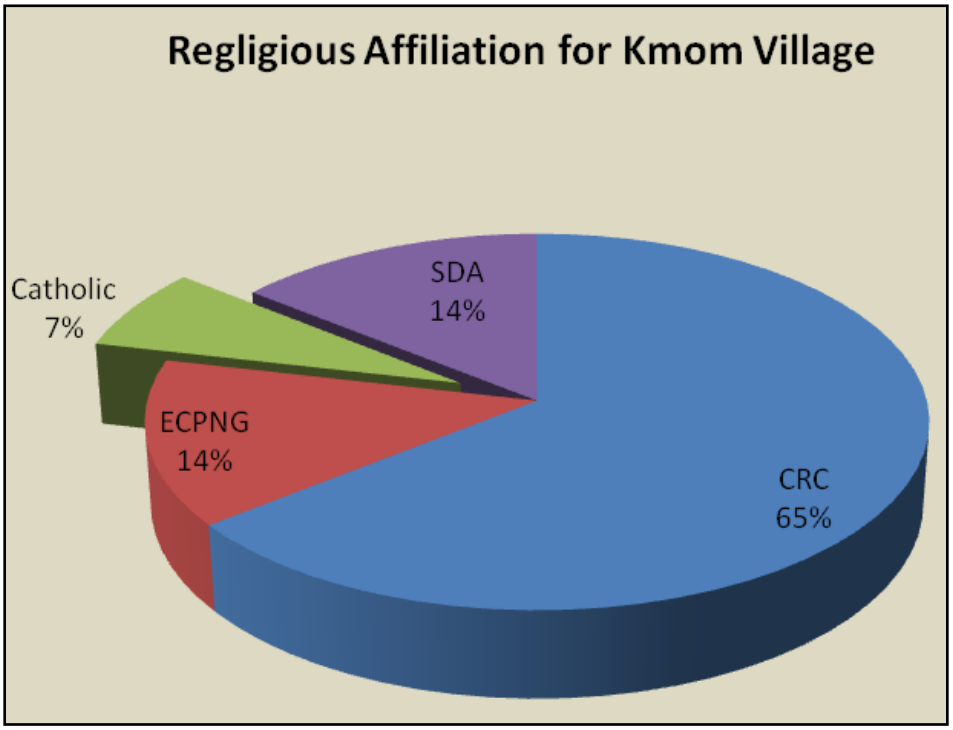

Figure 44: Religious Affiliation of Household Heads in Kmom Village.

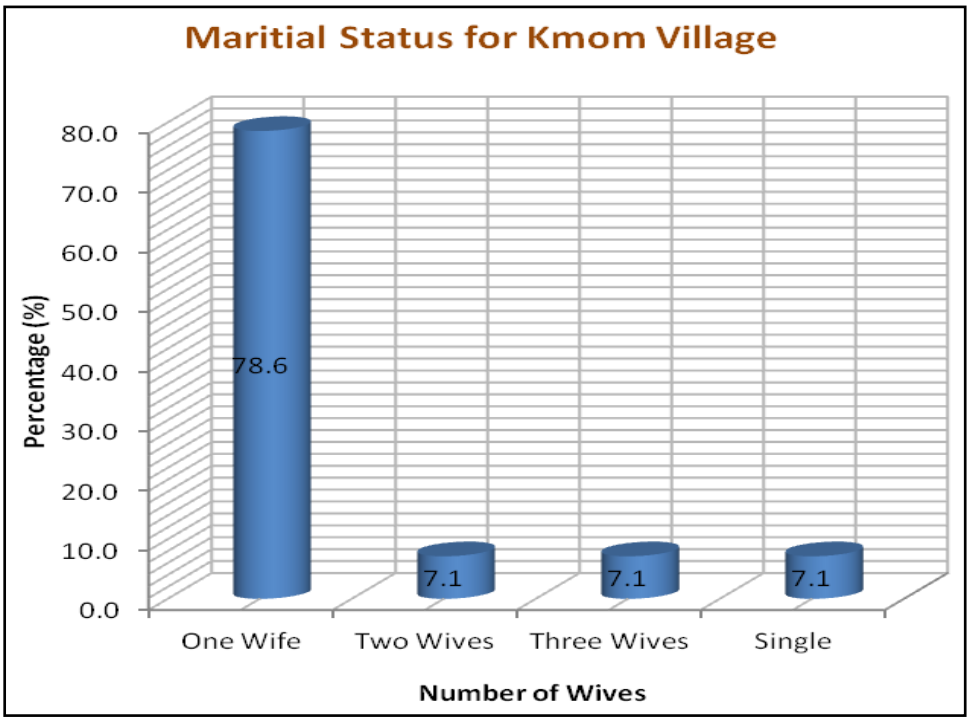

Figure 45: Marital Status (Number of Wives) for Kmom Villages.

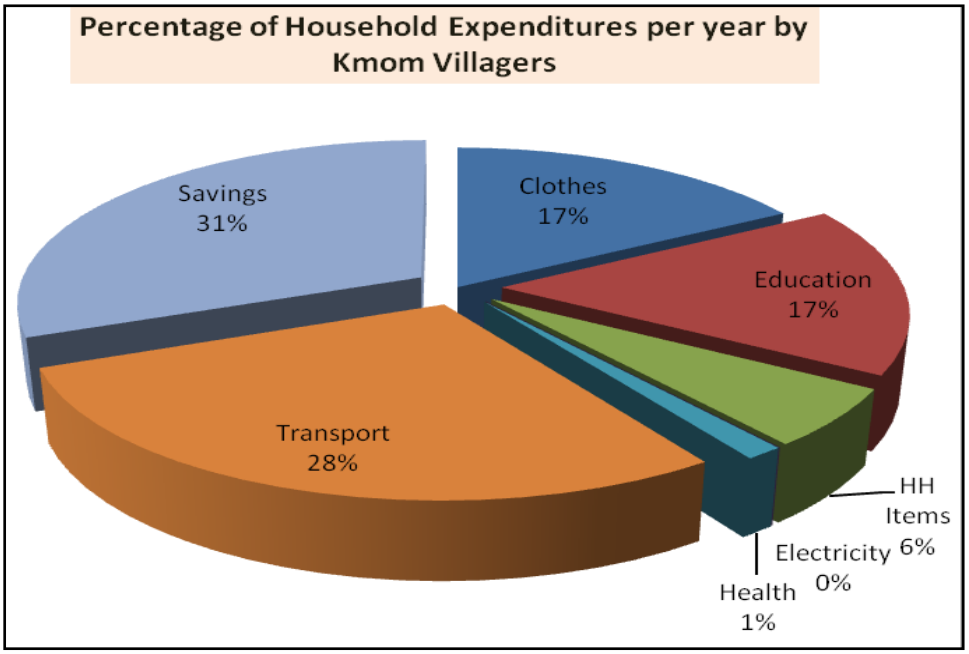

Figure 46: Proportion of Households Annual Expenditure (Kina) by Kmom Villagers.

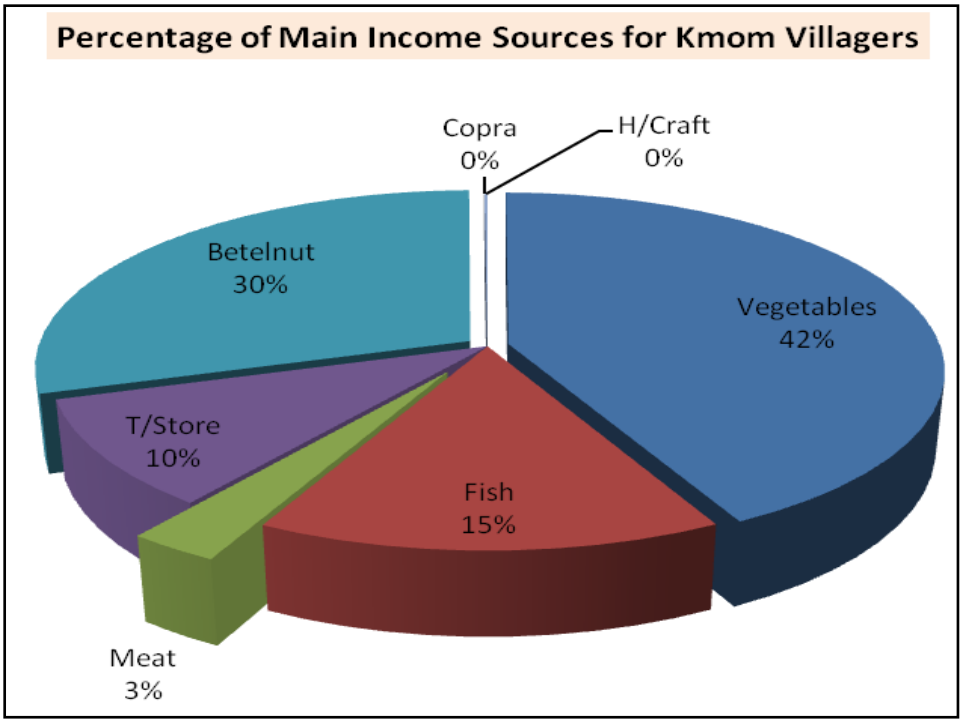

Figure 47: Proportion of Local Income Sources for Kmom Village.

