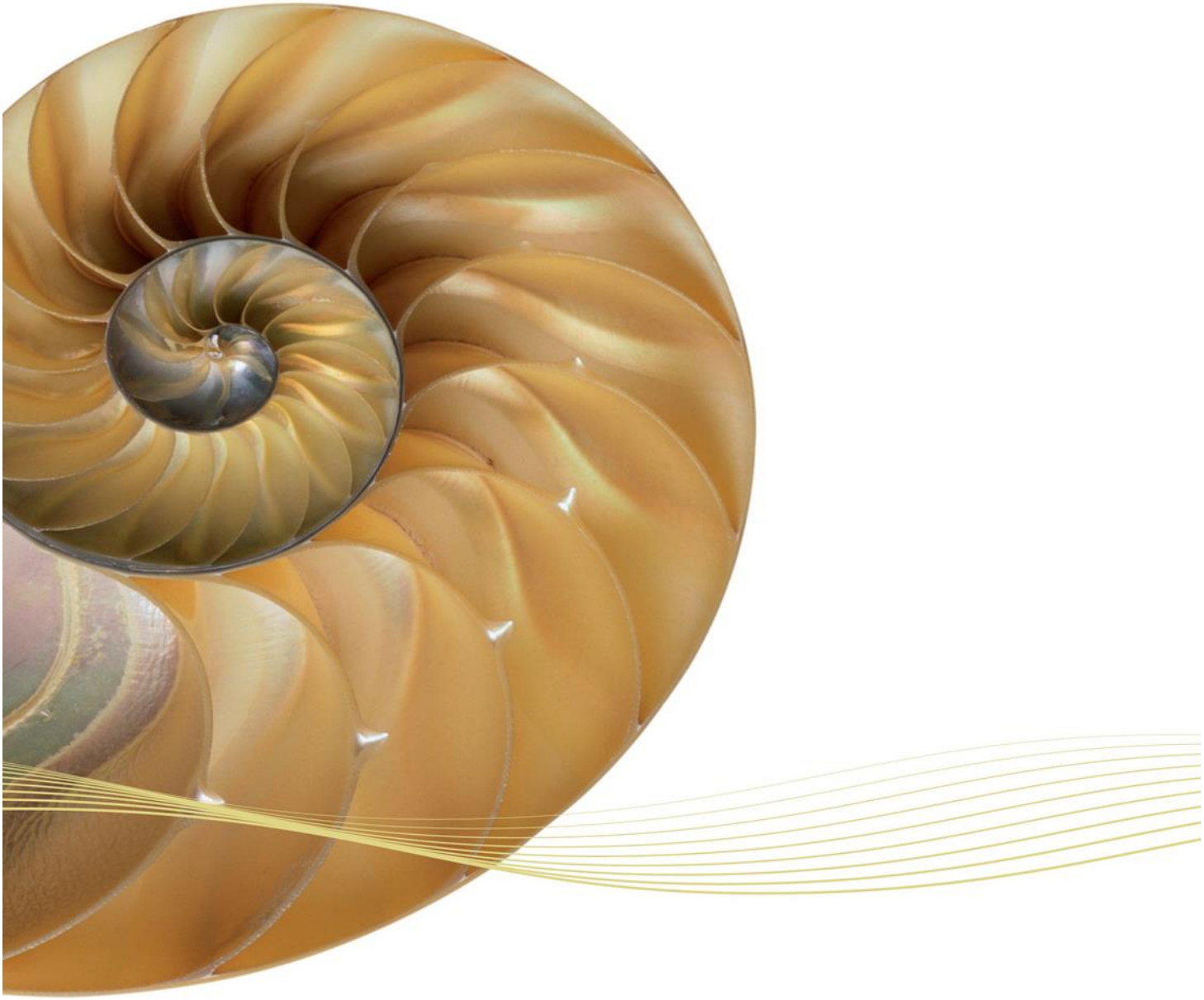

Environmental Impact Assessment for the Re-development and Enhanced Oil Recovery (EOR) Programme of the Mann Oil Field, Myanmar

EIA Report

22 October 2015

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ERM

The world's leading sustainability consultancy

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EIA Report

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Client:	Project No:
MPRL E&P	0267078
Summary:	Date: 22 October 2015
This document presents the **EIA Report** for the re-development and enhanced oil recovery (EOR) programme of the Mann Oil Field, Myanmar.	Approved by:  Craig A Reid *Partner*

1	EIA Report	JT	JT	CAR	22/10/15
Revision	Description	By	Checked	Approved	Date

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CONTENTS

EXECUTIVE SUMMARY

MPRL E&P Pte Ltd (MPRL E&P) operates the Mann Oil Field under a Performance Compensation Contract (PCC). Under the PCC, MPRL E&P is re-vitalizing the field with new technologies and methods to enhance production and improve the environmental performance of the oil field operations ("the Project"). This will be achieved with the support of the Myanmar Oil and Gas Enterprise (MOGE).

In this connection, MPRL E&P has commissioned **Environmental Resources Management** (ERM), supported by local specialists **Resource and Environment Myanmar** (REM), to undertake an Environmental Impact Assessment (EIA) in order to develop an Environmental Management System (EMS) for the Project which will cover a programme of re-development and enhanced oil recovery (EOR) to enhance and ensure sustainability of the Mann Oil Field in accordance with the *Environmental Impact Assessment (EIA) Procedures* ("*the Procedures*").

The overall purpose of the Study is to complete a robust EIA to meet requirements of the *EIA Procedures* for the EIA to be approved by the Ministry of Environmental Conservation and Forestry (MOECAF).

KEY ENVIRONMENTAL FEATURES

An overview of environmental baseline features for Mann Oil Field is presented in the EIA Study. The main parameters described include:

- Physical environment, including climate and meteorology, geology, noise, air, surface water, groundwater and soil quality; and

- Biological environment, including terrestrial habitats as well as the associated flora and fauna including avifauna, butterflies, herpetofauna, mammals and aquatic fauna.

Information on the above parameters has been collected through desktop review of publicly available information. Primary data collection has also been undertaken in May 2015 to establish the baseline physical and biological environment of the Project Area. The baseline data obtained have been used to characteristic the Project Area and informed the assessment of potential environmental impacts from the proposed re-development and EOR activities at Mann Oil Field.

IMPACT ASSESSMENT & ENVIRONMENTAL MANAGEMENT PLAN

During the impact assessment, potential impacts have firstly been identified through a systematic scoping process whereby the activities (both planned and unplanned) associated with the Project have been considered with respect to their potential to interact with environmental resources or receivers.

Interactions which may generate potentially significant environmental impacts ranging from those associated with the construction phase (e.g. disturbance to terrestrial habitats and physical environment during drilling activities), operation phase (e.g. disturbance to terrestrial habitats and residential sensitive receivers due to improper disposal of solid and liquid wastes) as well as accidental events (e.g. spillage) at the Mann Oil Field.

The potentially significant environmental impacts are further assessed in the EIA Study, with appropriate mitigation and enhancement measures recommended for alleviating potential negative impacts or enhancing potential positive impacts from the Project. With proper implementation of the mitigation measures, it is predicted that the potential environmental and impacts causing by the EOR and re-development activities of at Mann Oil Filed would be of **Negligible, Minor or Moderate** significance.

CUMULATIVE IMPACTS

Cumulative impacts refer to the additional impacts that may be generated by other developments or activities in the vicinity of the Project Area that when added to the impacts of the proposed EOR and redevelopment activities at Mann Oil Field combine to cause a greater impact. Such impacts may arise due to spatial overlap in an impact (e.g. overlap in spatial extent of air or water quality changes) or temporal overlap (e.g. noise impacts caused by construction activities at the same time from different sources). Within the Mann Oil Field, according to publicly available information, no other projects will be constructed or operated concurrently with the proposed EOR and re-development programme. As such, cumulative impacts with other concurrent projects are not expected to occur.

1 INTRODUCTION

1.1 PROJECT OVERVIEW

MPRL E&P Pte Ltd (MPRL E&P) operates the Mann Oil Field under a Performance Compensation Contract (PCC). Under the PCC, MPRL E&P is re-vitalizing the field with new technologies and methods to enhance production and improve the environmental performance of the oil field operations ("the Project"). This will be achieved with the support of the Myanmar Oil and Gas Enterprise (MOGE).

The location of the Mann Oil Field is shown in *Figure 1.1*.

1.2 PROJECT PROPONENT

The proponent of the Project is MPRL E&P Pte Ltd.

MPRL E&P is an independent oil and gas exploration and production company, headquartered in Yangon with operations in various offshore and onshore blocks in Myanmar. Further information about the company is available at the website http://mprlexp.com/.

1.3 THIS ENVIRONMENTAL IMPACT ASSESSMENT

MPRL E&P has commissioned **Environmental Resources Management** (ERM), supported by local specialists **Resource and Environment Myanmar** (REM), to undertake an Environmental Impact Assessment (EIA) in order to develop an Environmental Management System (EMS) for the Project which will cover a programme of re-development and enhanced oil recovery (EOR) to enhance and ensure sustainability of the Mann Oil Field. The EIA Study is undertaken in accordance with the relevant requirements of the Draft EIA Procedures ("the Procedures") of Myanmar [1].

This EIA Report has been prepared for MPRL E&P by ERM and presents the objectives, methodology and outcomes of the EIA in accordance with the Draft EIA Procedures. It is important to note that a Social Impact Assessment has not been conducted for the Project.

1.4 IMPACT ASSESSMENT OBJECTIVES

The overall purpose of the Study is to complete a robust EIA to meet requirements of the Draft EIA Procedures. Specifically, the objectives of the EIA are:

(1) EIA Procedures (6th Draft) dated January 2015.

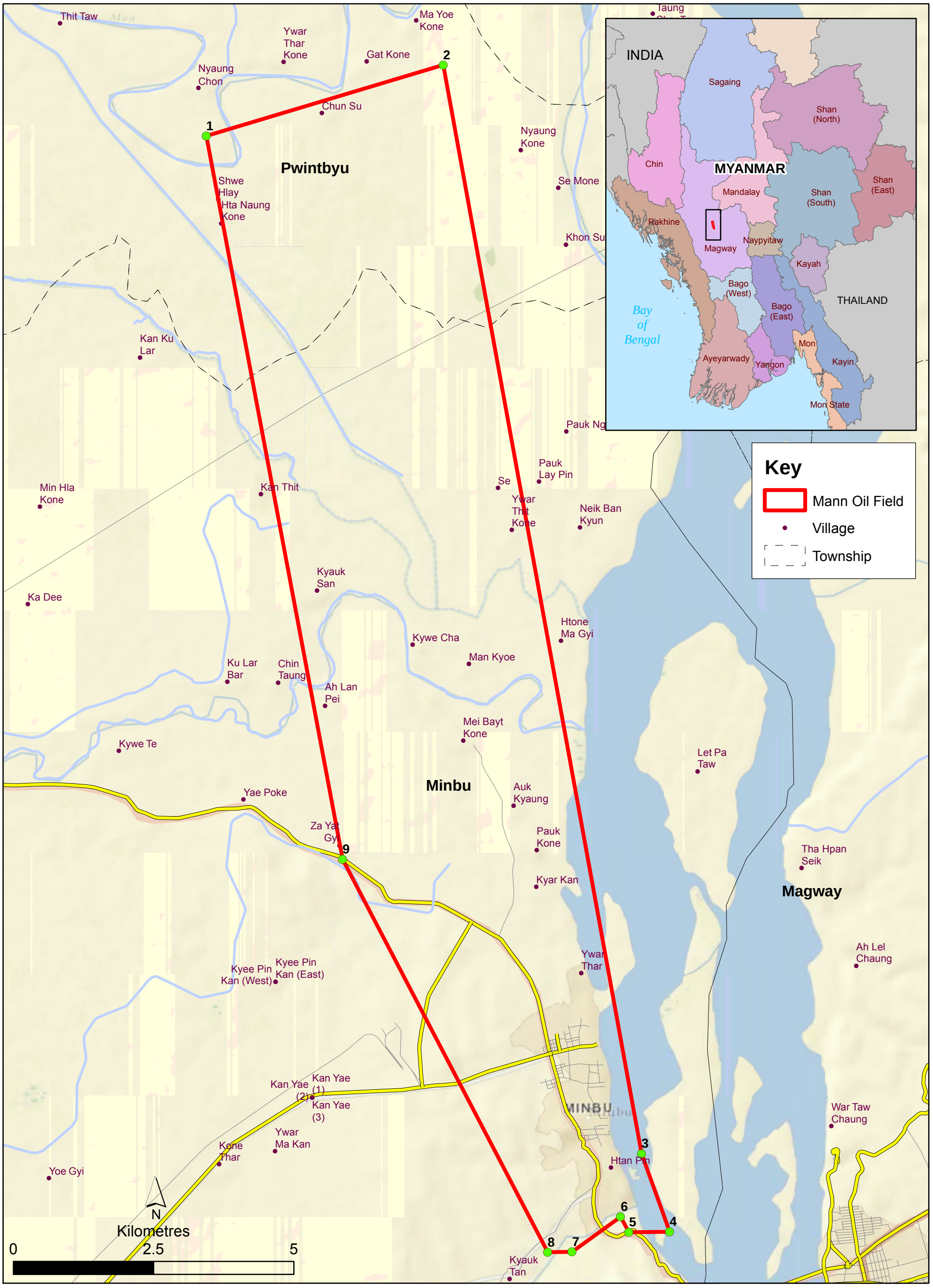

Figure 1.1

Project Boundary for the Mann Oil Field

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Date: 28/8/2015

Environmental Resources Management

ERM

- To review the proposed Project activities including its alternatives with respect to their potential to interact with environmental receptors and resources;

- To identify the potentially vulnerable environmental components;

- To identify and evaluate environmental impacts arising from the Project;

- To recommend mitigation or enhancement measures to remove, reduce or avoid negative impacts; and

- To provide an environmental management plan (EMP) including an approach for monitoring.

1.5 STUDY LIMITATIONS

This EIA is based on the Project description obtained from MPRL E&P at the time of the Study. Any future changes to the Project description, upon which this report is based or additional relevant information revealed as Project design, equipment and service procurement proceed may affect the analysis, assessment and conclusions contained in this report. Should significant changes occur, they would be the subject of further study to verify that the conclusions of this EIA do not change and to determine whether any additional mitigation, management or monitoring measures are warranted.

1.6 ENVIRONMENTAL IMPACT ASSESSMENT EXPERTS

The key EIA experts deployed for the Project are presented in *Table 1.1* below.

Table 1.1 EIA Experts deployed for the Project

Team	Name	Role	Organisation
Project Management Team	Craig A. Reid	Project Director	ERM
Project Management Team	Jovy Tam	Project Manager	ERM
Advisory Team	Dr Robin Kennish	EIA / EMP Expert	ERM
EIA and EMP Technical Team	Dr Jasmine Ng	EIA Specialist	ERM
EIA and EMP Technical Team	Mandy To	Noise Specialist	ERM
EIA and EMP Technical Team	Winnie Ko	Air Specialist	ERM
EIA and EMP Technical Team	Angus Choi	Soil and Groundwater Specialist	ERM
EIA and EMP Technical Team	Dr Tom Glenwright	Water Specialist	ERM
EIA and EMP Technical Team	Terence Fong	Ecology Specialist	ERM
EIA and EMP Technical Team	Manish Singh	SIA Specialist	ERM
EIA and EMP Technical Team	Kary Kwok	GIS Specialist	ERM
Local Team	Thura Aung	Noise, Air, Soil and Groundwater Survey Team Leader	REM
Local Team	Dr Ko Myint		REM
Local Team	Dr Win Kyi		REM
Local Team	Dr Myat Htoo Aung		REM
Local Team	Dr Win Maung	Local Specialist	REM
Local Team	Soe Thura Tun	Local Specialist	REM

1.7 REPORT STRUCTURE

The remainder of this report is structured as follows:

- *Section 2* defines the institutional framework for the Project including a summary of legislation, guidelines and standards applicable to / considered by the Project.
- *Section 3* presents the Project description and alternatives selection.
- *Section 4* presents a summary of environmental baseline conditions within the Project Area.
- *Section 5* presents the impact assessment methodology and the findings of the assessment of potentially significant impacts to environmental receptors and resources and proposed mitigation measures.
- *Section 6* presents findings of assessment of cumulative impacts to environmental receptors and resources within the Project Area.
- *Section 7* details the Environmental Management Plan and any monitoring measures to be completed.

2 POLICY, LEGAL AND INSTITUTIONAL FRAMEWORK

This section sets out the relevant legal and policy context in Myanmar and documents the environmental standards with which the Project will achieve compliance as well as the international standards that the Project will consider to follow. Specifically, this section summarises the following:

- MPRL E&P Health, Safety and Environmental (HSE) Policy;
- Myanmar administrative and legislative framework as well as existing regulatory requirements;
- Pending EIA requirements in Myanmar;
- International organizations such as the World Bank and International Finance Corporation (IFC) environmental guidelines and standards that relate to both conducting an EIA as well as to the technical performance standards considered by the Project; and
- A discussion of international conventions to which Myanmar is a signatory and with which the Project should consider.

Specific benchmarks used to assess individual impacts are also summarized under each assessment topic in *Section 5*.

2.1 CORPORATE HSE POLICY

MPRL E&P has adopted a comprehensive HSE Management System. This system is an important and integral part of the company's overall management system and is shown in *Figure 2.1* below. This EIA Study is conducted in accordance with MPRL E&P's environmental guidelines which require the Project to follow the fundamental goals of:

- Zero accidents;
- No harm to people; and
- No damage to environment.

Figure 2.1 MPRL E&P's HSE Policy

MPRL E&P HSE Policy

MPRL E&P is committed to continuous improvement in Health, Safety and Environmental performance, consistent with our fundamental goals of:

- Zero accidents,
- No harm to people,
- No damage to the environment.

MPRL E&P adheres to and strives to meet the following principles throughout its operations:

- All accidents are preventable.
- No activity is so important that it cannot be done safely.
- Minimize the environmental impact our activities may cause.
- Meet or exceed the requirements of applicable HSE legislation, regulations and Company HSE expectations.
- HSE performance depends on all employees and Contractor personnel working with MPRL E&P. Everyone is responsible for working safely.
- Continually strive to reduce the impact of our business on health, safety and the environment by applying safe work practices, reducing waste, and using energy efficiently.
- Eliminate injuries by rectifying and reporting all actions and conditions, which could result in an accident / incident.
- Conduct appropriate training to ensure all our personnel are competent in their respective jobs and understand and adhere to this policy.
- Ensure business plans and personal objectives include measurable HSE targets, which are established annually and reviewed regularly.

Responsibilities for HSE performance are visible throughout the organization, with clarity for line management accountability. The MPRL E&P Health, Safety and Environment Management System , is fundamental to our business and is applicable to all areas of our operations.

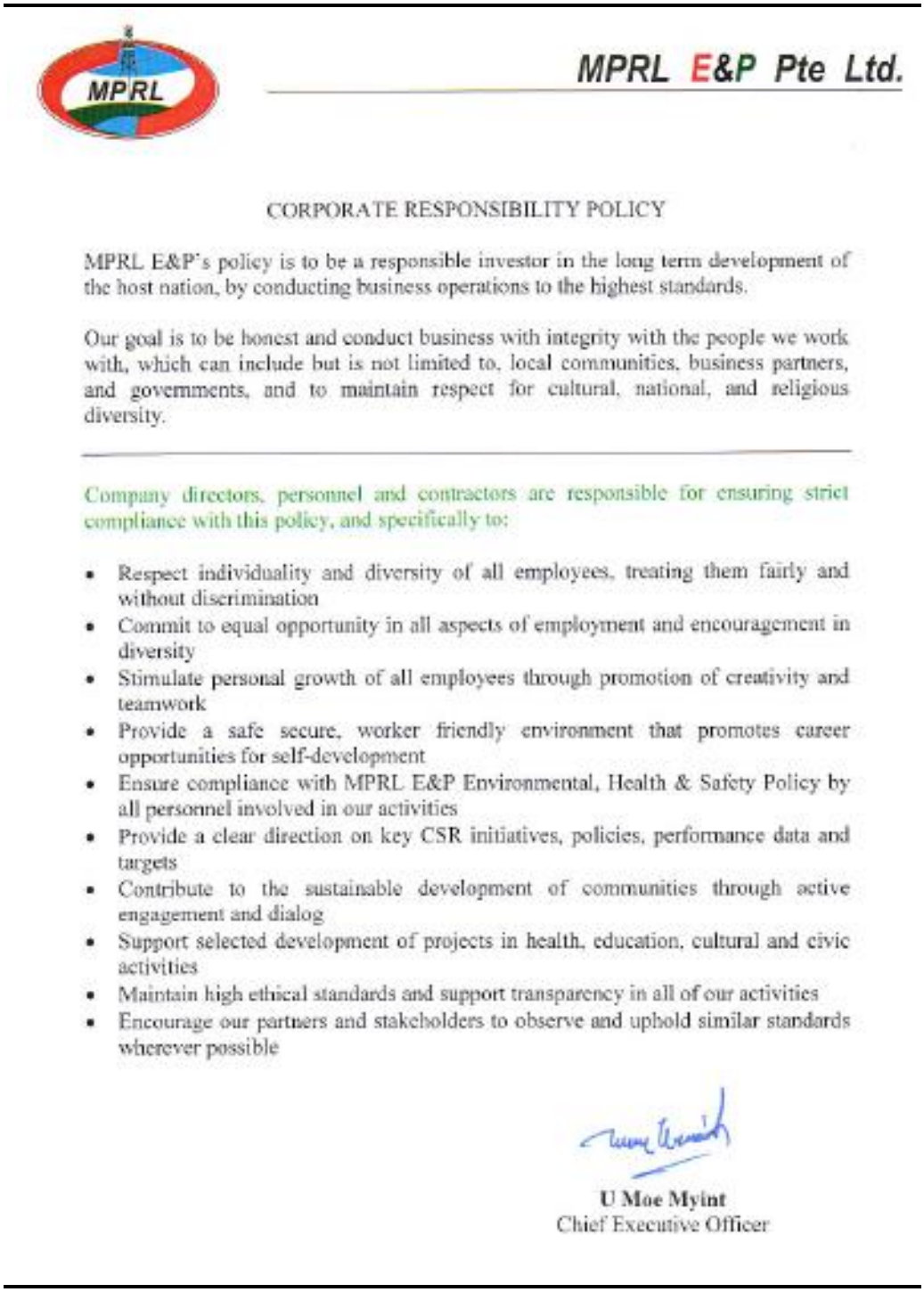
MPRL E&P Senior Management is accountable for implementation of this policy. Implementation is achieved by adhering to our management systems, and where appropriate the management systems used by those who work with us.

U Myo Tin
General Manager
MPRL E&P Pte Ltd.

Date of revision : 13-May-2013

Apart from the HSE policy, MPRL E&P also has in place a corporate responsibility policy and a human rights policy, as can be seen in the following *Figures 2.2-3*.

Figure 2.2 MPRL E&P Corporate Responsibility Policy



MPRL E&P Pte Ltd.

CORPORATE RESPONSIBILITY POLICY

MPRL E&P's policy is to be a responsible investor in the long term development of the host nation, by conducting business operations to the highest standards.

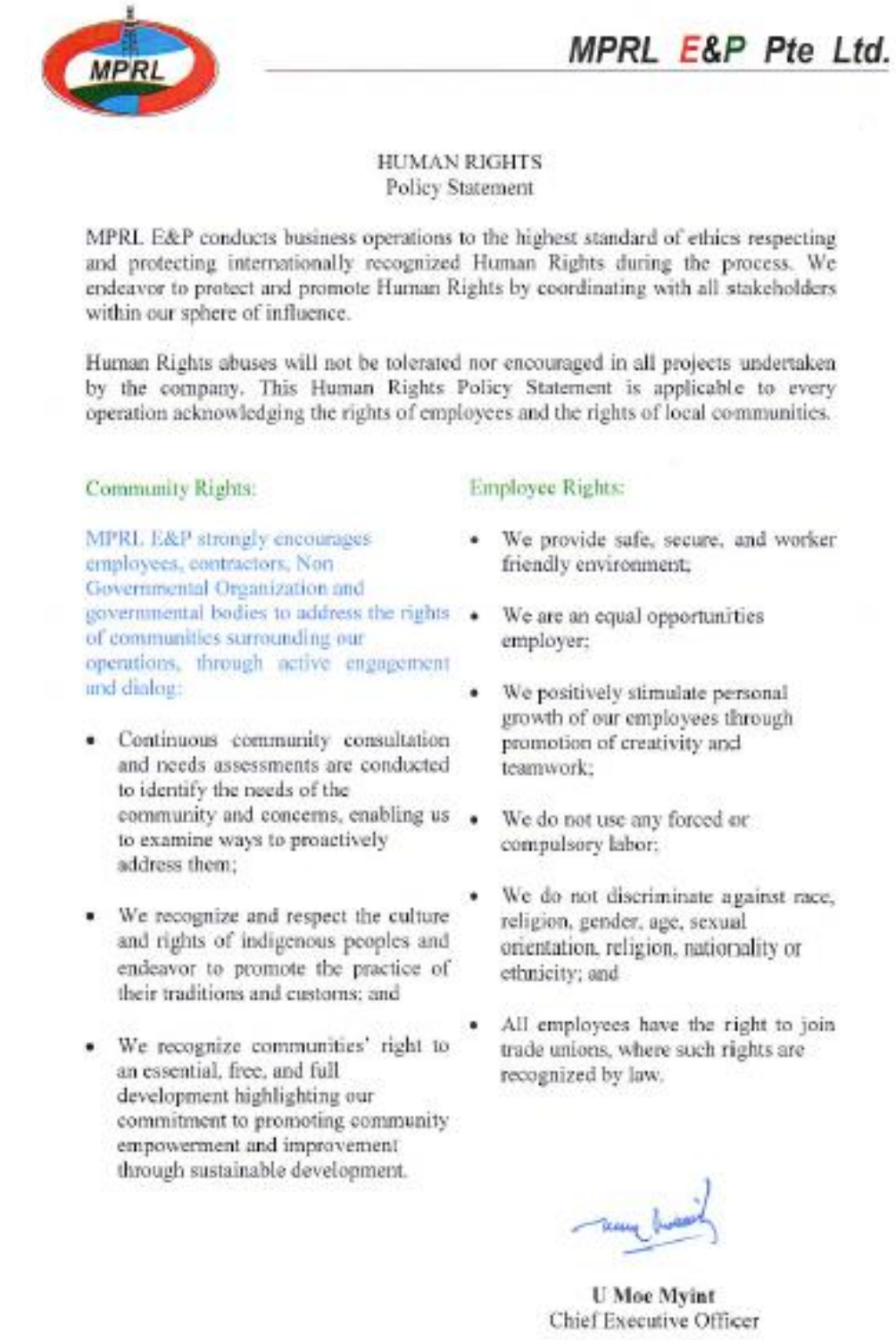
Our goal is to be honest and conduct business with integrity with the people we work with, which can include but is not limited to, local communities, business partners, and governments, and to maintain respect for cultural, national, and religious diversity.

Company directors, personnel and contractors are responsible for ensuring strict compliance with this policy, and specifically to:

- Respect individuality and diversity of all employees, treating them fairly and without discrimination
- Commit to equal opportunity in all aspects of employment and encouragement in diversity
- Stimulate personal growth of all employees through promotion of creativity and teamwork
- Provide a safe secure, worker friendly environment that promotes career opportunities for self-development
- Ensure compliance with MPRL E&P Environmental, Health & Safety Policy by all personnel involved in our activities
- Provide a clear direction on key CSR initiatives, policies, performance data and targets
- Contribute to the sustainable development of communities through active engagement and dialog
- Support selected development of projects in health, education, cultural and civic activities
- Maintain high ethical standards and support transparency in all of our activities
- Encourage our partners and stakeholders to observe and uphold similar standards wherever possible

U Moe Myint
Chief Executive Officer

Figure 2.3 MPRL E&P Human Rights Policy



MPRL E&P Pte Ltd.