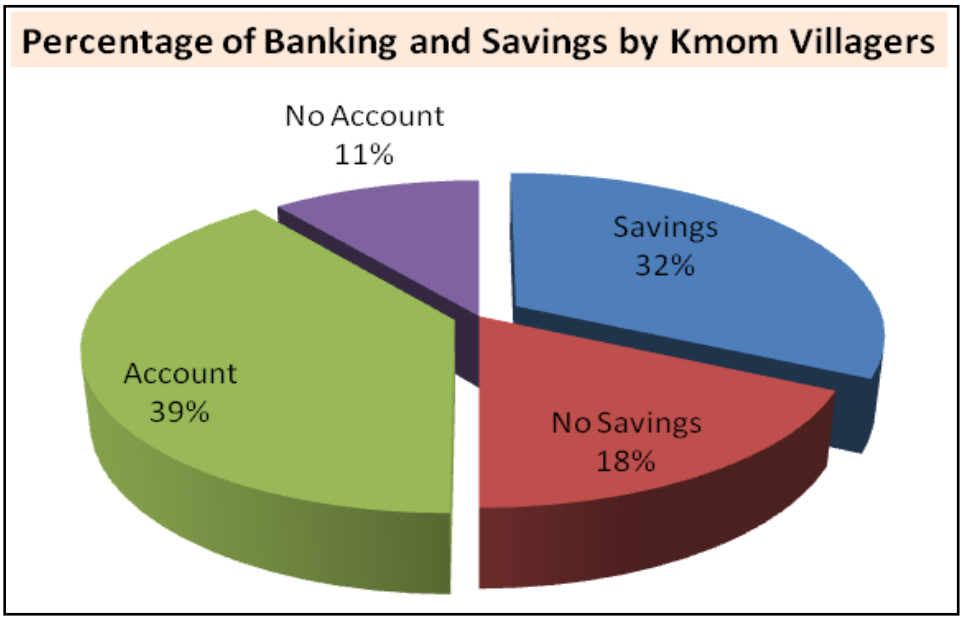

Figure 486: Proportion Banking Status for Kmom Village.

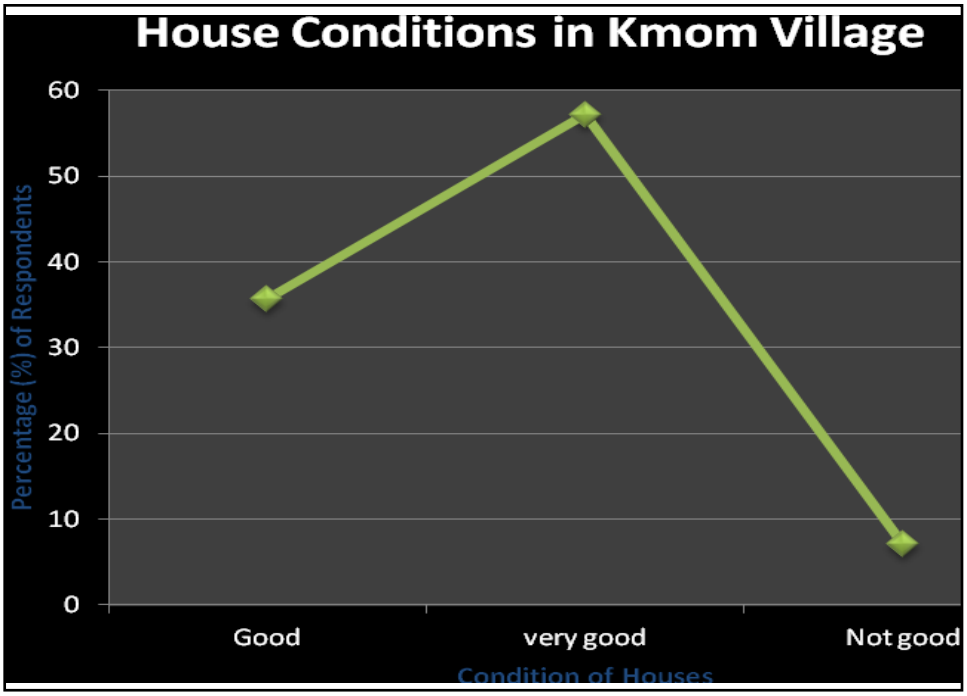

Figure 49: Proportion of House Conditions in Kmom Village.

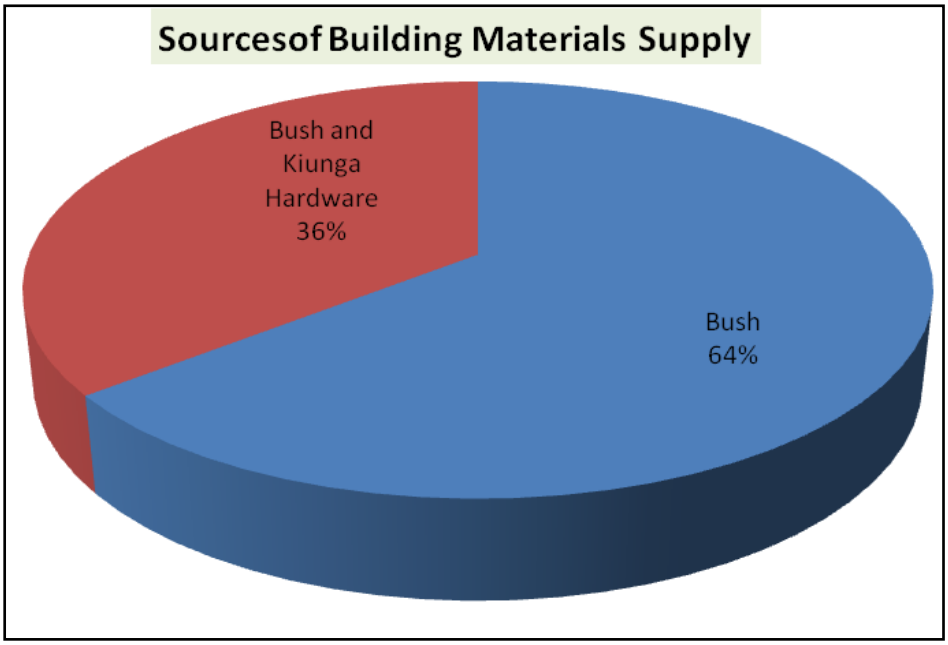

Figure 50: Proportion of Sources of Building Materials for Kmom Village.

Plate 339: PNG Village standard Very Good House at Kmom Village, 2014.