HUMAN RIGHTS
Policy Statement

MPRL E&P conducts business operations to the highest standard of ethics respecting and protecting internationally recognized Human Rights during the process. We endeavor to protect and promote Human Rights by coordinating with all stakeholders within our sphere of influence.

Human Rights abuses will not be tolerated nor encouraged in all projects undertaken by the company. This Human Rights Policy Statement is applicable to every operation acknowledging the rights of employees and the rights of local communities.

Community Rights:

MPRL E&P strongly encourages employees, contractors, Non Governmental Organization and governmental bodies to address the rights of communities surrounding our operations, through active engagement and dialog:

- Continuous community consultation and needs assessments are conducted to identify the needs of the community and concerns, enabling us to examine ways to proactively address them;
- We recognize and respect the culture and rights of indigenous peoples and endeavor to promote the practice of their traditions and customs; and
- We recognize communities' right to an essential, free, and full development highlighting our commitment to promoting community empowerment and improvement through sustainable development.

Employee Rights:

- We provide safe, secure, and worker friendly environment;
- We are an equal opportunities employer;
- We positively stimulate personal growth of our employees through promotion of creativity and teamwork;
- We do not use any forced or compulsory labor;
- We do not discriminate against race, religion, gender, age, sexual orientation, religion, nationality or ethnicity; and
- All employees have the right to join trade unions, where such rights are recognized by law.

U Moe Myint
Chief Executive Officer

2.2 *MYANMAR REGULATORY REQUIREMENTS*

Matters pertaining to HSE requirements are generally under the jurisdiction of the ministries and state-owned enterprises in the oil and gas sector. Key ministries/ agencies / state-owned enterprises that have jurisdiction over HSE matters in oil and gas operations include the following:

- MOECAF;
- Ministry of Fisheries, Livestock and Rural Development;
- Ministry of Labour;
- Ministry of Energy (MOE);
- MOGE; and
- Myanmar Investment Commission (MIC).

Table 2.1 provides a list of laws relevant to HSE of the proposed Project.

Table 2.1 List of Existing Sectorial Laws in Myanmar related to Environmental Issues as of September 2015

Sector	Relevant Laws in Myanmar
Culture	The Protection and Preservation of Cultural Heritage Region Law, 1998
Forestry, Environmental and Natural Resources	The Protection of Wild Life, Wild Plants and Conservation of Natural Areas Law, 1994
	Burma Wild Life Protection Rules, 1941
	The Protection of Wildlife and Conservation of Natural Areas Law - SLORC Law No. 6/94
	The Forest Department Notification No. 583/94
	Environmental Impact Assessment Rules – Draft
	Environmental Conservation Law (March 2012)
	Environmental Conservation Rules (June 2014)
	National Environmental Policy (1994)
	The Conservation of Water Resources and Rivers Law, 2006
Industrial	The Petroleum Act, 1934
Fisheries, Aquaculture and Water	The Underground Water Act (1931)
	The Law Relating to Aquaculture, 1989

2.3 *PENDING EIA LEGISLATION IN MYANMAR*

Legislation related to environmental assessment, conservation and protection in Myanmar is currently within a development phase. Under *Section 7* of the *Environmental Conservation Law (2012)* and *Articles 52* and *53* of the *Environmental Conservation Rules (2014)* of the Republic of the Union of Myanmar, there is a requirement for the undertaking of an IEE or an EIA to obtain an ECC for certain development projects. Presently, the MOECAF is

drafting both *EIA Procedures* and *EIA Guidelines*, along with the supporting of an EIA drafting committee comprising the representatives of relevant union ministries, union attorney general's office, development committees and Non-governmental Organizations (NGOs) and technical support by experts from the Asian Development Bank Greater Mekong Subregion – Environment Operations Center (ADB GMS-EOC). Within the latest *Version 6* of the *EIA Procedures* [1] made publically available in 2015, the requirements for an EIA system are described as follows:

"*An EIA investigation shall consider all biological, physical, social, economic, health, cultural and visual-components of the environment, together with all pertinent legal matters relating to the environment (including land use, resources use, and ownership of and rights to land and other resources) that may be affected by the Project during all project phases including pre-construction, construction, operation, decommissioning, closure, and post-closure; and shall identify and assess all Adverse impacts and risks that potentially could arise from the project.* "

An EIA process is also outlined in the *EIA Procedures* which are described in the following sections. It should be noted that the EIA Study of the Project is undertaken under MPRL E&P commitment to improve the environmental performance of the operation in Mann Oil Field. However, it is not required under the PCC to conduct such study in order to obtain any related approval (e.g. Environmental Compliance Certificate) before commencement of the Project activities. Nevertheless, the EIA Study is undertaken with the relevant requirements of the *Draft EIA Procedures* regarding the screening, scoping and impact assessment exercises. It is also important to note that a Social Impact Assessment has not been conducted for the Project.

2.3.1 Screening

The EIA process starts with the Screening Process as shown in *Figure 2.4*. The MOECAF is empowered and has the exclusive authority to define screening criteria for a project.

Guidance is provided as to which projects or activities should carry out an IEE or an EIA, as presented in the *Annex* to the *EIA Procedures (6th Draft)* [2]. If, as a result of that determination, an IEE or an EIA is required, then the proponent of the project or activity shall be obliged to prepare, obtain approval for, and implement an appropriate Environmental Management Plan (EMP) in respect of the proposed project or activity. Any appeal from such determination must be made in accordance with the *EIA Procedure*s.

The Annex to the *EIA Procedures (6th Draft)* shows for each type of economic activity, the criteria for selection of whether IEE or EIA apply to the proposed economic activity. The MOECAF determines whether the project is an IEE Type Project, or an EIA Type Project, or is neither an IEE or an EIA Type

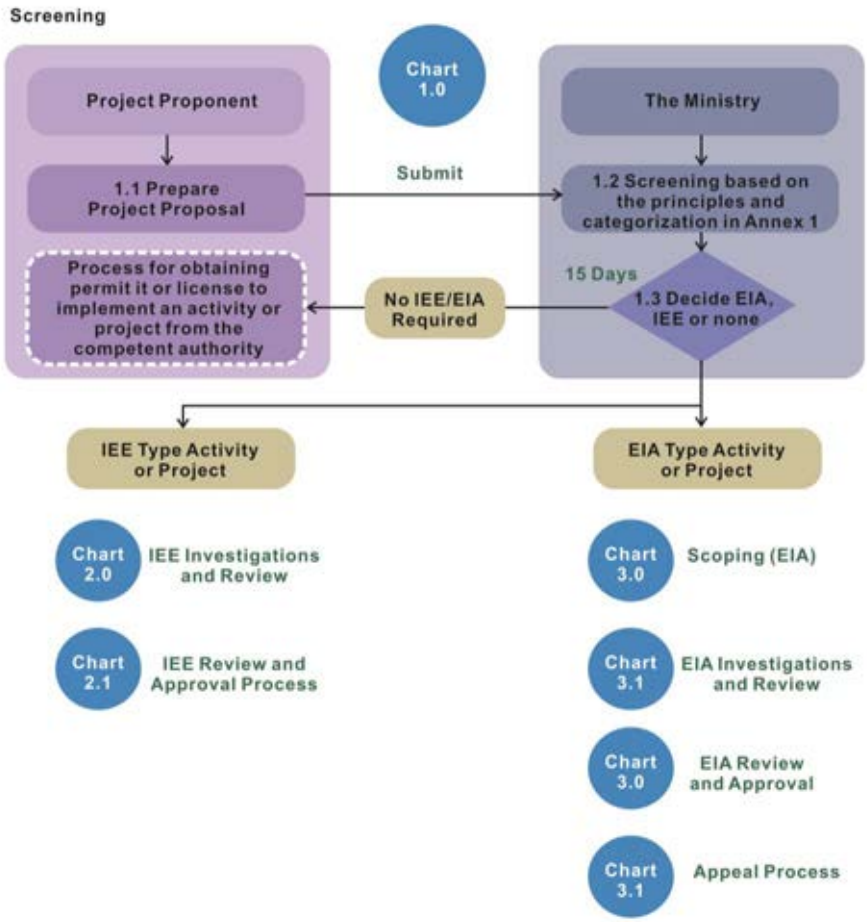
(1) EIA Procedures (6th Draft) dated January 2015.

(2) EIA Procedures (8th Draft) *Op. cit.*

Project and is therefore exempt from (not required) to undertake any environmental assessment.

For the purposes of this Project, the EIA has been selected as the methodology to follow under the *EIA Procedures*.

Figure 2.4 Screening within the Myanmar EIA Process



Source: EIA Procedures (6th Draft) Annex 2 - Environmental Assessment Procedure Flowchart [1]

On the basis that an EIA is to be conducted for the Project, the remainder of this discussion has focussed on the required EIA process.

The Project Proponent shall be required to submit a project proposal (completed in accordance with MOECAF's guidelines) to the Environmental Conservation Department of MOECAF for screening.

Within 15 days of receiving the complete project proposal, the MOECAF shall determine the type of environmental assessment (EIA, IEE, or none) which the project will require, and shall inform the Project Proponent in writing about its determination. In addition, the MOECAF can change the status of an IEE Type Project to be an EIA Type Project but there are no criteria for changing the status to none or exempt from environmental assessment.

(1) EIA Procedures (8th Draft) *Op. cit.*

Under the Procedure, a Project Proposal Report which recommended that an EIA should be conducted for the proposed Project was submitted to Ministry of Environmental Conservation and Forestry (MOECAF) [1].

2.3.2 Scoping

All EIA Type Projects are required to undergo Scoping. The Project Proponent shall be responsible to ensure that the Scoping and the preparation of the Term of Reference (TOR) for the EIA Report are undertaken in a professional manner and in accordance with any applicable guidelines issued or adopted by the MOECAF. The Scoping shall, in respect to the proposed Project:

a) Define the project area, area of influence, time boundaries, project phases, and potential stakeholders;

b) Start the process of understanding the applicable regulations and standards, and their context for Project design and completion of the EIA;

c) Make a provisional identification of environmental impacts, focusing in particular on the environmental issues that need to be addressed in subsequent EIA studies;

d) Provide an indication of what baseline data and information are required, and how it is proposed to obtain it (although there is no need to actually collect any data at this stage);

e) Provide an opportunity for consultants, relevant authorities, project developers, interested and affected parties to express their views and concerns regarding the proposal before an EIA proceeds;

f) Enable an efficient and comprehensive assessment process that saves time, resources, costs and delays; and

g) Identify potentially affected communities and other stakeholders with an interest in the project.

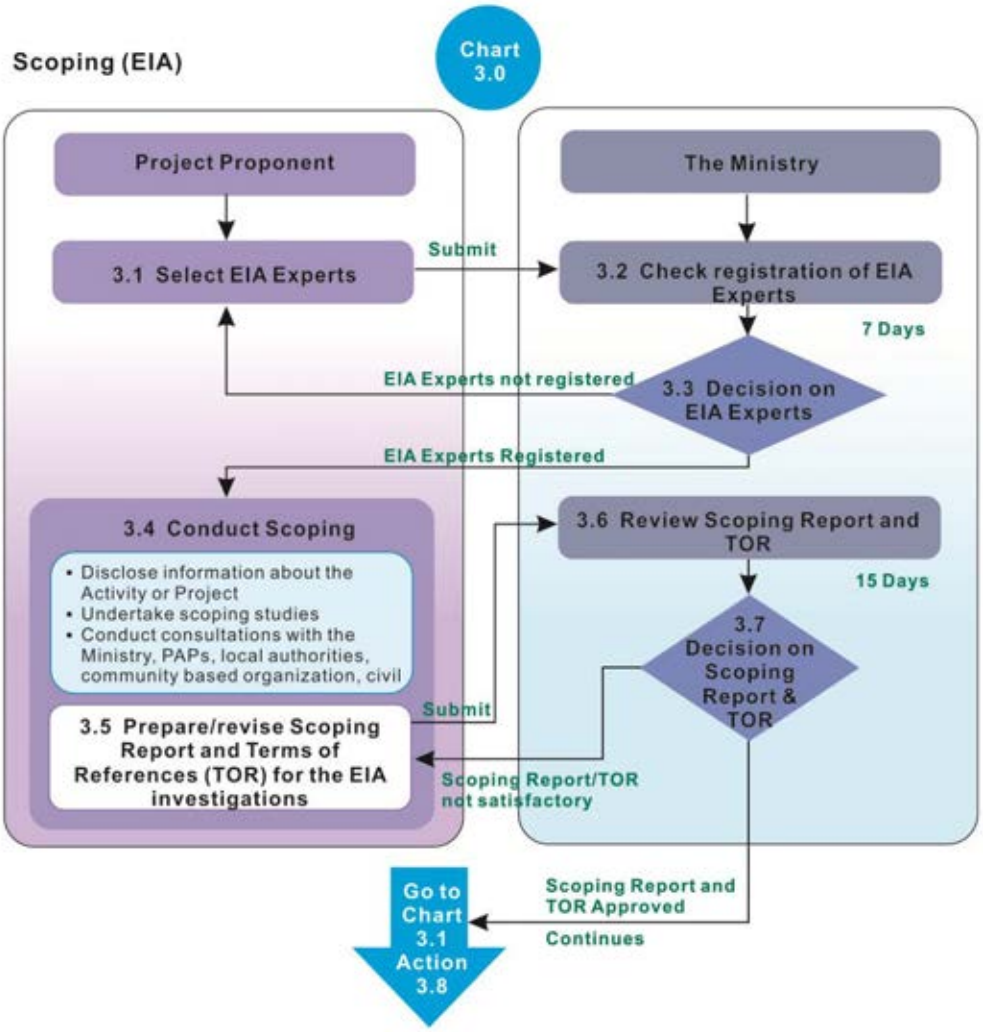
The Project Proponent shall prepare a Scoping Report and TOR for the EIA investigations and submit the completed Scoping Report and TOR to the MOECAF for review and approval. The Scoping process is shown in *Figure 2.5*.

It should be noted that stakeholder consultation was not undertaken under the EIA Study of the Project as the social impact assessment and the related consultation are outside the scope of the Study.

[1] ERM (2015) Project Proposal Report for the EOR and Redevelopment Activities at Mann Oil Field, Myanmar.

Under the Procedure, a Scoping Report with the TOR for the proposed Project was submitted to MOECAF [1].

Figure 2.5 Scoping within the Myanmar EIA Process



Source: EIA Procedures (6th Draft) [2]

2.3.3 *EIA Investigation and Report Preparation*

The Project Proponent shall ensure that the EIA investigation properly addresses all adverse impacts and is undertaken in accordance with the approved TOR. The EIA investigation shall consider all biological, physical, health, cultural and visual components of the environment, together with all pertinent legal matters relating to the environment (including land use, resources use, and ownership of and rights to land and other resources) that may be affected by the Project during all project phases, including pre-construction, construction, operation, decommissioning, closure, and post-closure; and shall identify and assess all adverse impacts and risks for the

(1) ERM (2015) Scoping Report for the EOR and Redevelopment Activities at Mann Oil Field, Myanmar.

(2) EIA Procedures (6th Draft) *Op. cit.*

environment and, if relevant, health that potentially could arise from the Project.

The Project Proponent is obliged to use, comply with and refer to applicable national standards, international standards adopted by the Government and/or the MOECAF, or, in the absence of relevant national or adopted international standards, such standards as may be agreed with the MOECAF.

Findings of the EIA Study will be presented in an EIA Report to be submitted to the MOECAF for comments. An EMP will be part of the EIA Report which documents the environmental mitigation and monitoring measures recommended in the EIA Study to alleviate potential negative environmental impacts of the Project.

2.4 INTERNATIONAL STANDARDS, GUIDELINES AND TREATIES/CONVENTIONS RELEVANT TO THE PROJECT

In addition to national legislation, a range of international standards, including IFC Performance Standards (IFC PS) and the World Bank Guidelines will be considered for the Project. These standards are set to complement national legislation and ensure the Project is conducted under best practices in a way that minimises risks, impacts and ensures compliance and fair practices.

The following international guidelines and standards will be considered for the EIA Study of the Project:

- IFC PS (2012): The IFC PS represent the 'policy framework' for the EIA and sustainable environmental management for the Project, whereas the World Bank Group's EHS Guidelines provide guidance on general and industry best practice as well as recommended numerical limits for emissions to the atmosphere, noise, liquid and solid wastes, hazardous wastes, health and safety, and other aspects of industrial facilities and other types of development projects.;

- World Bank Group (WBG) Environmental Health and Safety (EHS) General Guidelines (2007): The EHS Guidelines are technical reference documents with general and industry-specific examples of Good International Industry Practice (GIIP). The EHS Guidelines contain the performance levels and measures that are generally considered to be achievable in new facilities by existing technology at reasonable costs;

- WBG EHS Guidelines for Onshore Oil and Gas Development (2007); and

- Relevant international treaties to which Myanmar is a signatory, including those related to waste management and biodiversity conservation.

3 PROJECT DESCRIPTION AND ALTERNATIVE SELECTION

This section provides the detailed descriptions of re-development and EOR programme to be conducted within the Mann Oil Field. Information provided in this section is based on those made available during preparation of this EIA Report.

3.1 OIL FIELD DETAILS

The Mann Oil Field is located in Central Myanmar in the northwest of Magwe Division. The field is about 16 km long and 1.5 km wide, covering an area of ~82 km^2 within Block MOGE 2. The Mann Oil Field is generally flat at ~60 m above sea level, with the southern and most of the southwestern part straddling low hills. The Project Site is illustrated in *Figure 1.1.* Coordinates of the Mann Oil Field are provided in *Table 3.1* below.

Table 3.1 Block Mann Field Coordinates

Point	Latitude	Longitude
1	689303.42	2249525.16
2	693527.28	2250791.28
3	697062.53	2231386.30
4	697565.00	2229993.20
5	696839.00	2229985.00
6	696690.60	2230260.10
7	695826.40	2229635.30
8	695390.70	2229630.40
9	691733.26	2236632.30

The Mann Oil Field, discovered in 1970 by MOGE, currently includes 672 wells of which 330 were producing as of August 2015 while the remaining wells were shut-in. The total produced oil and associated gas from the Production Enhancement Project is 12.1 MMbbls, including 7.3 MMbbls above the normal decline curve, and 13.4 Bcf gas as of August 2015.

Facilities and equipment maintained and managed by MPRL E&P include:

- A camp inclusive with accommodation and health caring facilities for +/- 145 staff and office space for +/- 20 employees;
- One drilling rig, one workover rig and five pulling units;
- A warehouse, including all facilities for material planning, inventory control, loading and offloading facilities, transportation and tubular inspection;
- A workshop for repairing, rebuilding, overhauling and maintenance of drilling rigs, workover rigs, pulling units, rolling stock and ancillary mechanical equipment, as well as installation, repair and maintenance of all motors, generators, lighting systems and electrical devices;

- A workshop with dedicated equipment and manpower to prepare well sites, construction of access to sites and maintenance of roads, construction of camps and special projects, such as the maintenance and upgrade of the GOCS's, construction of state-of-the-art cellars of producing wells, etc; and

- A workshop with dedicated equipment and manpower to repair downhole devices and equipment, as well as repair and maintenance of hoisting systems and masts of pulling units.

3.2 ENHANCED OIL RECOVERY

3.2.1 General

Crude oil development and production in oil reservoirs can include up to three distinct phases: primary, secondary and tertiary (or enhanced) recovery (*Figure 3.1*). During primary recovery, the natural pressure of the reservoir or gravity drive oil into the wellbore, combined with artificial lift techniques (eg pumps) which bring the oil to the surface. Secondary recovery techniques extend a field's productive life generally by additional energy, such as injecting water or gas, supplied to the oil reservoir to recovery more oil and gas. Typically by-products from oil are the associated gas and water which are waste streams to be managed at surface or re-injected into the reservoir. Treatment is recommended if re-injecting fluids back into the reservoir to ensure that no plugging or precipitation reactions occur in the formation.

To improve the performance of existing oil fields, tertiary recovery or EOR will be adopted to access reserves that were previously unattainable due to geology or expense, or when primary and secondary recovery techniques have been exhausted. EOR is chiefly concerned with affecting the mobility of the oil through the drilling process, late in the life span of the well. It primarily does this through the use of injecting fluids in the drilling process, such as steam, air, detergents, carbon dioxide or microbes, to recovery additional oil from the reservoir. There are three primary techniques of EOR (*Figure 3.1*):

- Gas injection: it involves the use of gases such as natural gas, nitrogen, or carbon dioxide (CO_2) in which a miscible displacement process maintains reservoir pressure and improves oil displacement by reducing the interfacial tension between oil and water.

- Thermal injection: it involves the introduction of heat to the reservoir to vaporize some of the oil by reducing oil viscosity and hence improving mobility ratio; and,

- Chemical injection: it involves the use of long-chained molecules called polymers to aid mobility and the reduction of surface tension to increase production.

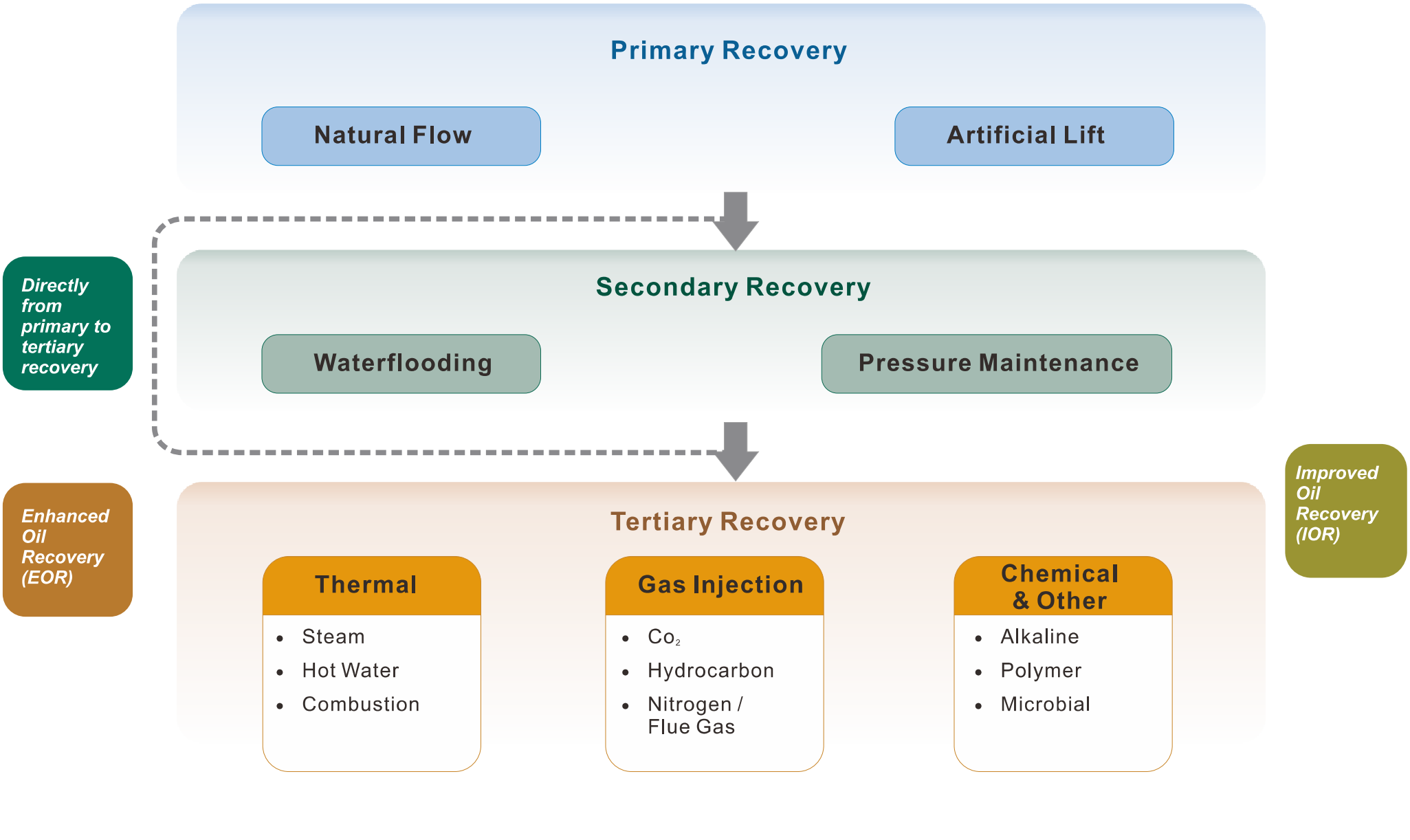


Figure 3.1

Methods of Crude Oil Recovery

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For the proposed Project in Mann Oil Field, EOR by the means of chemical injection using microbes and detergents are the proposed technique to be employed. Various typical chemicals used are biocides, detergents and water softeners to ensure that oil is maximized from the reservoir. The concentrations of these chemical additives are very low in concentration and will be recycled by continuous re-injection to minimize the impacts to environment.

The schematic of the EOR work is presented in *Figure 3.2*.

3.2.2 Construction

Additional facilities are necessary to be constructed for the enhanced recovery of oil from existing wells within the Mann Oil Field. These may include injection wells and associated equipment, pipelines and chemical storage warehouses. Most of these additional facilities will be similar to those used in the existing routine oil field operation within the Mann Oil Field, except for the injection wells and associated equipment used for chemical injection.

It is expected that the construction of these new facilities will mostly be undertaken on formed land where existing facilities are located. The construction activities will involve the use of Powered Mechanical Equipment (PME) such as generators, cranes, forklifts, rig and pulling units which would be the sources of air emission and noise. Ground breaking, excavation and drilling would be the major activities for the construction of the injection wells. Construction activities will also involve pipe laying, welding, scaffolding and building of the chemical storage warehouses.

No additional workforce will be required for the construction activities. As such, no additional labour camps will be required.

3.2.3 Operations

During operation, it is expected that chemicals will be required to be transported to the oil field and stored in the chemical storage warehouse. Chemicals will be supplied to the injection wells through trucks.

Displacing agent (e.g. detergent in this Project) will be injected into the reservoirs via the injection wells for enhanced oil recovery. The displacing agent will interact with the reservoir rock/ oil system to create condition favourable for residual oil recovery by reducing the interfacial tension between the displacing agent and oil, increasing the capillary forces and water viscosity. Ultimately, oil viscosity reduced and then displaced to the production well for refinery process. The chemicals that will be used include paraffin dissolvent, paraffin inhibitor, pore point depressant and GreenZyme and their Material Safety Data Sheet (MSDS) are shown in *Annex A*. Information regarding application and toxicity of these chemicals are shown in *Table 3.2* below.