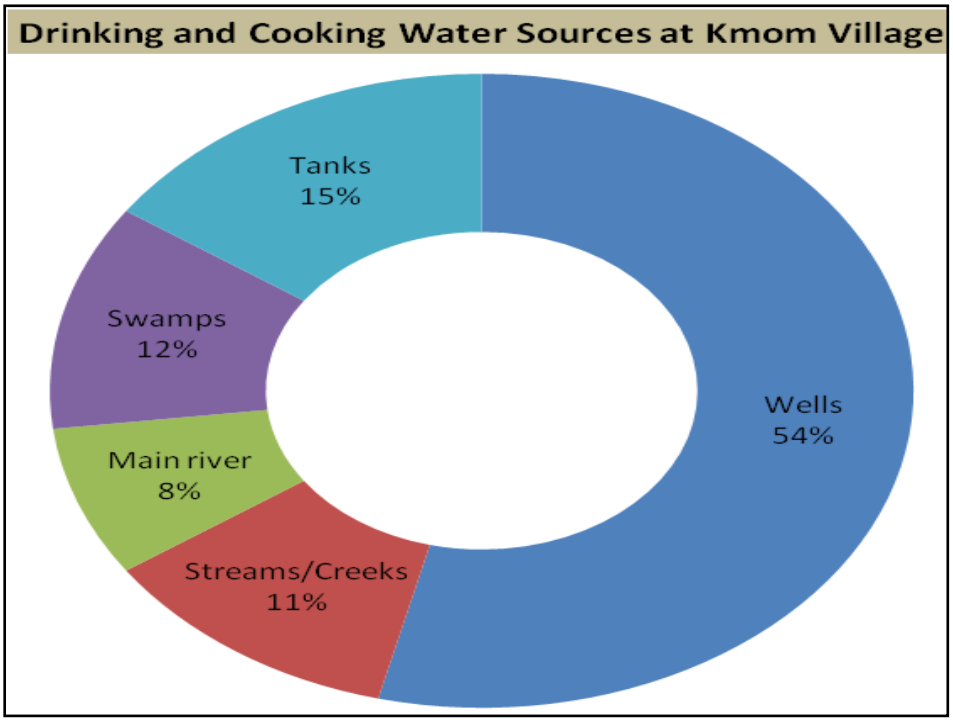

Figure 51: Proportion of Drinking and Cooking Water Sources for Kmom Village

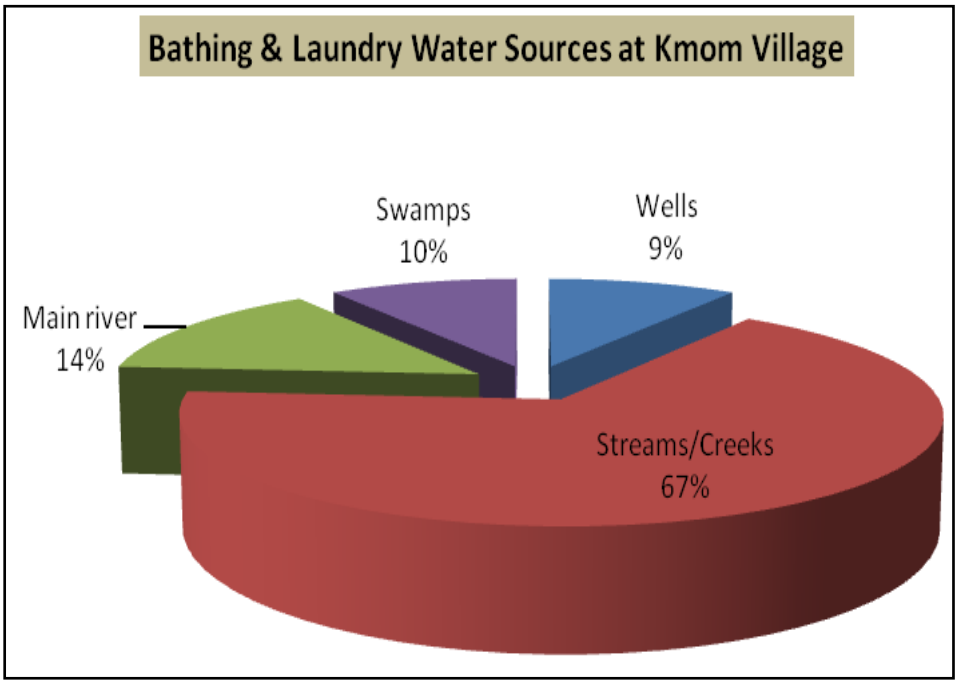

Figure 52: Proportion of Bathing and Laundry Water Sources for Kmom Village

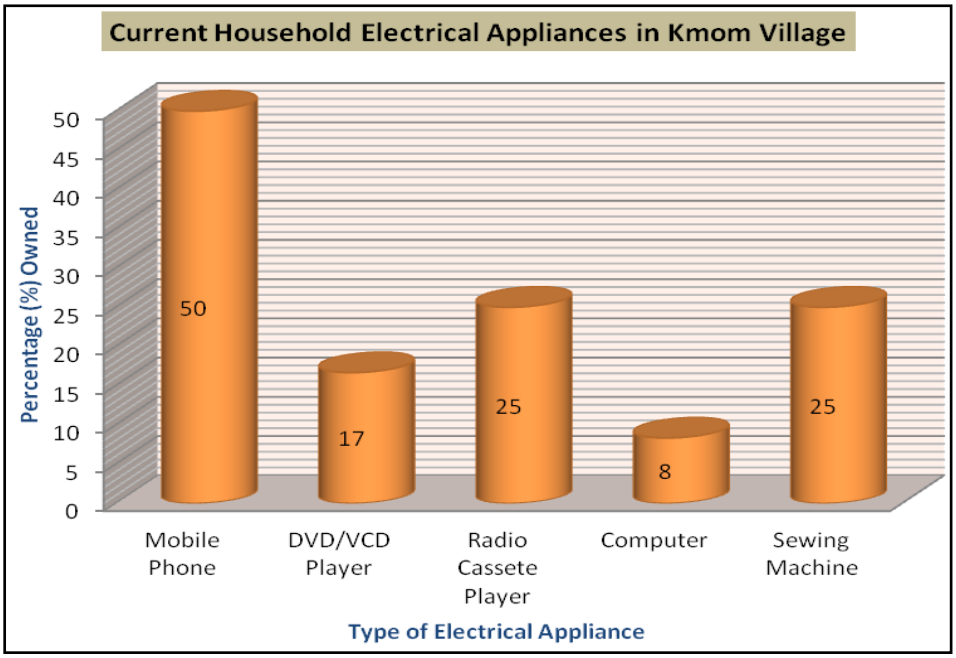

Figure 53: Household Electrical Appliance recorded in Kmom Village.

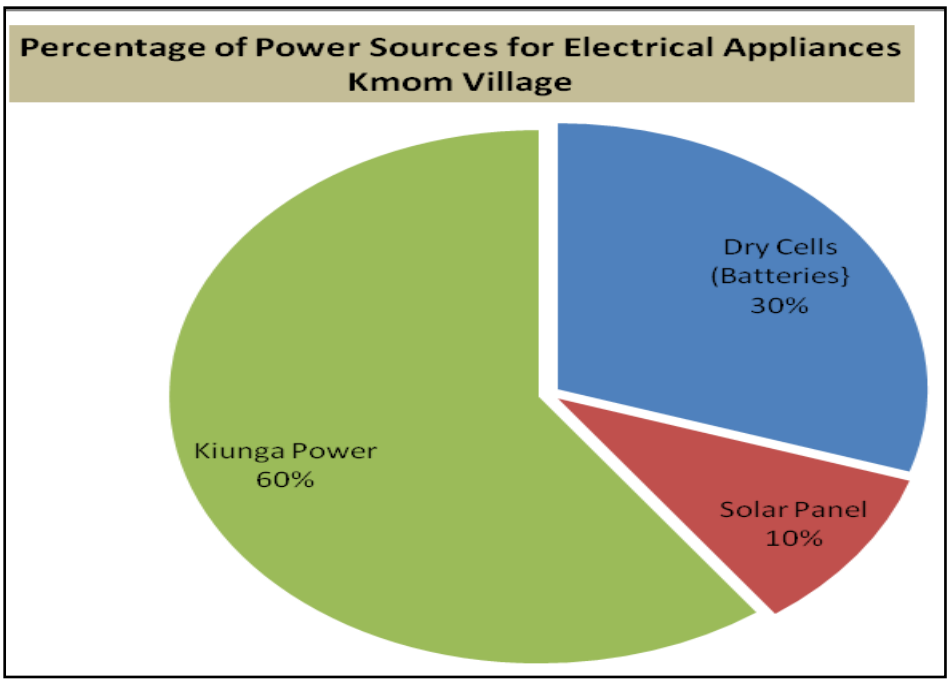

Figure 54: Proportion of Power Sources used for Electrical Appliances in Kmom Village.

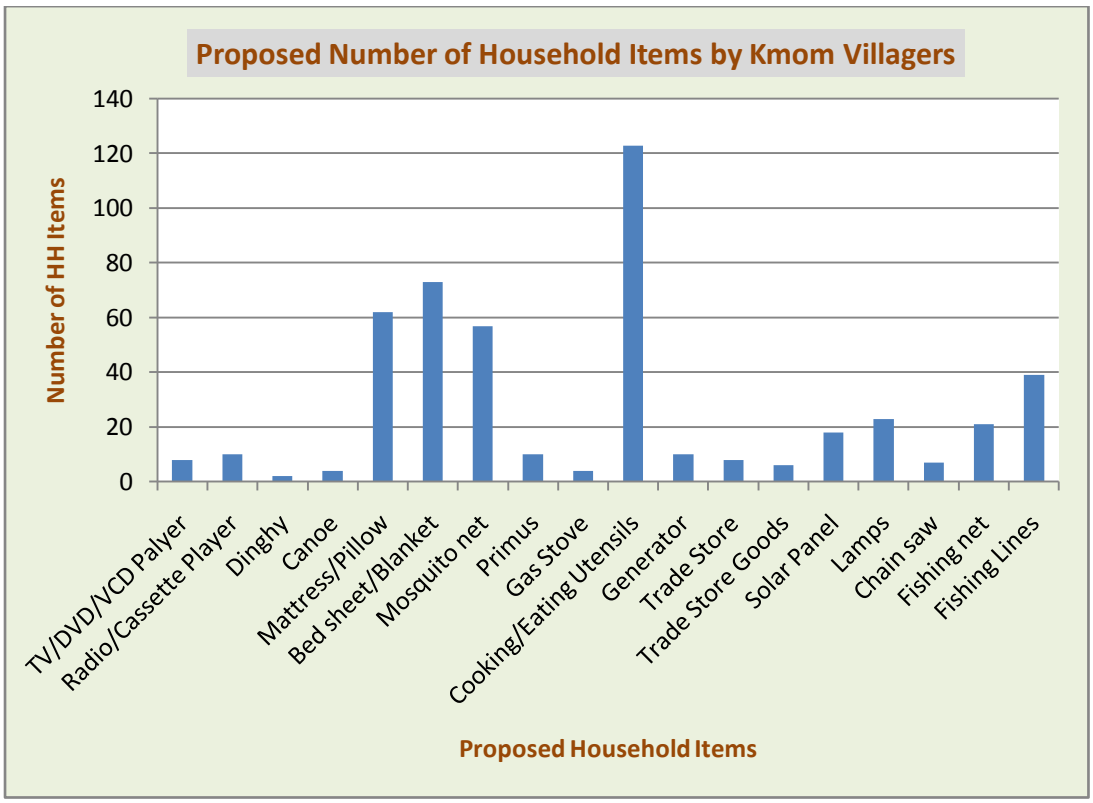

Figure 55: Household items Proposed by Kmom Villagers.