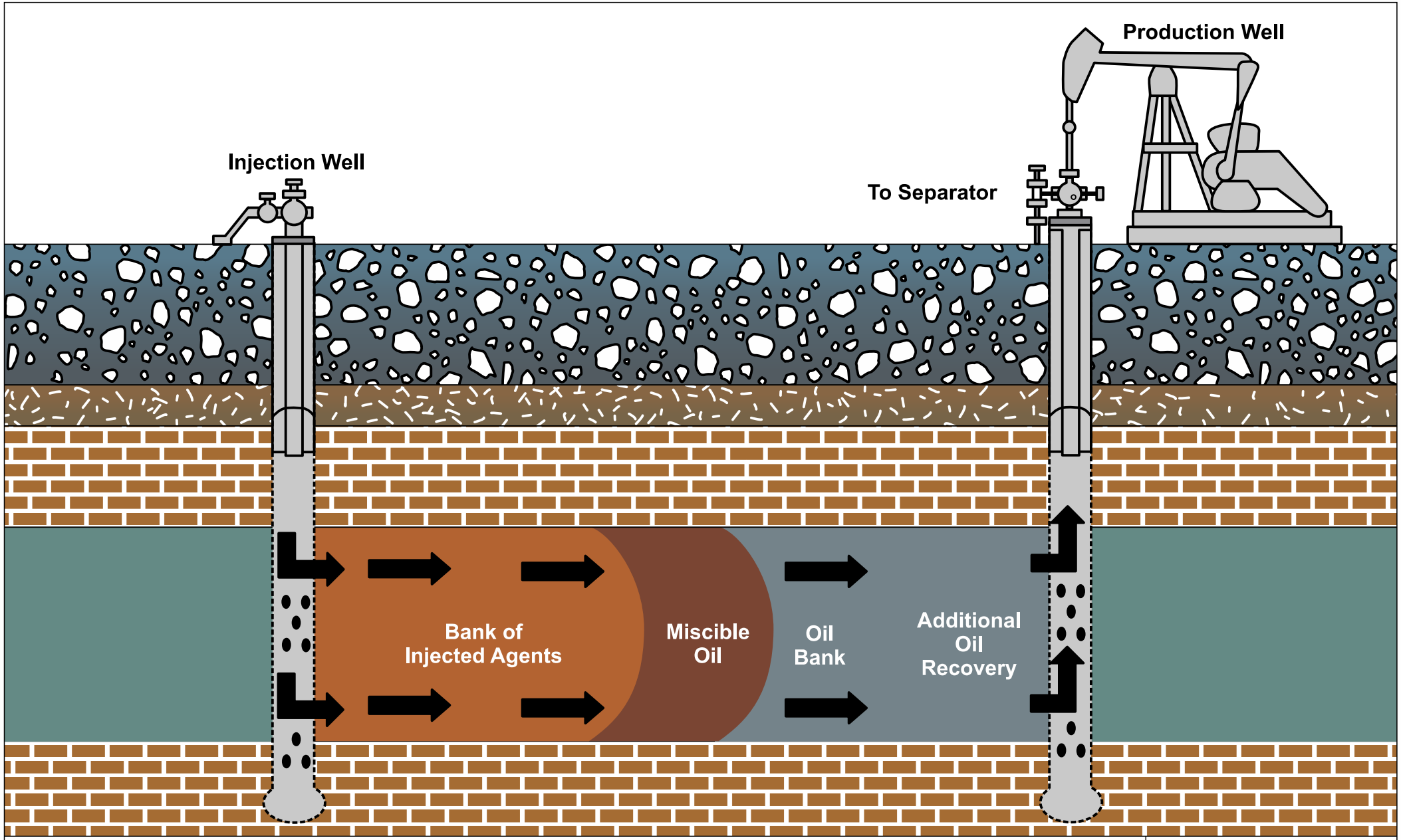

Figure 3.2

Schematic Diagram of Enhanced Oil Recovery (EOR)

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Table 3.2 Application and Toxicity of Chemicals that may be used for the EOR Process

Chemical	Application	Dosage per event	Toxicological information	Biodegradable?
Paraffin Dispersant	To clean up down hole, flow lines and storage tank by enhancing the heavy oil flow such that the production for wells and pipelines can be increased.	Few gallons	Insufficient information. One of the major ingredient of this chemical is toluene which could lead to acute lethal effect on mammals at 5,100 ppm for LC_{50} and No Observed Adverse Effect Level (NOAEL) at 200 ppm	This product is considered relatively stable
Paraffin Inhibitor	Paraffin Inhibitor is used to improve the pumpability of a wide range of waxy crude oil. It acts as the solvent by blending with crude oil at a ratio of 25% of inhibitor to the annulus and socking for about 4-hour.	25 % of Paraffin Inhibitor for each portion of crude oil	Data deficit	Data deficit
Pour Point Depressant (PPD) (Airflow 1535)	PPD is a polymer to control wax crystal formation in order to improve oil flow performance. It will be applied in drip by the beam driven pump to the annulus continuously.	Control at low dosage depending on the crude oil and the desired pour point	Data deficit	Data deficit

Chemical	Application	Dosage per event	Toxicological information	Biodegradable?
GreenZyme	GreenZyme is a biological liquid enzyme. It is a protein-based non-living catalyst that is used to enhance production of oil in wells. It will be mixed with other additives (e.g. 2 % KCl, filtered water & mild acetic acid) and then inject into the well at low pressure by the injection pump.	Control at low dosage	Considered non-hazardous and relatively harmless	Yes

During operation, gas venting will be undertaken at approximately 80 wells in the Mann Oil Field. Venting is the controlled release of gases into the atmosphere in the course of oil and gas production operations. These gases may be natural gas or other hydrocarbon vapour, water vapour, and other gases, such as carbon dioxide, separated in the processing of oil or natural gas. In venting, the natural gases associated with the oil production are released directly to the atmosphere and not burned. In addition, under abnormal conditions, the control and safety systems must release gas to the emergency vent to prevent hazards to the employees or public.

Enhanced recovery operations would result in brines and chemically complex produced waters. In current level of environmental controls, the amount of chemical injected in a chemical flood would be designed to be retained by adsorption, channelling and dilution in the petroleum reservoir. Chemicals dissolved in the produced brines will be recycled through the brine treatment system and reinjected into the reservoir. Chemicals dissolved in the oil will be transported to the refinery to be processed as a part of the crude oil. Produced water will be treated in the wastewater treatment system before disposal. Further descriptions of the wastewater treatment system are provided in *Section 3.3* below.

No additional workforce will be required for the operation. As such, no additional labour camps will be required.

3.3 RE-DEVELOPMENT OF MANN OIL FIELD

Under the PCC, MPRL E&P is undertaking a re-development programme of the Mann Oil Field to improve the environmental performance of the operations. This programme involves the following components:

- Improvement of Pumping Unit – pumping units will be / have been repaired to reduce the likelihood of spills to the surrounding areas. Smartjack will be installed to enhance oil production while reduce gaseous emissions.

- Refurbishments of the Gas and Oil Collecting Stations (GOCS), Flow Pipes and Drain Pits – to ensure health and safety to surrounding communities and reduce the risk of spills.

- Rehabilitation of Shut-in Wells – sealing off shut-in wells to avoid contamination of surrounding and restoring surrounding areas to resemble original state.

- Re-perforations will be undertaken for better control of the well. Re-perforation creates a channel between the pay zone and the wellbore, causing oil and gas to flow to the wellbore easily. Before re-perforations are conducted, scrapping, bailing, and if necessary drilling, will be undertaken first to remove debris at the desired depth. During re-perforations, explosive materials will be used at the desired depth to create the perforations

- Development of Produced Water Treatment System – development of a network of drain pits, centrifugal pumps, filtration units, holding tanks and dumping wells to treat and disposed of produced water. Oil recovered from the produced water will be collected and pumped back to process tank. Slug from the treatment process will be buried underground and enclosed in appropriate plastic liner. Treated wastewater, with oil and slug content reduced and has undergone biological treatment as needed, will be dumped in dumping wells. The treatment process is illustrated in *Figure 3.3*.

Representative photos showing the facilities before and after improvement in the Mann Oil Field are shown in *Figure 3.4*.

The re-development activities are expected to be mostly undertaken on formed land where existing facilities are located and will involve the use of PMEs which would be the sources of air emission and noise. Ground breaking, excavation and drilling would be the major activities for the construction of the dumping wells. Construction activities will also involve pipe laying, installation of the produced water treatment facilities (e.g. filtration units, holding tanks) and excavation of drain pits.

Figure 3.3

Waste Management Plan in Mann Oil Field

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Refurbishment of the Gas and Oil Collecting Stations (GOCS)

to ensure maximum health and safety to surrounding communities and reduce the risk of spills.

Refurbishment of Flow Pipes

to ensure flowlines are systematically organized appropriately, positively impacts operation and minimizes the risk of environmental damage. Walkways have also been installed to further emphasise the value of safety.

Refurbishment of Drain Pits

Extensive renovation was required to strengthen waste management efforts, which would reduce impact to the the surrounding communities.

Rehabilitation of Shut-in Wells

sealing off shut-in wells to avoid contamination of surrounding and restoring surrounding areas to resemble original state.

Figure 3.4

Proposed Re-development Activities in Mann Oil Field

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No additional workforce will be required for the construction and operation activities of the re-development programme. As such, no additional labour camps will be required.

3.4 RE-DEVELOPMENT AND EOR PROGRAMME

At present, the EOR programme is yet to be confirmed and approved. It is anticipated that the programme will be commenced in the first quarter of 2017, as present activities are to plan for this Project. This involves simulation modelling of various chemicals, wells and block combinations, depending on the oil composition.

The re-development programme is on-going activities of the Mann Oil Field.

3.5 MATERIALS, EQUIPMENT, SUPPLIES & LOGISTICS

It is assumed that the majority of material, supplies and logistics necessary to undertake the programme of re-development and EOR are already available from the Mann Oil Field with its existing operation. Transportation of labour and materials will mainly use trucks, buses or cars. Additional materials and equipment supplies will be imported from overseas and then delivered to Mann Oil Field via the existing highways (e.g. Yangon-Mandalay Highway and Ayeyarwady Bridge). For river transport, the existing facility at Ywar Thar Foreshore will be used (*Figure 3.5*). New roads may be built and it is expected that these roads will have appropriate drainage. A traffic management plan will be developed to minimise the impact associated with road traffic.

Figure 3.5 Photo of Existing Bridge and Water Transport at Magway nearby Mann Oil Field

3.6 CONSIDERATION OF ALTERNATIVES

Consideration of Project options and alternatives is a fundamental requirement in the planning of any project as a means of avoiding or reducing adverse environmental impacts and maximising or enhancing project benefits. Several options that have been / are considering for the Project include the following:

- No Project alternative has been considered - For the re-development programme, it is expected that the environmental performance of the oil field operations will not be improved without the Project. As such, it is considered necessary to undertake the re-development programme. The EOR programme will enhance the recovery of oil from the wells using chemical injections. Without the EOR programme, more extensive well operations, such as drilling of more wells, may be required to reach the same production level. This may lead to more significant environmental impacts when compared to the EOR programme. It is thus considered that that EOR programme is necessary to enhance oil production while ensuring environmental performance of the Mann Oil Field.

- Construction of new facilities versus improvement / refurbishments of existing facilities – under the re-development programme, it is proposed to improve / refurbish existing facilities as far as possible instead of constructing new facilities. Generally, improvement / refurbishments of existing facilities will involve less PMEs to be used, thus would have

gaseous and noise emission reduced when compared to construction of new facilities. In addition, improvement / refurbishments of existing facilities will mostly be undertaken on formed land which will reduce the extent of direct loss of natural habitats.

- Alternative equipment - for the improvement of the pumping units, it is proposed to use smartjack to enhance oil recovery. This equipment is preferred as it can at the same time reduce gaseous emissions from the operations. Smartjack will also be installed on the pumping unit without causing any increase in Project footprint.

Many of these options are of relevance to potential environmental impacts. Therefore, the relative impact of each option is required to be considered within the EIA Study in order to demonstrate that the impact is as low as reasonably practicable (ALARP).

4 DESCRIPTION OF THE SURROUNDING ENVIRONMENT

This section provides information on the bio-physical baseline characteristics and conditions in the Project Area. The discussion is limited to the factors and environmental components that could have a direct impact on the Project, or which may be impacted by the Project. The baseline is presented as follows:

- Physical Environment; and,
- Biological Environment.

4.1 SETTING THE STUDY LIMITS

For the purposes of defining the Project Area, environmental components within the entire Mann Oil Field, where the enhanced oil recovery and redevelopment activities will be carried out, have been considered as appropriate. Other environmental resources / components located further away from the block have also been described where relevant to this EIA.

4.2 OBJECTIVES AND METHODOLOGY

The objectives of the baseline review and data collection are as follows:

- To characterise the baseline environmental components of the Project Area which may potentially be affected by the Project activities;
- To provide baseline information for the assessment of potential impacts from the Project to the environmental components of the Project Area; and
- To provide baseline data before commencement of the Project which may be used for future monitoring of the Project impacts by comparing the baseline data within the impact monitoring (i.e. obtained during Project implementation) and post-project monitoring data (i.e. obtained after Project completion).

The information presented has been obtained through desktop research on secondary information and primary data collection through baseline field surveys. Baseline field surveys were conducted in May 2015 (wet season) within Mann Oil Field. Detailed methodologies of the baseline field surveys are presented in the relevant sections under which the baseline findings are discussed.

4.3 LITERATURE REVIEW

The information provided in this section is based on a desktop review of published information and through review of available MPRL E&P, ERM and REM in-house literature. It is important to note that literature on the physical and biological environment of Myanmar are both limited spatially and temporally, and are arguably outdated in many areas / disciplines.

4.3.1 Physical Environment

Geography

The main geographic features of Myanmar can be divided into four physiogeographic zones, characterized by elongated north-south trend regions (*Figure 4.1*). The four physiogeographic zones are:

- Rakhine Coastal Area;
- Western Ranges (Rakhine Mountain Ranges);
- Central Lowlands; and
- Eastern Highlands.

A major topographical feature of Myanmar is the Ayeyarwady River watershed. The Ayeyarwady Delta is considered very fertile and covers about 47,000 km^2. Hkakabo Razi, which is the highest peak in Southeast Asia at 5,881 m, is located in Myanmar. The Arakan Yoma range (a barrier between India and Myanmar) has peaks that range between 915 m and 1,525 m. Almost half of Myanmar is covered in forests that are comprised of teak, rubber, cinchona, acacia, bamboo, ironwood, mangrove, coconut and betel palm. The forests in the northern highlands are comprised of oak, pine and many varieties of rhododendron. There are many tropical fruits including citrus, bananas, mangoes and guavas in the coastal region.

The topography of Magway Division is generally undulating with the rolling topography, except for the Taungdwingyi. Mann Oil Field is situated on the northern plunging end of the ~48 km long Mann-Minbu structure trend in the proved oil province of the Central Lowland where is a relatively low-lying terrain drained by the Ayeyarwady River and its major tributaries. The length and width of the producing area of Mann Oil Field is about ~16 km and 1.6 km, respectively.

Climate and Meteorology

Myanmar is characterised by a dominant tropical monsoon climate. Seasons can generally be classified as into a cool dry season from December to April and a hot rainy season from May through November which is driven by the

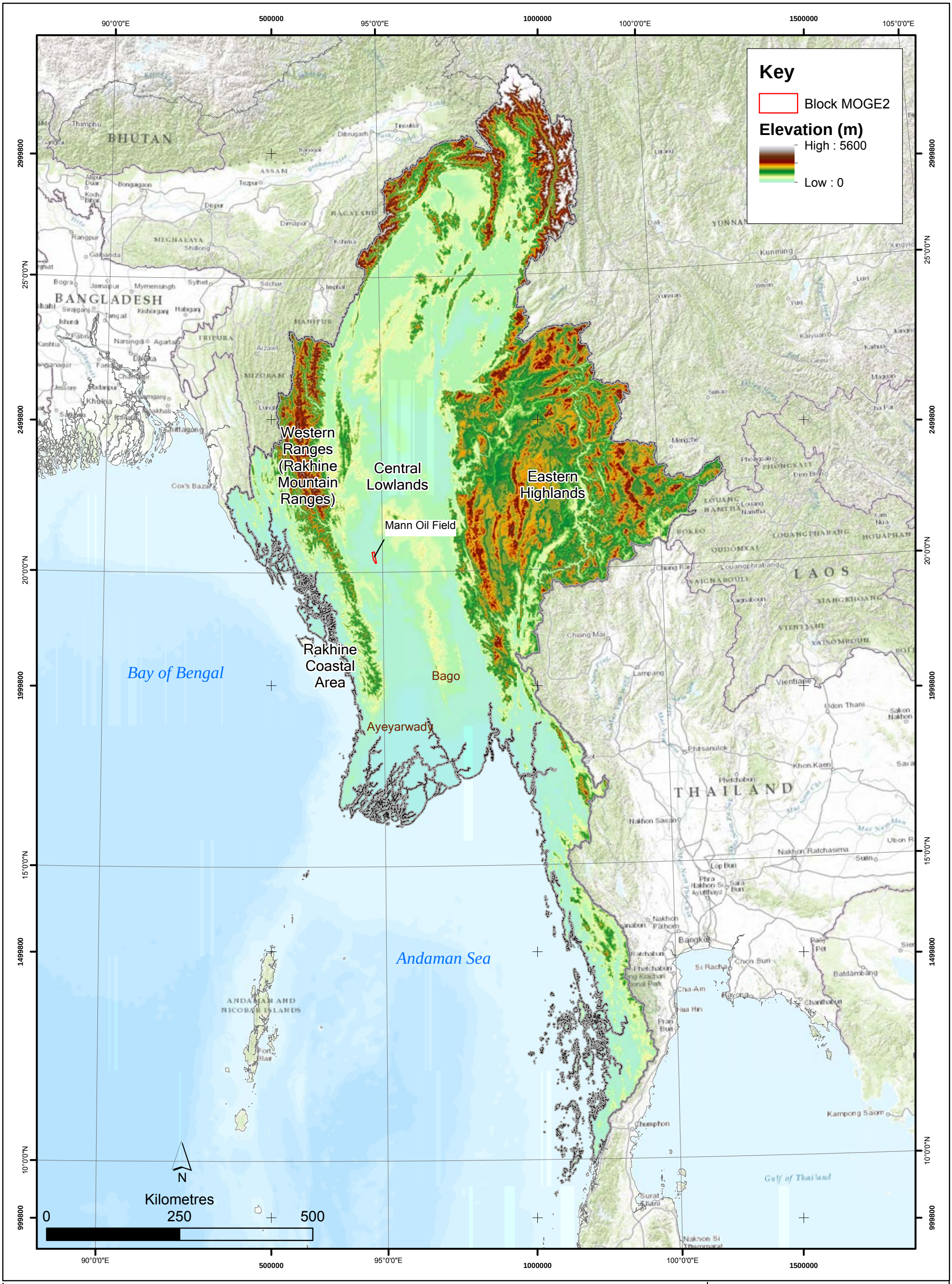

Figure 4.1

Myanmar's Geographic Zones

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rainy southwest monsoon [1]. The southern part of Myanmar is the first part affected by the southwest monsoon starting in May and the entire country is experiencing the rainy season by the beginning of June. Climate variability within the country is largely controlled by topography which affects exposure to the southwest monsoon.

Mann Oil Field is in the Magway Division which borders the Mandalay Region on the east, Sagaing Region on the north, Chin State and Rakhine State on the west and Bago Region on the south. The area of the Magway Division is ~44,820 km^2 and its capital is the Magway City [2]. The Mann Oil Field covers an area of ~82 km^2. The area is generally flat, around 60 m above sea level, with the southern and most of the southwest part straddling low hills (*Figure 4.2*). The area is mostly covered by small (typically one acre) fields of bean, sesame, sunflower, groundnut crops and paddy fields where water is available for more than 3-4 months of the year. Fields and large swaths of ground are often left fallow and invaded by endemic thorny bushes. The soil is mostly sandy and interspersed with gravel. The southern boundary of the Mann Oil Field lies below the city of Minbu where it terminates at mud volcanoes near the Sabwet Chaung.

Figure 4.2 Photo of Geomorphology of Mann Field

The Magway Division falls in the dry zone area of central Myanmar. It is being categorised as *Tropical Savanna Climate (Köppen climate classification Aw).* The average temperature in Magway Division is 27.6 °C with the warmest month in April (average temperature 32.4 °C) and the coolest month in January (average temperature 22.0 °C) [3]. Heavy rain falls in the summer

(1) Kye Baroang (2013) Background Paper No. 1 - Myanmar Bio-Physical Characterization: Summary of Findings and Issues to Explore.

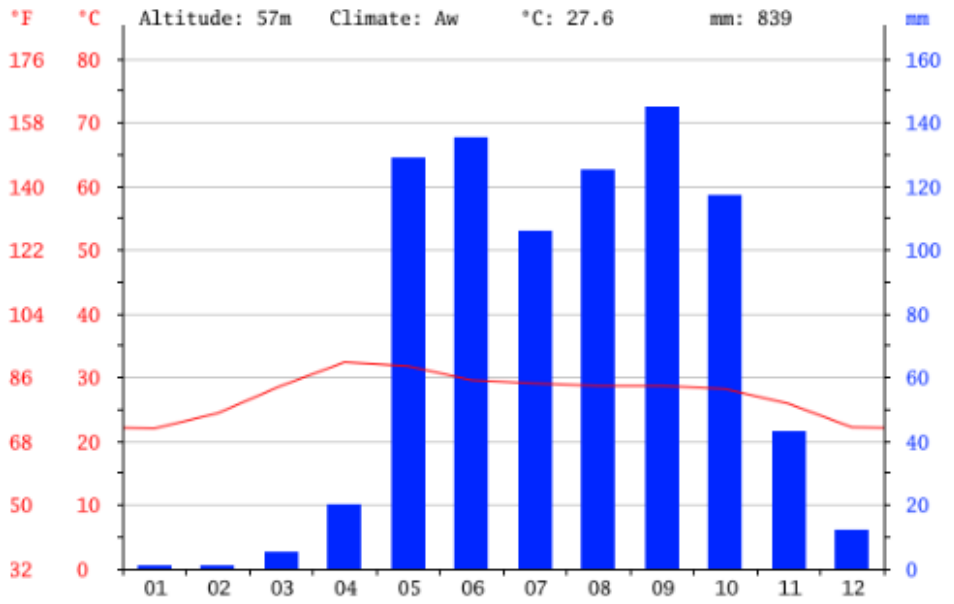
(2) http://www.myanmars.net/myanmar/magway-division.htm, accessed 21 Oct 2014

(3) http://en.climate-data.org/location/308/

particularly in the month of September with average rainfall of 145mm has been recorded in the region [1].

The average temperature and rainfall of the Magway Division are presented in *Figures 4.3.*

Figure 4.3 ***Average Monthly Temperature and Rainfall Chart of Pyay, Myanmar (1982 – 2012) (Sources: http://en.climate-data.org/location/308/)***



Tropical Cyclones and Flooding

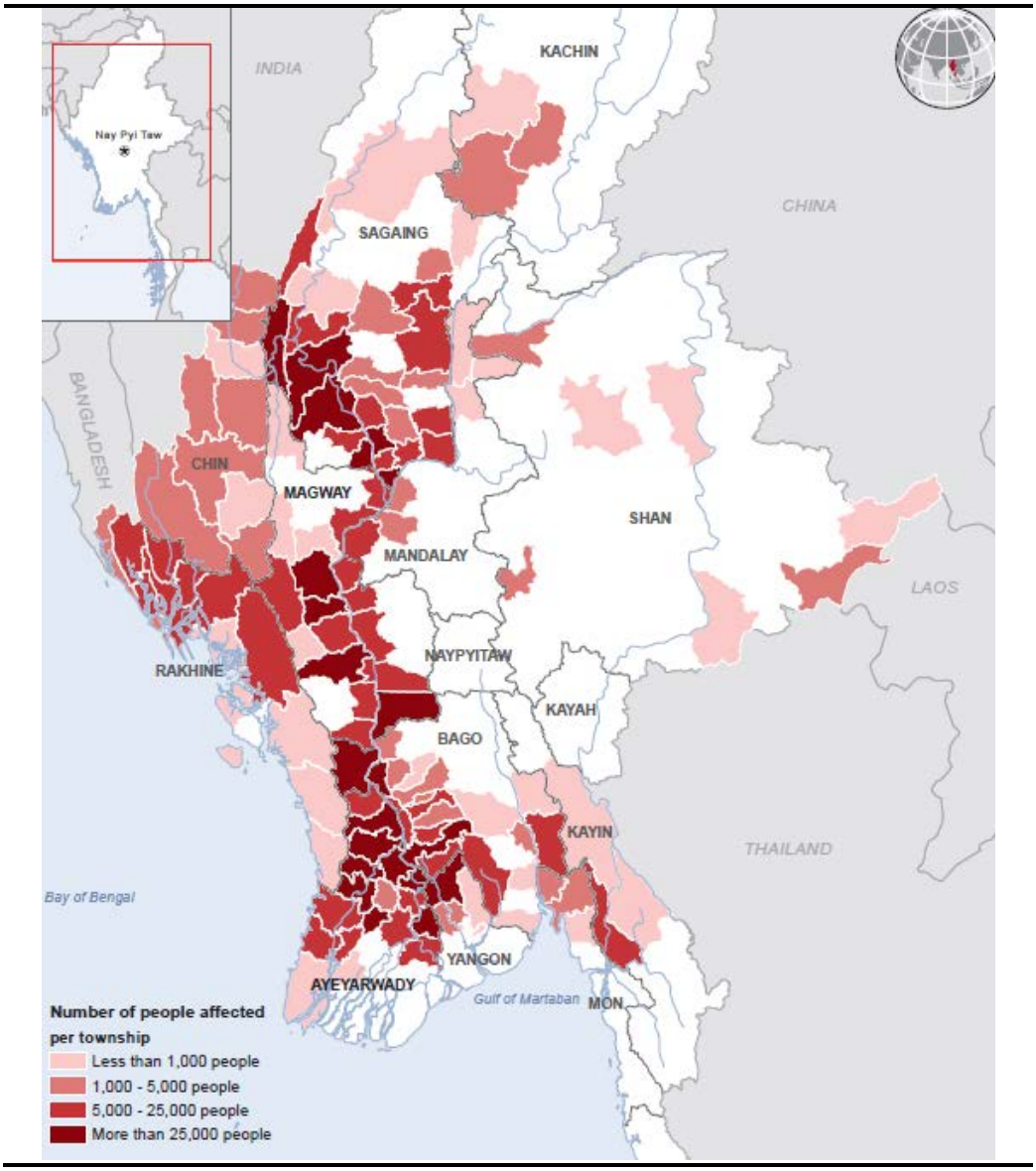
A tropical cyclone is a tropical storm with rotating winds at speeds of greater than 119 km per hour. Myanmar is vulnerable to cyclones, which often originate in the Southern Andaman Sea and enter the Bay of Bengal. These cyclones can result in heavy rains, storms, and floods. There are two prominent cyclone seasons for the country, between April to May and October to December. Historically, cyclone-related disasters tend to occur every 3 to 4 years in this region and on average every ten years a major cyclone makes a landfall in Myanmar [2].

While the available desktop information did not appear to indicate that the area of Mann Oil Field is frequently affected by tropical cyclone, it should be noted that the Cyclone Komen which hit Myanmar in July 2015 has brought high winds and further heavy rain to several states and regions in Western and northern Myanmar, with twelve regions and states affected by flooding, including the northern and southern parts of Magway Division (*Figure 4.4*).

1) http://en.climate-data.org/location/308/

(2) Asian Disaster Reduction Centre, 2003. Theilen-Willige B., (2009) Natural Hazard Assessment of SW Myanmar – A contribution of remote sensing and GIS methods to the detection of areas vulnerable to earthquakes and Tsunami Cyclone Flooding. Science of Tsunami Hazards., Vol. 28 No. 2, page 108

Figure 4.4 *Flood Affected Areas in July and August 2015 under the Impact of Cyclone Komen [1].*



[1] http://reliefweb.int/sites/reliefweb.int/files/resources/Myanmar_Flood_Affected%20areas_20Aug2015.pdf

Climate Change Projections

Projected climate changes over Myanmar have been studied based on both General Circulation Model (GCMs) used in the Intergovernmental Panel on Climate Change (IPCC's) fourth assessment, and using dynamic downscaling with regional climate models forced by the GCMs [1].

Myanmar has been witnessing changing weather events in almost every year during the last two three decades. These include the onset, withdrawal, duration and intensity of monsoon, and the frequency of the monsoon depressions [2]. The frequency of hot days and nights is expected to increase, while the frequency of cold days/nights will decrease.

Earthquakes

A review of available literature has shown that Myanmar is seismologically unstable and vulnerable to earthquakes [3]. Historic records show that at least 15 major earthquakes with magnitudes M≥7.0 have occurred in Myanmar in the last hundred years (*Figure 4.5*).

Historical records of earthquakes are noted for the Magway Division but not nearby area of Mann Oil Field. The most recent earthquake in Magway Division with a magnitude of 5.4 is recorded on 21 July 2015 at Chauk, which is located > 60 km from the Mann Oil Field.

Air Quality

Secondary data are not available on ambient air quality in the Project Area. The principal sources of emissions to the atmosphere in the immediate vicinity of the Project Area are likely to be from household fires for domestic purposes (i.e. heating and cooking) and exhaust emissions from road transportation and existing oil and gas activities.