Plate 3410: Kmom Community Inception meet at the access track to the Village, 2014.

Plate 3511: Nama SEIA Questionnare Survey at Kmom Village, 2014.

3.0 Potential Impacts and Management Control

This chapter identifies and assesses the direct and indirect physical and biological impacts associated with the construction and operation components of the Nama drilling project. Measures have been identified to mitigate and manage impacts which will be adopted and implemented by Eaglewood Energy Inc during construction and operation activities. These methods will be used in other exploration sites within the license area.

The following chapters cover the environmental impacts and mitigation measures of the physical, biological and socio-economic environment.

3.1 Physical Environment Impacts and Mitigation Measures

This section addresses the impact, issues and mitigation measures of drilling on the recipient physical environmental features.

3.1.1 Water Quality Impacts and Mitigation Measures

Water is the prime constituent of any drilling operations therefore its management and control is of paramount importance. The source of water for the drilling project will be extracted from Sum creek which is located 500 m east of the drill site. Sum creek is a small and shallow creek which transports ground water, run-off and water from seasonal creeks around the area to the larger Tiyo creek. Sum creek is also an essential water source for vast and diverse fresh water aquatic life which is consumed by the people leaving within the project area. Maintaining the water quality of this creek is of paramount importance to the company.

During site clearing and construction phase, the following activities may impact water quality through contamination;

- Soil erosion, soil run-off and leaching;
- Fuel leaks and chemical spills;

During the drilling phase, the following activities may affect water quality and aquatic life;

- Sedimentation and turbidity of waterways downstream caused by soil erosion and earthworks upstream;
- Reduced primary production due to siltation of periphyton producing substrates and reduced light penetration of water column from increased turbidity;
- Contamination of surface drinking water and ground water during drilling and discharge activities

Mitigation measures of water quality during the site clearing and construction and drilling operational phases that will be adopted and implemented by Eaglewood Energy Inc. includes but is not limited to;

- Construction, adoption and implementation of measures preventing erosion into water-ways, seasonal creeks and Sum creek;
- Construction, adoption and implementation of measures preventing oil and chemical spills;
- Regular monitoring and testing of water quality;
- Implementing and adopting Spill Management Plans and Monitory programs.

3.1.2 Soils Quality Impacts and Mitigation Measures

Impacts of soil from site clearing and construction as well as drilling operation activities of the project is also important due to the adverse impact of soil on water quality and air quality.

Specific impact on soil during the site clearing and construction phase includes;

- Temporary clearance of the natural vegetation leaving a relatively intact ground cover;
- Clearance of all vegetation cover, exposing soils;
- Removal of topsoil, exposing bedrock which will then be susceptible to erosion;
- Compaction of the soil surface;
- Revegetation of completed work areas, including side-cast materials, which consolidates and stabilizes soils and landforms and contains surface erosion;
- Increase risk of soil contamination from drilling fluids, hydrocarbon fuels, oils and chemicals that are transported, stored and handled during construction;
- Increase sedimentation downstream.

Impacts to soils during operations could also occur as a result of accidental leaks or spills of fuels, hydrocarbons, lubricants and other chemicals

Mitigation measures of soil impacts during the construction and operation phase that will be adopted and implemented by Eaglewood Energy Inc. includes but is not limited to;

- Avoid construction on areas within the project site that are prone to erosion such as creek banks, steep areas, etc;
- Rehabilitation of areas through revegetation and regarding disturbed areas that are not in use;
- Stocking and reusing topsoil in disturbed areas;
- Construction of walls and barriers in project areas to stop erosion and run-off into creeks and rivers;
- Creating buffer areas along identified waterways, creeks and rivers;
- Implementing and adopting Spill Management Plans and Monitory programs.

3.1.3 Air Quality Impacts and Mitigation Measures

Site clearing and earthworks during construction will form dust and debris in the air which can deplete the air quality. Due to its remoteness and location from human settlements, the air quality impacts will be limited and will only impact the workers at the project site.

Specific impacts on air quality include;

- Dust and debris will be generated during clearing, and earthworks;
- Fumes from outboard motors and generators will also deplete the air quality;

During drilling operations drilling fluids will be used which composes of a combination of individuals and mixtures of chemicals which can be toxic to the environment. There is potential of spills and leaks from these chemicals which can produce toxic fumes contaminating the surrounding air if they are not properly handled or stored.

Mitigation measures of air impacts during the construction and operation phase that will be adopted and implemented Eaglewood Energy Inc. includes but is not limited to;

- Proper PPE in the form of face masks and safety glasses will be given to workers and other employees working at construction site and when handling toxic chemicals;
- Hosing and spraying dusty areas with water;
- Implementing and adopting Spill Management Plans and Monitory programs.

3.1.4 Noise Quality Impacts and Mitigation Measures

Noise will be generated during the construction and operation phases of the project which may impact the surrounding environment. Due to its remoteness and location the impacts of noise disturbance will be limited and will only affect the project site.

During the construction phase, noise will be generated from excavation machinery, generators and motor from boats.
During the operation, noise will be generated from generators operating power tools and machinery.

Mitigation measures of air impacts during the construction and operation phase that will be adopted and implemented by Eaglewood Energy Inc. includes but is not limited to;

- Proper PPE in and of ear muffs or ear plugs for workers and other employees that will be handling noisy machinery or working in a noisy environment;
- Implementing and adopting noise restrictions during project activity.

3.1.5 Hydrological Impacts and Mitigation Measures

This section addresses the impact, issues and mitigation and management measures of the project construction and operation on significant hydrological environment.

Issues to be addressed during the construction phases generally have the following effects on water resources and hydrology;

- The exposure of surgical materials to rainfall, erosion and scour delivers coarse and fine sediment via surface runoff of watercourses and water

bodies, with corresponding changes in the magnitude, timing, or duration of natural bed and suspended sediment transport and loading;
- The discharge of hydrotest water can increase the stream flow of smaller of smaller local watercourses;
- Water abstraction fro project requirements such as civil works and process water may affect water availability and stream flow;

Mitigation measures that will be implemented and adopted during the construction phase will include but is not limited to the following methods;

- Erosion and sediment control;
- Limiting sediment delivery to watercourses and creeks;
- Development of management procedures for erosion and sediment control, surface water and storm water;
- Water abstraction will follow and meet all environment (water extraction) permit conditions;
- Water discharge will follow and meet all environment (water discharge) permit conditions;

3.2 Biological Impact and Mitigation Measures

The Biological environment will also be affected by project activities. Constituents of the biological environment include terrestrial fauna and flora as well as the aquatic fauna and flora. The potential impacts may occur directly or indirectly and the following subsection highlights impacts on the biological environment and describes Eaglewood Energy Inc. plans on mitigating these impacts.

3.2.1 Impact on Terrestrial Environment

Impacts on the terrestrial fauna and flora include but are not limited to the following;

- Habitat Loss;
- Edge Effects;
- Hunting by project workers and contractors;
- Collection of flora by project workers and contractors;
- Materials handling;
- Waste Disposal;
- Noise, lights and other sensory disturbances; and
- Introduction of invasive flora and fauna species

3.2.1.1 Habitat Loss and Mitigation Measures

To allow commencement of drilling activities the drilling site will be cleared and the area of forest around the drill site will be cut down.

The clearing of land will cause loss of habit for fauna species including breeding grounds, nesting as well as feeding and hunting areas.

Mitigation will be achieved through:

- Directional felling to avoid damaging trees not scheduled for felling;
- Avoiding damage to other trees, not scheduled for felling, by machinery;
- Conducting appropriate environmental awareness training to staff involved in forest clearance;
- Maintaining any access roads at the minimum width necessary;
- Allow rootstocks of removed vegetation to remain in situ where possible;
- Avoiding use of herbicides to clear vegetation unless absolutely necessary to remove noxious weeds;
- Maintain buffer zones along watercourses including assisting with the rehabilitation of existing buffer zones;
- Ensure, where possible, that buffer zones and other areas of undisturbed forest are linked together to provide continuous wildlife corridors;
- Install appropriate erosion control measures;
- Prohibit establishment of gardens by project staff and contractors; and
- Develop and Implement a Rehabilitation Plan to assist re-vegetation in cleared areas not required for project infrastructure.

3.2.1.2 Edge Effects and Mitigation Measures

Edge effects refer to the continued retreat of the forest edge where a cleared area and forest meet. Edge effects can extend several hundred meters into the forest. As a consequence interior forest birds and microhylid frogs lose more habitat than just that caused by the forest clearing alone, as they move further into the forest away from the slightly drier conditions at the edge. Fauna species more tolerant of dry light conditions will colonize the forest adjacent to the edge. Edge effects occur due to the following:

Exposure of the edge of the forest to sun and wind which dries out the vegetation at the edge, making the microclimate of the forest interior adjacent to the edge drier, hotter and lighter. This affects trees and flora that are adapted to low light conditions. The drier areas are also more susceptible to fire. Where the cleared area is wide, or on a steep slope exposed to the wind, this effect will be amplified;

Greater exposure to wind leads to increased wind-throw of trees close to the edge. Careless felling of trees during clearing or falls of debris from slopes smothering trees can also lead to a greater edge effect;

Aggressive species of weeds or exotic flora can invade the forest from the edge.

In order to prevent edge effects, the following mitigation measures are recommended:

- Directional felling to avoid damaging trees not scheduled for felling;
- Avoiding damage to other trees by machinery;
- Maintaining any access roads only at the minimum width necessary;
- Allow rootstock of removed vegetation to remain in situ where possible; and
- Avoiding use of herbicides to clear vegetation unless absolutely necessary to remove noxious weeds; and
- Conducting appropriate environmental training to staff involved in forest clearance.

The impact of edge effects will decline as the forest edge seals itself. Edge effects will be prolonged if maintenance activities are allowed to damage the forest edge.

Mitigation of edge effects during operational activities will be encouraged by:

- Planting tree seedlings (selected from adjacent areas of forest) to facilitate sealing of the forest edge;
- Maintenance of controls of access roads at a minimum width;
- Continued environmental training to staff and contractors.

3.2.1.3 Hunting by Project Workers and Contractors and Mitigation Measures

Hunting of fauna is one of the major causes of the decline in overall numbers of animal species. Hornbills, Goura Pigeons and Cassowaries, although still displaying a wide range in PNG are becoming much rarer within their range as a result of uncontrolled hunting. Workers and contractors, if allowed to hunt, could further reduce numbers of such animals.

Mitigation will be achieved through:

- Conducting appropriate environmental awareness training to project workforce;
- Prohibiting hunting of fauna or possession of fauna by project workers or contractors while working, in project vehicles, or living in company accommodation.

3.2.1.4 Collection of Flora by Project Workers and Contractors and Mitigation Measures

Collection of flora such as orchids or medicinal plants by workers and contractors in small areas such as around camps, and townships and in buffer zones could lead to the local extinction of some plant species with a subsequent potential reduction in the local habitat diversity.
Mitigation will be achieved through:

- Conducting appropriate environmental awareness training to project workforce;
- Prohibiting harvesting of forest products by project workers or contractors while working, in project vehicles or living in company accommodation.

3.2.1.5 Use of Hazardous Material and Mitigation Measures

Fuels and lubricating oils, chemicals, wastes and other contaminants and hazardous materials can enter the terrestrial environment through spillages, or through waste streams. These materials can kill plants and fauna when ingested.

Spills from storage tanks may have a significant effect on the terrestrial environment if not mitigated.

Mitigation will be achieved through:

- Adherence to the PNG Environmental Code of Practice for Petroleum Storage;
- Observance of recommended procedures for the use, handling, storage and disposal contained in the updated Material Safety Data Sheets issued for each hazardous chemical;
- Conducting appropriate environmental training to project workforce; and
- Development and implementation of Spill Control plan.

3.2.1.6 Waste Disposal and Mitigation Measures

Disposal of wastes can impact fauna as animals become trapped in wire, in abandoned plant, equipment and materials, or by ingestion of plastic wastes and other contaminants.

Inappropriate waste disposal practices during site clearance and operations have the potential to attract vermin to the project area, increasing competition for native fauna.

Mitigation will be achieved through;

- Development and implementation of a Waste Management Plan; and
- Conducting appropriate environmental awareness training to project workforce**.**

3.2.1.7 Invasive Species – Flora

Some exotic species of flora are invasive, i.e. when they become established in a new environment, such as virgin rainforest that has not been subject to human impact, they prevent the normal flora from becoming reestablished, thereby bringing about permanent changes to the local ecology.

The movement of machinery freight and people into the project area will increases the risks of accidental or deliberate introduction of invasive species of flora into the project area.

While intact rainforest is usually resistant to weed invasion, the opening up of areas of forest for roads, plantations and other infrastructure allows weeds to enter and become established. Many species have been present in PNG since at least the early 1900s and are generally non invasive, their presence illustrates the ease with which weeds species can enter newly cleared areas and become established.

Other invasive plant species are gradually expanding their range within PNG, though are they are not currently present in the project area. Provided attention is paid to sensible safeguards the introduction of new invasive species will be prevented.

Mitigation during site clearance and operational activities will be achieved through:

- Use of disinfection procedures, through wash down of plant and machinery prior to its arrival at the project area;

- Conducting appropriate environmental awareness training to project workforce;
- Prohibiting establishment of gardens by project staff and contractors; and
- Development and implementation of an Invasive Species Management Plan.

3.2.1.8 Invasive Species – Fauna

Without any control the movements of freight and people into the project area would increase the risk of accidental or deliberate introduction of exotic pests into the project area. This includes the introduction of domestic hunting animals such as dogs and cats. Impacts from invasive species are likely to continue throughout the operational activities.

Introduction of exotic animal species is a significant conservation issue in Papua New Guinea. The effects of such invasions on the local fauna can include:

- Predation of small mammals and birds (e.g. by cats, dogs);
- Poisoning of predators (e.g. through eating the introduced Cane Toad which excretes toxic chemicals from its skin); and
- Displacement of native fauna through competition or other means (e.g. fire ants)

Many invasive animal species, though not currently present in the project area, (for example the little fire ant**,** *Wasmanniaauropunctata*)aregradually expanding their range within PNG. By following sensible safeguards this project should not contribute to this expansion.
Mitigation during project activities will be achieved through:

- Conducting appropriate environmental training to project workforce;
- Development and implementation of appropriate procedures for checking incoming goods and people;
- Prohibiting possession of cats and dogs on company sites.
- Development and implementation of an Invasive Species Management Plan.

3.2.2 Impact on Aquatic Biology

A range of aquatic ecology impacts are associated with the project activities. The majority of these are associated with the site clearance activities, however some will continue throughout the operational phase. This has been indicated below.

Identified potential impacts include:

- Increased sedimentation;
- Increased suspended sediment concentrations and turbidity;
- Contamination by discharge of treated wastewaters (treated sewage effluent); and
- Fishing by project staff and contractors.

3.2.2.1 Increased Sedimentation

Watercourses in the project will potentially be exposed to an increase in sediment load from site clearance activities. These land-based activities include land clearance for oil palm plantations, road works, bridges, clearing and leveling of sites for facilities and spoil tips. Sedimentation can affect aquatic ecology by the reduction of habitat diversity, through covering surfaces with sand and silt.

The invertebrate and fish fauna in the main watercourses and smaller creeks where the water is clear would be affected by any increased sediment. However, provided the increase in sediment loads is of short duration, provided cleared surfaces re-vegetate quickly, it is expected that these streams will recover quickly and invertebrates will be able to re-colonize from other areas.

3.2.2.2 Increased Suspended Solids Concentration and Turbidity

The same activities that lead to increased sedimentation also lead to increased suspended sediments and turbidity in local watercourses.

Turbidity and suspended solids reduce light penetration and reduce photosynthesis which in turn reduce primary production in watercourses.

Macro invertebrates can be affected by abrasion effects and clogging of respiratory organs especially mayflies, dragonflies and damselflies and crustaceans (prawns), and by loss of food due to reduced primary production. In streams and rivers near project works, there may be minor local impacts However, when the source of sediment ceases, the streams will recover quickly as invertebrates can be recruited from elsewhere in the system.

Provided impacts are localized, recovery of fish fauna, after turbidity returns to normal, can be from recruitment from nearby unaffected streams. Similarly, aquatic tadpoles may be impacted by increased turbidity in small streams but as not all streams will be affected, sufficient habitat will remain. It is expected that once the source of increased sediment ceases these streams will rapidly return to normal conditions.

Mitigation measures for sedimentation and turbidity during site clearance and pipe laying and operational activities are the same and will be achieved through:

- Development and implementation of an Erosion and Sedimentation Control Plan; and
- Ensuring wastewater streams comply with recommended Water Quality Standards for Papua New Guinea (DEC 1997) and the Water Quality Criteria in the Environment Act 2000, PNG Code of Practice for Oil Palm Processing and any other limits set by the DEC under any Environment Permit for waste discharge; and
- Conducting appropriate environmental training to project workforce;
- Carry out appropriate mulching, especially during construction.