Noise

Secondary data are not available on noise in the Project Area. However, the sources of noise pollution are likely to include the road traffic from the nearby main road and existing oil and gas operations.

Soil

The Land Use Division (LUD) of Myanmar Agricultural Service is responsible for carrying out soil surveys, producing soil maps and coordinating the research activities with related agencies for the introduction of soil conservation and land improvement practices. According to the soil analysis

(1) Intergovernmental Panel on Climate Change. IPCC Fourth Assessment Report (AR4), (2007), Climate Change: Synthesis Report

(2) Tun Lwin, Khin and Cho Cho Shein., 2006. Hydrology and Meteorology report of Myanmar.

(3) Theilen and Pararas-Carayannis (2009) *Op cite*

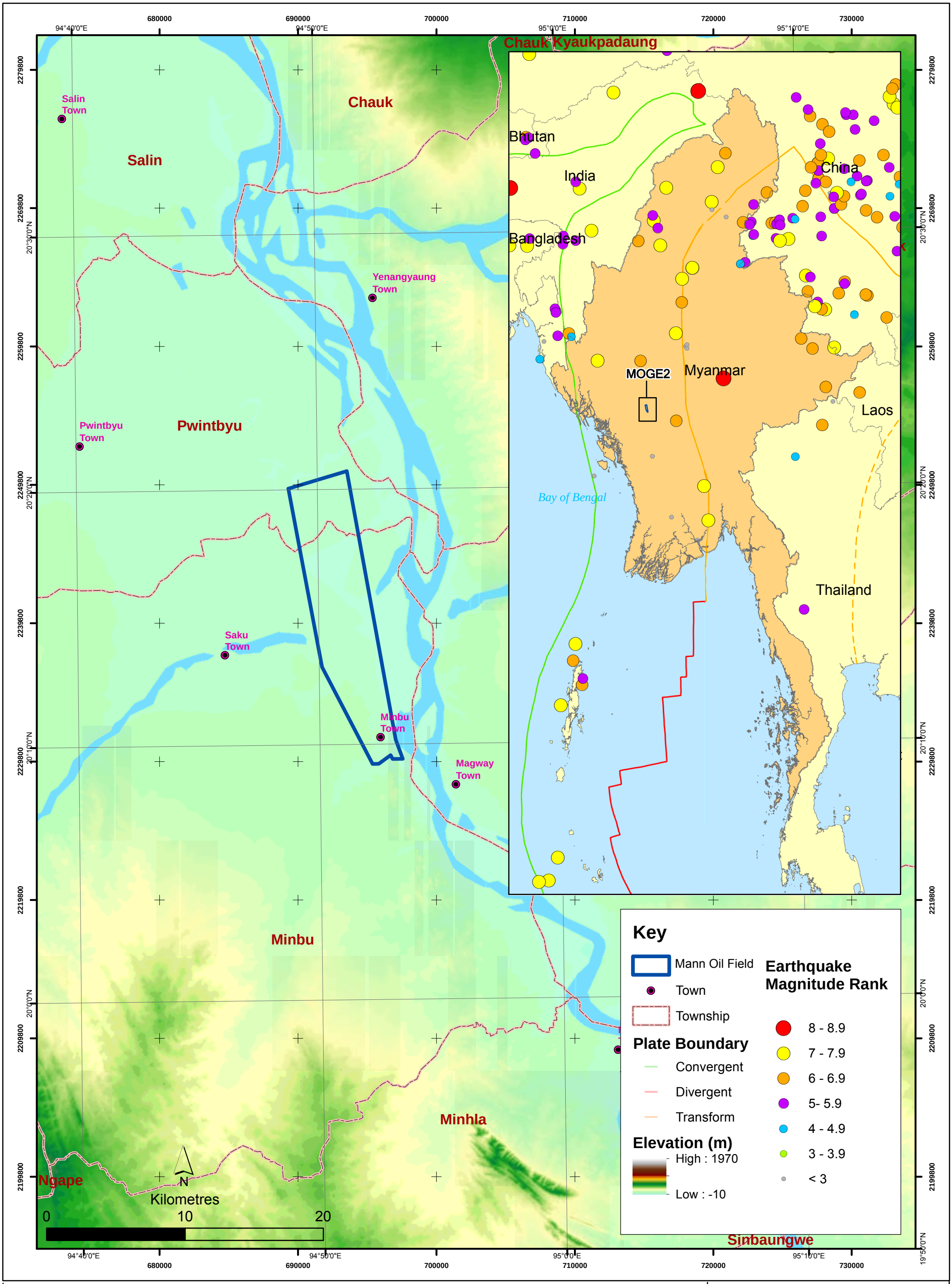


Figure 4.5

Earthquake Magnitude and Tectonic Plate Boundary in Myanmar

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undertaken by LUD, Myanmar has altogether 24 different soil types which are related with adaptable crops.

The Magway Division, where Mann Oil Field is located, is composed of sedimentary rocks of both Ayeyarwaddy and Bago Groups (*Figure 4.6*). High rates of soil erosion and reduced sediment delivery have contributed to a sedimentation problem throughout the Ayeyarwady River Basin. The sediment budget has broad effects upon several processes of soil erosion in the Ayeyarwady River Basin which are of serious concern. In addition, the Magway Division is located in dry zone area where soils have low fertility and declining levels of organic matter, potassium as well as nitrogen [1]. Available soil moisture holding capacity of the soils of Magway Division is low and with high level of evapo-transpiration, constitute a major constraint to crop growth during periods of low rainfall [2].

Surface Water Quality

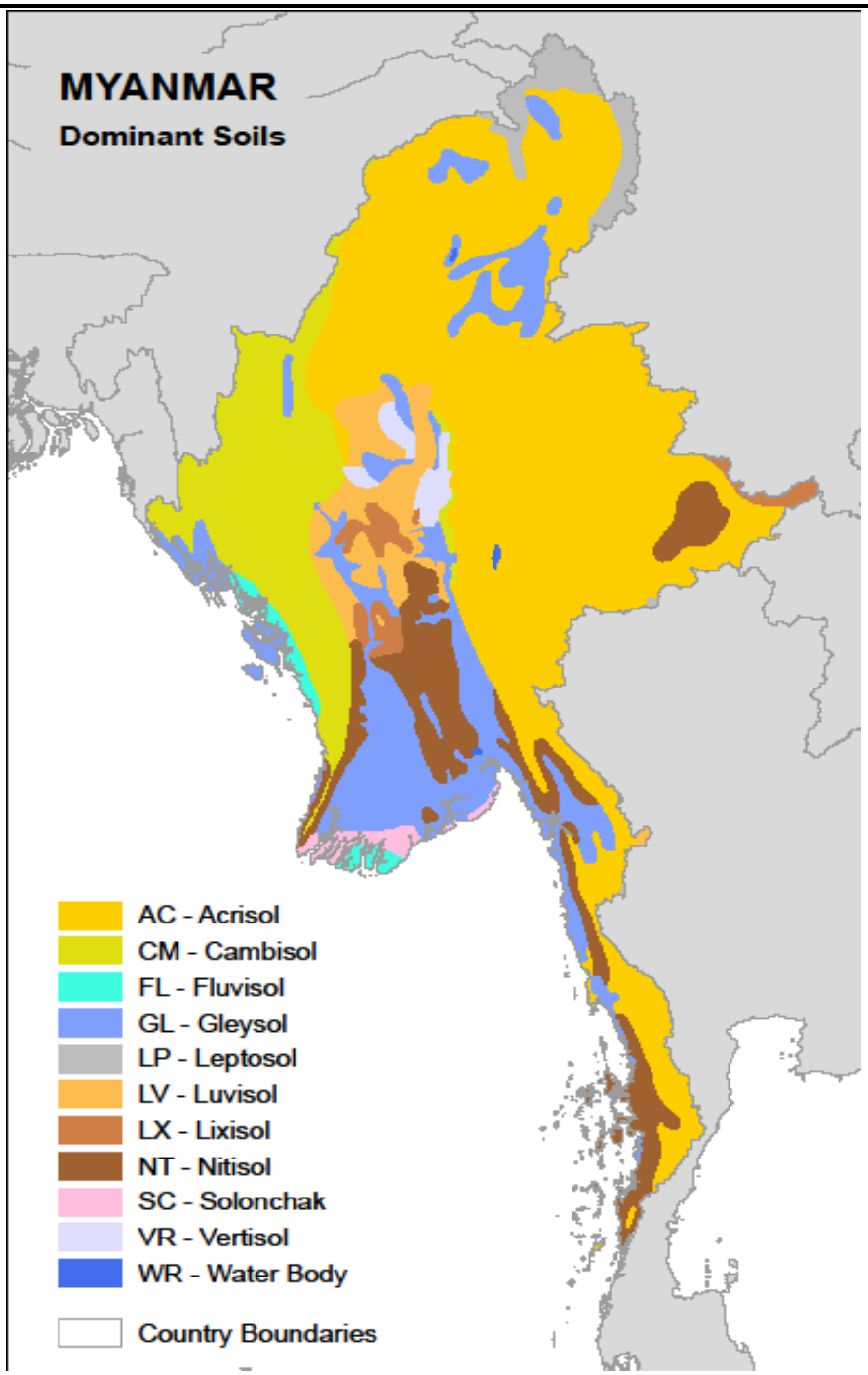
The main source of surface water within Magway Division is noted to be the Ayeyarwady River which drains from northwest to southwest and then flows forwards the south. The Mann Oil Field is located on the eastern boundary of the Ayeyarwady River with the tributaries flowing from west are Yaw, Salin and Mann (*Figure 4.7*). The principal sources of pollution to the Ayeyarwady River are expected to be potential water contamination from agriculture inputs, boat vessel emissions and surface run-off. Agricultural inputs, such as chemical fertilizers and pesticides, are increasingly distributed either partially or wholly by the private sector [3]. The Project will also use the existing facility at Ywar Thar Foreshore of the Ayeyarwady River for river transport.

[1] http://archive.lib.cmu.ac.th/full/T/2008/agsys0508wz_ch3.pdf

[2] http://www.fao.org/docrep/010/ag120e/AG120E15.htm

[3] Kan Zaw, Nu Nu Lwin, KhinThida Nyein, and Mya Thandar, 2011. Agricultural Transformation, Institutional Changes, and Rural Development in Ayeyarwady Delta. Economic Research Institute for Asean and East Asia.

Figure 4.6 Soil Types and Distribution in Myanmar



Source: Reliefweb International (2014) [1]

[1] http://reliefweb.int/sites/reliefweb.int/files/resources/329CF8B14D479D85852574560063A495-2-fao_NTR_mmr080527.pdf accessed, 14 June 2014.

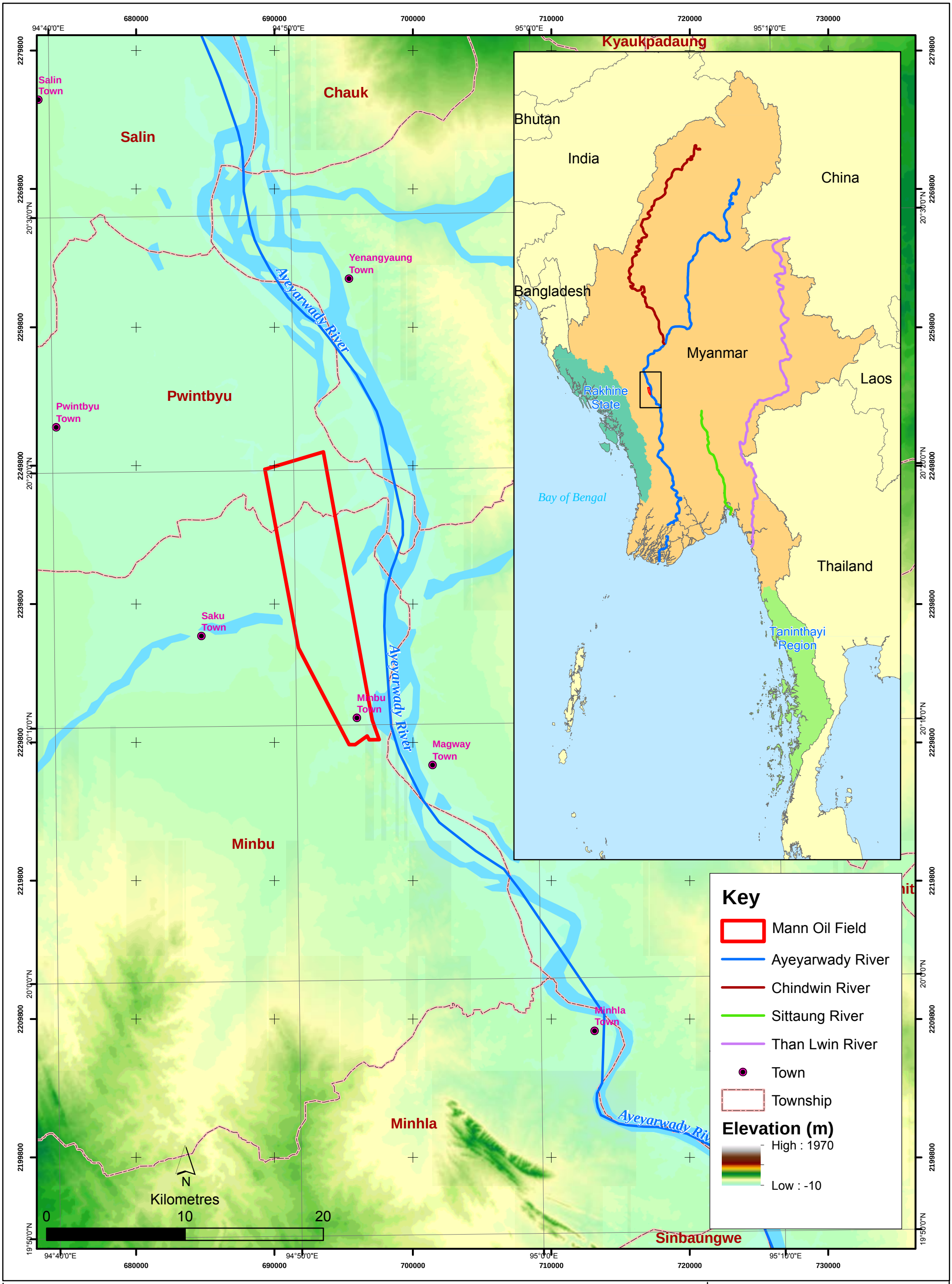


Figure 4.7

River Basin in Myanmar

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Groundwater Quality

In Myanmar groundwater resources have been estimated as 454 km^3/year; but a large part of this water (about 443 km^3/year) comprises the base flow of the rivers and is also accounted for as surface runoff [1]. It was estimated that 91% of the total water withdrawal in Myanmar comes from surface water and 9% from groundwater [2]. Currently there is no single institution that is responsible for the overall management of national water resources in the public and private sectors.