3.2.2.3 Discharges of Treated Wastewater

The discharge into water bodies of poorly treated human wastes, plant material, waste-water including site storm water runoff that is potentially contaminated with hazardous material such as petroleum products can all have an impact on aquatic ecology. Effluent from oil palm mills is very high in organic content and will severely affect water quality if not adequately treated prior to discharge.

The dilution effects of the larger rivers serve to reduce any impact from wastewater discharges. In small streams however, the impacts can be significant. Fast flowing streams can recover quickly once the waste discharge ceases.

Organic waste leads to an increase on microorganisms that break down such waste, using up oxygen in the process. Increases in nutrients such as nitrates lead to an increase in algae which eventually die and decay; thereby contributing to lower oxygen. Aquatic plants do not survive in such conditions and would be replaced by more environmentally tolerant species such as sewage fungus.

Mitigation during site clearance and operational activities will be achieved through:

- Ensure wastewater streams comply with recommended Water Quality Standards for Papua New Guinea (DEC 1997) and the Water Quality Criteria in the Environment Act 2000 and any other limits set within any Environment Permit for waste discharge;
- Ensuring human wastes is adequately treated to remove bacteria and nutrients prior to discharge;
- Preventing plant material from entering any watercourse; and
- Conducting appropriate environmental awareness training to project workforce.

3.2.2.4 Fishing by Project Personnel and Contractors

Fishing by project staff may add to the current level of fishing by local people and increase competition for already scarce resources.

Mitigation will be achieved through;

- Prohibiting all fishing by project staff
- Conducting appropriate environmental awareness training to project workforce; and
- Developing a community awareness program that will help raise awareness among local villages about the damage that inappropriate fishing techniques can cause.

3.3 Socio-Economic Impacts and Mitigation Measures

The expected impacts of the Nama Exploration Drilling Project are most anticipated during the construction phase while operation (drilling period) will also have carryon effects mostly on the socioeconomic issues of the project.

The Socio-economic impacts can be both negative and positive. These impacts may occur either directly or indirectly during the lifespan of the project. The following subsections highlight some of the common socioeconomic impacts that may accrue to the stakeholders, especially the impact zone communities.

3.3.1 Positive Socio-Economic Impacts

There are both positive and negative socio-economic issues that will emerge from this project. Positive outcomes at village level should include:

- Employment (especially during construction)
- Training and capacity building
- Improved access to the outside world
- Business Development Opportunities due to increase local cash flow
- (Probable community support) Improved Government Services.

At different levels of Government (Local, Provincial and National) the project will bring the following positive benefits:

- Taxes
- Improved transport access to main service centre, especially Kiunga.
- Capacity to improve Government Services.

3.3.2 Negative Socio-Economic Impacts

Negative impacts that may occur include both direct and indirect impacts of the project. Normally the indirect impacts are best handled by relevant government agencies, with some assistance on occasions by Eaglewood Energy Inc Limited.

Direct Socio-Economic Impacts Include:

- Direct Impacts of the project on land, water and other resources used by the local communities relate to site clearing of habits, noise and waste discharges.
- Risk of HIV/Aids and other STIs introduced by Project Staff and contractors.

Indirect Socio-Economic Impacts Include:

- Stress on existing Government Services (especially Health, Education, Law & Order)

- Risk of increased disease (especially HIV/Aids) between community members.
- Risk of breakdown of family and community values.
- Risk of resource ownership conflict.
- Immigration of outsiders, placing additional pressure on the community and its services

These potential negative impacts are discussed in more detail below:

- Risks of loss or damage to natural resources used by the local community

These resources include:

- Hunting and fishing
- Water Supplies
- Gardens
- Sacred sites
- Bilas Sites etc.
- Transit rights

These resources will all be identified and avoided wherever possible.

- Risks of introduction of HIV/Aids to the project area by Eaglewood Energy Inc Staff and Contractors

This matter will be the subject of a special HIV/Aids Management Program which will be included in the overall Health and Safety Management plan for the Nama Exploration Drilling project. It will basically cover awareness activities to the communities and the employees of the Eaglewood Energy Inc.

3.3.3 Indirect Socio-Economic Impacts

3.3.3.1 Migration

There is a risk of outsiders migrating to the area, in search of employment or better services. Such migrants can put pressure on local communities, on their services and occasionally lead to Law & Order problems.

These problems can be mitigated by public awareness programs with the local communities; to strength their awareness of the risks that immigration poses, the provision of planning and legal assistance to Local Level Government to develop tools (Legislation) needed to manage such problems and by strengthening the Law & Order sector (Courts and Police).

3.3.3.2 HIV/AIDS

There is a likelihood that the incidence of some diseases will rise in the community (especially HIV/Aids) as a result of outside workers entering the project area, and by increased exposure within the existing population.

Much can be done with awareness and testing programs, and Eaglewood Energy Inc already has established HIV/Aids testing and awareness programs for its Nama Drilling Project that will be augmented in this project by both Eaglewood Energy Inc and its contractors. For the wider community; Eaglewood Energy Inc will work with HIV/Aids services providers, to ensure co-ordination of effort- *see Work Place Policy on HIV/Aids (EIS, 2010).*

3.3.3.3 Health, Education, Law & Order Services

Many of the Government Services in the area are inadequate and poorly maintained. Eaglewood Energy Inc will survey and monitor the capacity of these services and develop a program of partial assistance.

3.3.3.4 Work Force Training Opportunities

Many of the employment opportunities will be unavailable to local villagers, due to their inadequate skill levels. Eaglewood Energy Inc will provide some relevant training programs to eligible members of the local communities.

3.3.3.5 Resource Ownership Disputes

There are disputes between the villagers living near the Nama Drilling Project – the local communities - and the downstream communities; regarding ownership of the project area (and the project benefits). These matters need to be resolved by the relevant government agencies including Lands, Petroleum and Energy and if needed in due course, by the Courts.

3.3.4 Monitoring and Management of Socio-Economic Impacts and Mitigation Measures

It will be important to monitor the socio-economic impacts and mitigation measures during the life of the project, and to deal with any issues that may arise. Eaglewood Energy Inc will develop a detailed Environmental Monitoring and Management Plan to give effect to these needs.

The following measures are prepared by Eaglewood Energy Inc to mitigate to improve and to manage socio-economic impacts;

3.3.4.1 Damage or Loss of Natural Resources

The Oil and Gas Act establishes a procedure for compensation payable to landowners and land occupiers for:

- The deprivation of the use and enjoyment of the surface of the land;
- Damage to the surface of the land, or to trees, fish and animals;
- Right-of-way over the land;
- Any other damages that are consequences of the use of the land.

The Environmental Act 2000, (Section 87) in similar fashion provides for compensation to owners or occupiers or to any persons within customary rights; in respect of entry onto land, or occupation of the land by the holder of an Environmental Permit. Compensation is payable for:

a) Depreciation of use and enjoyment of the surface of the land or of right to water customarily associated with the land.
b) Damage to the surface of the land, or any part of it, or any improvements on it or to any flora and fauna.
c) Rights of way and easements.
d) Any damage consequential in the permit holders use and occupation of the land or use of control of water on a water source.

Further provisions of the Environmental Act sets out procedures for establishing and setting compensation matters with particular powers for the Director to concentrate in cases of dispute.

Eaglewood Energy Inc will pay compensation for such damage using the provisions of both Acts. Compensation will be established by way of a formal Compensation Agreement with the landowners.

3.3.4.2 Risk of Loss of a Damage to Natural and Cultural Resources used by the Local Community

The surveys carried out by Eaglewood Energy Inc indicate that the uses of resources by the local community are limited to areas on and close to the Kiunga-Tabubil Road. Practically all of the project impacts will be away from the river, except for work associated with the condensate export pipeline and the movement of materials up the Fly River and onto the project site.

As a principle, such resources will be identified and avoided whenever possible. Compensation will be paid through the mechanism of the Compensation Agreement where such damage is unavoidable.

Once the particular site of these activities is chosen, discussion will be held within landowners and other interested parties to identify resources of value to the landowners.

3.3.4.3 Community Assistance Programs

Eaglewood Energy Inc recognizes the need to assist in the well being of the local community. To deliver on this recognition, Eaglewood Energy Inc will develop a community assistance program. There will be two parts to this program.

a) Co-operation with Government Services Providers to improve Government Services in the project area (Health, Education, Law & Order etc.). Eaglewood Energy Inc recognizes that these services are government Services and that significant funds, in the form of royalties and Government Grants will become available to these agencies, once the project is operational but that further assistance may be appropriate from time to time.

b) Direct assistance to local communities.

The Community Assistance Program will be developed for both the Construction Phase and for the Operational Phase of the project.

3.3.4.4 Community Awareness and Liaisons

I. Liaison

Eaglewood Energy Inc will establish and service a Social Impact Committee, composed of Local Communities representatives, service providers and Eaglewood Energy Inc Management; to meet at regular intervals to discuss social and environmental issues of concern. This committee will be established prior to the commencement of construction. Further liaison will be carried out on a regular basis by the Eaglewood Energy Inc Community Services Group.

II. Community Awareness

Programs of Community Awareness plan will be developed and presented to the communities. Particular sub-programs will include:

- Employment, business and training opportunities.
- Environmental Awareness.
- Wildlife Conservation Promotion and Protection.
- Domestic Violence.
- Substance abuse
- Immigration
- Other.

A detailed Community Awareness plan will be prepared 3 months before commencement of construction (and also 3 months before the commencement of operations).

III. Contingency/ Emergency Plans Availability

Eaglewood Energy Inc will prepare an Environmental Risk Assessment. Arising out of that Risk Assessment, the Contingency Plan will be prepared for these risks that could affect the environment. They include spills, fires etc. The Environmental Risk Contingency Plans will be one in phases, to co-ordinate with the Physical Environmental Management Plans. The Environmental Risk Contingency Plan will be submitted to the Department of Environment and Conservation in each case 3 months before the implementation of the appropriate phase of the project.

3.3.5 Social Management and Monitoring Program

The Department of Environment and Conservation normally requires for major projects, the establishment of a Social Impact Liaison Committee. Such committee is seen as desirable, especially during construction. This committee, through the work of its members (i.e.; Police may undertake to closely enforce drinking legislation, or Eaglewood Energy Inc may provide a degree of extra support on occasion to help alleviate particular problems).

Eaglewood Energy Inc will establish a Social Impact Liaison Committee for the Nama Drilling project. The Social Impact Liaison Committee will consist of Eaglewood Energy Inc Limited and representatives from each of the impact Communities or the Landowner Groups along with Police and others, as needed. The committee will conduct discussions on issues as they arise.

Specific Social Impact Monitoring Programs for Nama Drilling Project will include:

- A mid Drilling Environmental monitoring after the construction/establishment of Drilling and related facilities, and
- Final Socioeconomic Impacts Assessment report at the end of the Exploration Drilling Campaign.

3.3.5.1 Consultation Activity

Consultation between landowners and Eaglewood Energy is ongoing through the allocated CA officers.

4.0 Risk Assessment

4.1 Introduction

Eaglewood Energy Inc. the operator of PPL 259 is about to commence drilling at its Nama drill site. The drill site is located 22 km north-east of Kiunga Town, Western Province, Papua New Guinea. **Figure 1 shows the locality of the Nama drilling project site.**

Prior to drilling, an Environment Permit Application (EPA) is to be lodged with DEC as part of statutory obligations under the PNG Environment Act 2000. An Environment Impact Assessment (EIA) was commissioned by Eaglewood Energy Inc. and its joint venture partner Horizon Oil (PNG) Ltd at the proposed drill site. The EIA study was undertaken by Douglas Environmental Services (DES) at the proposed Nama drill site. Studies involved field observation, sampling and analysis as well as research and literature review of the Nama drill site and surrounding areas to identify its physical, biological and social-economical environment characteristics, and, the potential impacts and risks that are likely to be caused by the project.

An Environmental Risk Assessment was carried out for the Nama drill site which followed the principles and guidelines developed by ISO 31000 – 2009. An Environmental Risk Assessment is simply a careful examination of what can cause harm to the environment, so that preventive and mitigation measures can be applied to avoid and mange these risks.

The goal of the risk assessment is to assess the likelihood of harm to the environment from drilling or associated activities during operations at the Nama drill site and campsites. The Risk Assessment measures the probability of risk/hazard to occur (likelihood), the exposure of the natural environment to the specific risk/hazard, and, the consequences that will be faced as a result of the risk/hazard. Most risks are man-made or result from human error or influence.

A qualitative risk assessment matrix was used to measure each risk/hazard against financial cost, safety and environmental impact to assess the final value of each risk for the purpose of controlling each risks/hazard. Control measures were than identified and highlighted to avoid, mitigate and manage these risks/hazards.

4.2 Definition

A **risk** is the probability (likelihood) of harm or damage occurring from exposure to a hazard, and the likely consequences of that harm or damage.

The **environment** in this case describes the physical, biological and social environment within the project area.

A **hazard** is a situation that has the potential to harm a person, the environment or damage property.

4.3 Drilling Activities

The drilling project has four (4) main phases;

- Site Clearance
- Construction
- Drilling Operations
- Site Closure

4.3.1 Site Clearance

Site clearance involves the removal of trees and vegetation in and around the drill site to cater for the construction of well pad, drilling facilities as well as temporary accommodation and messing facilities. Large machineries such as bull dozers and tractors will be used to build a temporary access road linking the project area to Drimgas road to facilitate the movement of workers and transport machinery to and from site **(see figure 1).** Large trees will be cut down and stumps will be removed from site to allow levelling of the soil where the drilling well and facilities as well as temporary housing and messing facilities will be accommodated.

4.3.2 Construction

Construction of well pad and drilling facilities will commence once site clearance is completed. The well pad will consist of the drilling facilities which includes the drill, generator, water pump, cement casing, mud system, and effluent ponds. The effluent ponds will be used to dispose of rock cuttings and drilling mud and other wastes.

4.3.3 Drilling Operations

The operational phase will involve the drilling of the well pad using the drill pipe and drill casings accompanied by the drilling mud and cement slurry. The main functions of drilling mud are cooling and lubrication, removal of cuttings and maintaining the well under pressure to control ingress of liquid and gas. The cement slurry solidifies around the drill casing and provides support and stability. The drilling mud is than separated through a series of shakers and screens to remove drill cuttings and the reprocessed mud is recycled through the drilling process. The drill cuttings and other wastes are discharged into effluent ponds for storage, dilution and later discharge in the designated discharge site.

4.3.4 Site Closure

The site closure program will commence at the end of the drilling program. This will include the removal of drilling and drilling facilities, messing and accommodation facilities from site. The waste ponds, incinerators and landfills will be covered and the soil areas that have been contaminated through spills and leaks during storage or handling of chemicals and fuels will be scraped off and removed from site. Empty drums and waste containers will also be removed from site.

4.4 Risk Assessment Procedure

The process of risk assessment follows the procedure of identifying, analyzing, evaluating and treatment of risks.

4.4.1 Identify Risks

Identifying risks involves examining all risks that are common in all onshore drilling projects, taking into account the difference in project sites (remoteness, accessibility, etc), equipments to be used and the exposure to hazards or hazardous environment. This also includes the examining of all situations, scenarios specific to the local area that are likely to directly or indirectly affect the achievement of drilling at the Nama drill site.

4.4.2 Analyze Risks

Risk analysis involves the consideration of the source of risk, the consequence and likelihood to estimate the inherent or unprotected risk without controls in place. It also involves identification of the controls, an estimation of their effectiveness and the resultant level of risk with controls in place (the protected, residual or controlled risk).

Applying the risk matrix, is required to define each risk, its likelihood and consequences criteria. Typical definitions of the likelihood and consequence are contained in the risk matrix **(Table 1).**

Using the consequence criteria provided in the risk matrix, the consequences of the event occurring (with current controls in place) will be determined. To determine the likelihood of the risk occurring, the likelihood criteria (again contained in the risk matrix) are applied. The risk level is identified by intersecting the likelihood and consequence levels on the risk matrix.

4.4.3 Evaluate Risks

Once the risk level is identified a control will be adopted by Eaglewood Energy Inc. to avoid, mitigate or manage the risk. This controls will be adopted and implement in the event when the risk occurs or is likely to occur.

4.4.4 Treatment

The objective of this stage of the risk assessment process is to develop cost effective options for treating the risks. Treatment options which are not necessarily mutually exclusive or appropriate in all circumstances are driven by outcomes that include:

- Avoiding the risk,
- Reducing (mitigating) the risk,
- Transferring (sharing) the risk, and
- Retaining (accepting) the risk.

Table 7: Risk Assessment Matrix.

Significance				Likelihood					
				Frequency	More than once per year	Yearly to once every 10 years	Every 10 to 100 years	Every 100 to 1000 years	Less than once every 1000 years
				Historical	Regular occurrence in similar operations	Occasional occurrence in similar operations	Seldom occurrence in similar operations	Isolated occurrence in similar operations	Remote occurrence may occur in exceptional circumstances
Consequence	Financial	Safety	Environment		A. Frequent	B. Likely	C. Possibly	D. Unlikely	E. Rare
	>K1 million	Multiple fatalities as a result of short or long term health effects or irreversible impacts to >50 people	Wide spread irreparable damage to highly valued area	I. Critical		**MATERIAL**			
	K100, 000 – K1 million	Single fatality or severe irreversible impacts to >10 persons	Wide spread long to medium term damage to valued area	II. Major			**HIGH**		
	K50,000 – K100, 000	Irreversible disability or impairment to one or more persons	Localized medium term damage to an area of local value	III. Serious				**MEDIUM**	
	K5, 000 – K50, 000	Reversible disability and or medical treatment injury requiring hospitalization	Localized short to medium term damage to an area of minor significance	IV. Moderate					**LOW**
	<K5, 000	Low level symptoms requiring treatment with first aid only	Limited damage to a localized area. No lasting effects	V. Minor					

4.5 Identified and Analysis of Risks

The following chapter identifies common activities that will be associated with the Nama drilling project, and examines its potential properties and characteristics that may cause it to become a potential risk.

4.5.1 Well Blow-out (leak)

During drilling operations, it is possible for hydrocarbons contained in high-pressure rock formations within the reservoir to flow into the borehole. This increases the risks of hydrocarbons leaking and reaching the surface. This in turn can lead to loss of control over the well causing potential fire hazards and/or hydrocarbon entering surrounding waterways.

4.5.2 Fire and Explosion

Crude oil and natural gas are mixtures of flammable hydrocarbons which can cause fires or explode if not properly monitored. Oil and gas leaks and spills increases the risk of fires and explosions which can cause large environmental damage, loss of lives and loss of property and company assets.

4.5.3 Fuel spills and leaks

Fuels and drilling chemicals are mixtures of flammable hydrocarbons which are potential fire hazards and contaminants if they are not handled, transported, disposed or stored properly. In normal drilling operations, fuels such as petrol and diesel are used to power vehicles and large machineries as well as generators. Leaks and spills of fuels may cause fires and contaminate land and waterways.

4.5.4 Drilling fluids discharge

Drilling fluid is a general term given to identify a combination of liquids used in drilling. The initial component is drilling mud which is used in the actual drilling process. The constituents of drilling mud used in the drilling process include bentonite (powdered rock) and barite/barium sulphate ($BaSO_4$) mixed in aquas solution of potassium chloride (KCl) and polymer glycol. These chemicals aid in the corrosion of bedrock allowing the drill to penetrate deeper into the earths crust. The second component is the alteration of drilling mud after it has gone through the drilling process with drill cuttings in liquid suspension. Drilling fluids pose a risk of environmental damage if not properly discharged.

4.5.5 Other Hazardous Wastes

Hazardous wastes are waste that that pose substantial or potential threats to the environment. They are known or tested to exhibit ignitability (flammable), reactivity, corrosivity, toxicity. This includes batteries, scrap metal, used/empty drums and containers, old and damaged electrical appliances and such. These hazardous waste maybe environmental risks if they are not properly stored or disposed.

4.5.6 Conflicts

Internal or external conflicts and conflict situations may arise during the course of the project operations. Internal conflicts included conflicts among laborours, supervisors or management staff. External conflicts include conflicts among villagers and landowners or between the company and landowners as well as law and Order issues. Conflicts are common in PNG and may cause laborours and staff to go on strike and/or stop-work, whereas in serious situations fights and arguments may result in company personal or villages obtaing bruisers or serious bodily harm, even death.

4.5.7 Natural Disasters

Natural disasters such as flooding, earthquakes, landslides, and tsunamis are untimely and may occur unexpectedly. This poses risks to project operations and the health and safety of project personals. Natural disasters are dangerous and deadly if no proper plans or equipments are put in place to cater for this risk.

4.6 Evaluation and Treatment

The following chapter measures each identified risk by evaluating its likelihood (probability) and consequence (result) to determine its significance (importance) using the risk matrix **(Table 1)**. To evaluate these risks the environmental characteristic were taken into consideration. **Table 2** evaluates each risk according to their liklyhoodn consequence and overall significance in the project.

After evaluation of risks, the best management and control actions that the company will adopt and implement to mitigate these risks are identified and listed. **Table 3** shows the overall mitigation and management controls of the company to manage those risks.

Table 8: Evaluation of Drilling Risks.

Risk	Likelihood	Consequence	Significance
Well blow-out (leak)	Possibly (there has never been a case reported in PNG)	Serious (localized medium term damage to an area of local value with some cases of health issues and it may cost the company more than K50, 000 to manage and mitigate)	Medium
Fire and explosion		Serious (irreversible disability or impairment to one or ore persons witj a localized medium term damage to the drill site environment. It may cost the company more than K50, 000 to mitigate and manage)	Medium
Fuel and chemical spills and leaks	Fequent (occur frequently due to poor management and control)	Moderate (localized short term damage specific to the drilling area and its mitigation and management may cost the company more than K5, 000)	High
Drilling fluids waste	Frequent (the wastes of drilling fluids will be discharged into a selected discharge site during operations)	Minor (limited damage to the drill environment as well as the downstream recipient environment)	Medium
Other hazardous wastes			
Conflicts and Law and Oder	Likely (landowner issues are common in PNG)	Moderate (injuries or fatalities relating to LO issues are not common and the conflict is usually localized)	Medium
Natural disasters	Rare (drill site is not within an earthquake, flooding or bush fire area)	Minor (climate change will be the only result)	Low

Table 9: Overall Evaluation of Risks and Treatments.

Risk Identification			Risk Analysis		Risk Evaluation	Risk Treatment
Activity	**Hazard/Risk**	**Potential Environmental Consequences**	**Consequence**	**Likelihood**	**Risk Ranking**	**Controls (Avoidance, Mitigation and Management Measures**
Anthropogenic (Man-made)						
Drilling Discharge	Discharge of water based drilling cuttings and muds into nearby seasonal creek	Smothering of creek/river habitat in immediate area of discharge (within <200m)	Minor	Frequent	Medium	• Drill cuttings will be treated on the shale shaker and by centrifuges prior to disposal to maximize recovery / reuse of drill muds, and minimum loss to the environment • Low toxicity and natural dispersion of cuttings will aid benthic recovery within two years.
	Discharge of cement (in slurry form)					• Selection of cementing chemicals • Prevent discharge of cement to seabed for subsequent casing strings
		• Short term and localized increased turbidity in water				• WBM is low toxicity and rapidly disperses in the water column.

		column from low-toxicity WBM but cuttings/muds sink rapidly.				• Recovery and recycling of drilling fluids so only the amount adhered to cuttings is discharged.
Fire and Explosion	Well blowout, human error on drilling rig causing explosion and fire.		Serious	Possible	Medium	• Emergency response plan and external emergency • Communication • Active and passive fire protection is in place • Safe location mustering and temporary refuge points • Shutdown on non-essential machinery to reduce risk of ignition.
Well-blow out	Uncontrolled release of reservoir fluid during exploration drilling leading to well blow-out with associated consequences	• Widespread damage to the bio-physical environment • Toxicity effects on water quality. • Pollution of aquatic environment	Serious	Possible	Medium	• Prior site analysis and understanding of likelihood of intersecting over-pressured strata. • Maintenance of all well control equipment. • Installation of blow out preventers • Routine monitoring of pressure of drilling fluid system • Oil spill and emergency response plan. • Ensure that the drilling

						program is carried out in the shortest time practicable • Ensure the drilling program is carried out in compliance with and management frameworks. • Ensure the wells are designed and constructed in compliance with Drilling Management System.
Chemical spills and land contamination	Improper disposal, handling, transporting, and storage of drilling chemicals, fuels and other chemicals used on drill site.	• Widespread contamination of soils and biological environment. • Fumes can cause health risk among workers • A potential fire risk	Moderate	Frequent	High	• Proper disposal, handling, transporting and storage of all chemicals, • Provide proper PPE to workers. • Educate and train workers on proper methods of disposal, handling and storage of chemicals. • Restrict the handling of chemicals to certified personnel only. • Set up restricted zones for the general public and workers.

						• Spill and emergency response plan.
Fuel spills	Fuel residues and leaks on the river edges	• Contamination of river bank vegetation and fauna	Moderate	Frequent	High	• Spill and emergency response plan
Conflicts	Conflicts arising from tribal, ethnic, election related events.	• Workers and expatriate safety at risk • Loss of work hours	Likely	Moderate	Medium	• Set up security at camp sites and drill sites to ensure safety of camp and drilling personnel • Restrict access of general public to project areas • Ensure police personnel are present during negotiations
	Landowner issues					• All land owner issues must be managed and controlled by CA officers. • Ensure police personnel are present during negotiations. • Compensation and royalties.
	Workers/personnel					• Develop disciplinary protocols and procedures for complaints and incidents.

						• Ensure workers are aware of incident and complaint procedures
	Law and Order					• Ensure police personnel are present at camp.
Natural Disasters	Flooding, Earthquake, Drought, Bushfire	• Compromise workers health and safety • Loss of work hours • Contamination of natural waterways • Destruction and damage of company property	Minor	Rare	Low	• Develop emergency evacuation plans. • Train personnel and workers on emergency evacuation drills • Choose a muster point.

5.0 Confidential Information

Details of this project or processes used in the operation of this activity including its financial nature is classified as **'confidential information'** before it is made available for public review.

6.0 Reference

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7.0 Appendices

This chapter contains environmental reports conducted as initial assessment for the Nama Rig Site Project. The list below shows the order in which they have been compiled as appendices to this main EIA document.

7.1 Soil Assessment

7.2 Water Quality & Hydrology Assessment

7.3 Aquatic Fauna Assessment

7.4 Aquatic Flora Assessment

7.5 Socio – Economic Impact Assessment

7.6 Risk Assessment