The area of Mann Oil Field is located within the Ayeyarwady River Basin which has the highest groundwater potential in Myanmar (*Figure 4.8*). Groundwater in the region is dependent upon natural recharge from Ayeyarwady River. Villages within Mann Oil Field reported the use of groundwater from deep tube wells and hand dug wells as water supply. Study in the Ayeyarwady Division, which is adjacent to Mann Oil Field and also located within the Lower Ayeyarwady River Basin, has shown that arsenic contamination is a problem occurred in the groundwater of the basin [3]. It was observed that 66.6 % of the groundwater samples from wells have arsenic levels of >50 µg/L, which is much higher than the World Health Organization (WHO) guideline value in drinking water (10µg/L) [4].

4.3.2 Biological Environment

Habitat

Myanmar is well endowed with forests and other natural resources. Forests cover about 40% of the total land area. There are also about 7,000 species of vascular plants, including over 1,600 species of climbers, 65 species of rattans, and around 850 species of orchids. Some 85 species of trees are identified as multiple-use timbers of premium quality [5]. The central dry zone of Myanmar has very harsh climatic condition and only dry forests are naturally found. As trade develops in the region with an increase in population, the demand for forest products has increased steadily. Due to unsystematic extraction of timber and other forest products, forests have been deteriorating [6]. Forest exploitation is controlled by law but the government allows rural communities to use various forest products (except protected plants and animal species) [7].

(1) FAO (2010), FAO's information system on water and agriculture, http://www.fao.org/nr/water/aquastat/countries_regions/myanmar/index.stm, accessed 19-06-2014

(2) FAO (2010), *Op cite*

(3) http://www.bioline.org.br/pdf?hn06020

(4) World Health Organization (2011) Guidelines for Drinking-water Quality. Fourth Edition.

(5) http://documents.wfp.org/stellent/groups/public/documents/ena/wfp234780.pdf, accessed 18 Oct 2014

(6) http://www.moecaf.gov.mm/userpage2.aspx?mid=26, accessed 22 Oct 2014

(7) http://www.fao.org/docrep/005/ac648e/ac648e08.htm, accessed 21 Oct 2014

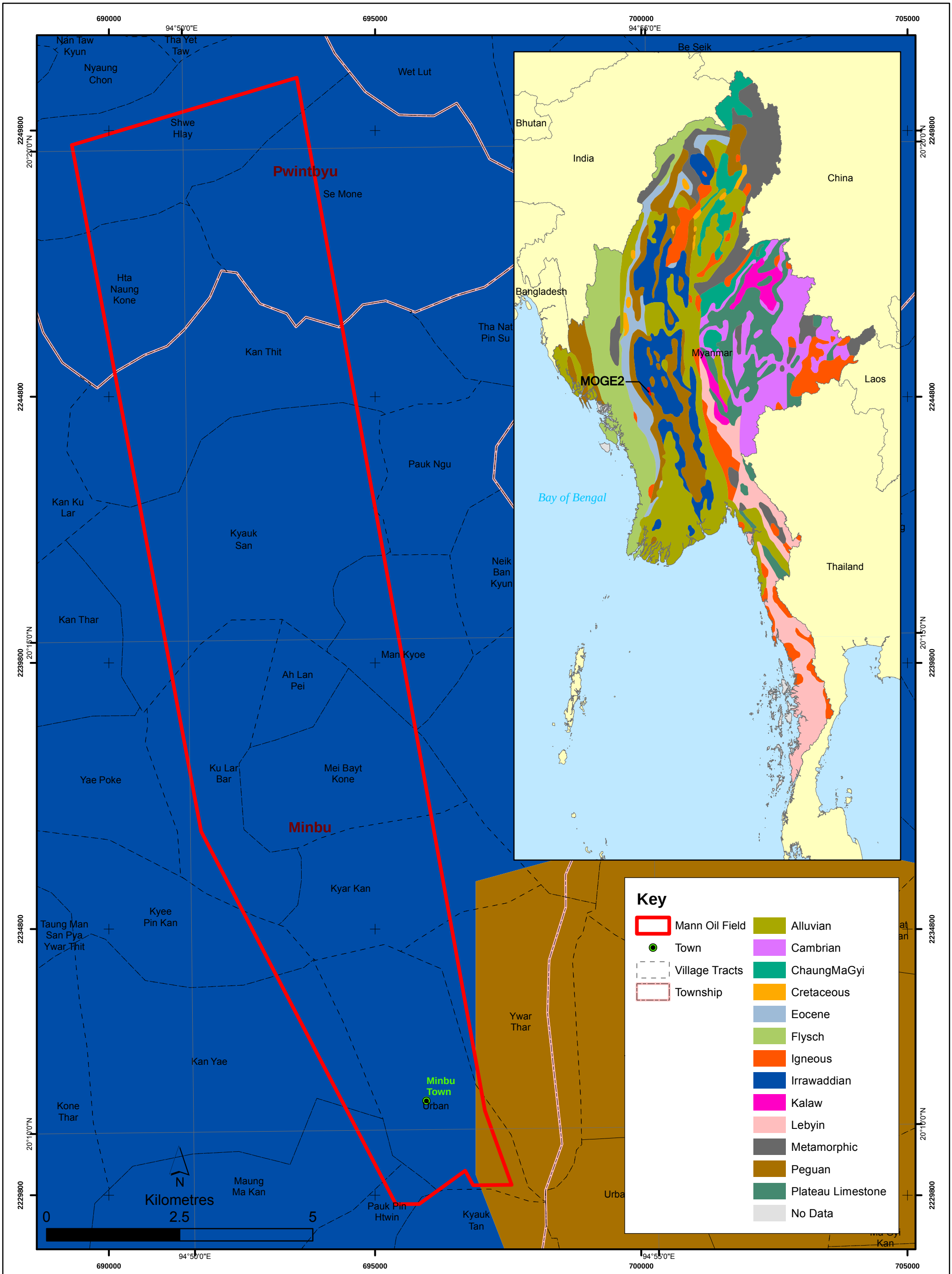

Figure 4.8

Types of Aquifer in Myanmar

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Limited information is available for the habitat type within the Mann Oil Field. However, it is expected that the majority of natural habitat has already been affected by the existing oil and gas operations.

Terrestrial and Aquatic Fauna

Limited baseline ecological information is available for the terrestrial and aquatic fauna groups within Mann Field. The Mann Oil Field is located on the banks of the Ayeyarwady River, where Irrawaddy Dolphin (Ayeyarwady River subpopulation) has been reported to inhabit. The Irrawaddy Dolphin is a euryhaline species of oceanic dolphin found in discontinuous subpopulations near sea coasts and in estuaries and rivers in parts of the Bay of Bengal and Southeast Asia. In Myanmar, it is found in the Mekong, Ganga, Brahmaputra and Ayeyarwady rivers. The Irrawaddy Dolphin (Ayeyarwady River subpopulation) is regarded as Critically Endangered under the IUCN Red List (2015) [1]. The Ayeyarwady River is also home to a large diversity of animals, including about 43 fish species [2].

The Ayeyarwady delta is located to the southeast of the Mann Oil Field and is rich in birds, especially from the end of the rainy season in September and October when a large number of migrant birds fly south from their breeding sites in Central Asia and Siberia to winter in Myanmar. Many of the waders make their way to the paddy plains, coastal mud flats and tidal creeks of the delta [3]. Due to the migratory nature of the species, it is expected that some species normally found in the neighbouring delta may pass by or through the Project Site.

Protected & Environmentally Sensitive Areas

Information from the Istituto Oikos and BANCA (2011) [4] reported a total of 43 designated or proposed protected areas with IUCN categories existing in Myanmar. It should be noted that some of the locations are proposed as protected area without authorised designation (i.e. "soft" designation). None of these protected or environmentally sensitive areas lie within the Mann Oil Field (*Figure 4.9*).

4.3.3 Conclusion of Literature Review

From the literature review of desktop information presented above, it is revealed that significant information gaps existed on the physical and biological environment within Mann Oil Field. These data gaps would require to be filled in for the understanding of potentially significant impacts from the Project and derivation of appropriate mitigation measures to control such impacts to the environmental receptors. Thus, the baseline surveys of

(1) The IUCN Red List of Threatened Species. Version 2015.2. <**www.iucnredlist.org**>..

(2) http://fish.mongabay.com/data/ecosystems/Irrawaddy.htm, accessed 15 Oct 2014

(3) http://www.worldwildlife.org/ecoregions/im0116, accessed 04 Oct 2014

(4) http://www.istituto-oikos.org/files/download/2012/MyanmarProtectedAreas.Context_CurrentStatusandChallenges.pdf

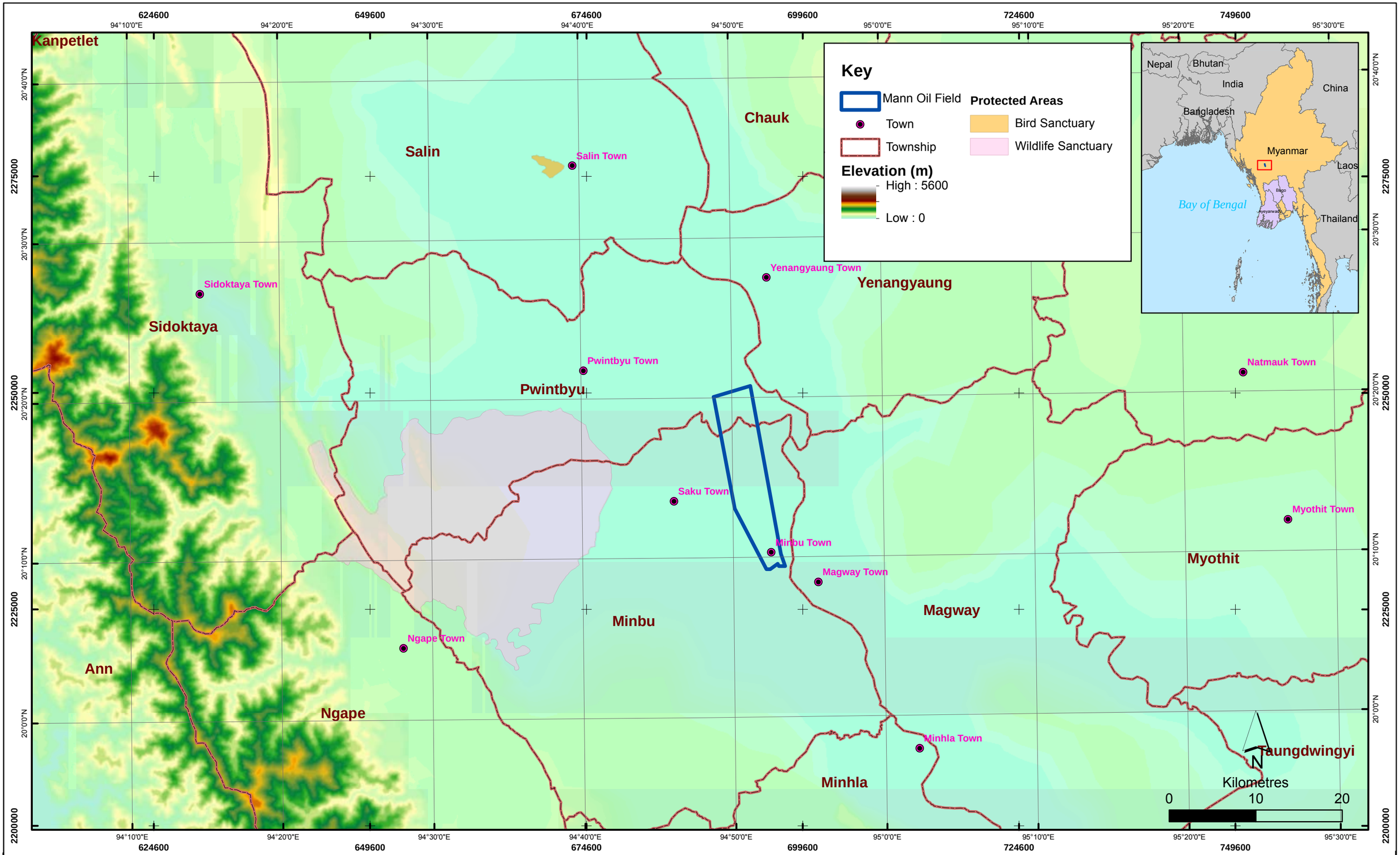

Figure 4.9

Protected Area in the Proximity of Mann Oil Field

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the following aspects were conducted prior to the commencement of the Project to address the key environmental issues:

Biological Environment

- Habitat mapping and vegetation surveys;
- Terrestrial fauna surveys, including avifauna (birds), mammals, herpetofauna (amphibians and reptiles) and butterflies; and
- Aquatic fauna.

Physical Environment

- Ambient air quality;
- Ambient noise;
- Groundwater;
- Surface water; and
- Soil quality.

The methodology and findings of surveys for physical and biological environment are detailed in the following *Sections 4.4-5*.

4.4 BASELINE SURVEYS FOR PHYSICAL ENVIRONMENT

4.4.1 Air Quality

Methodology

Four air quality monitoring stations (Z1AQN, Z2AQN, Z3AQN and Z4AQN) were set up within the Mann Oil Field. The designated monitoring stations are chosen to assess the potential impacts to the Air Sensitive Receivers (ASRs) in the Project Area. Details of the monitoring location are shown in *Table 4.1* and illustrated in *Figure 4.10*. The surrounding environment of the air quality monitoring stations is showed in *Figure 4.11*.

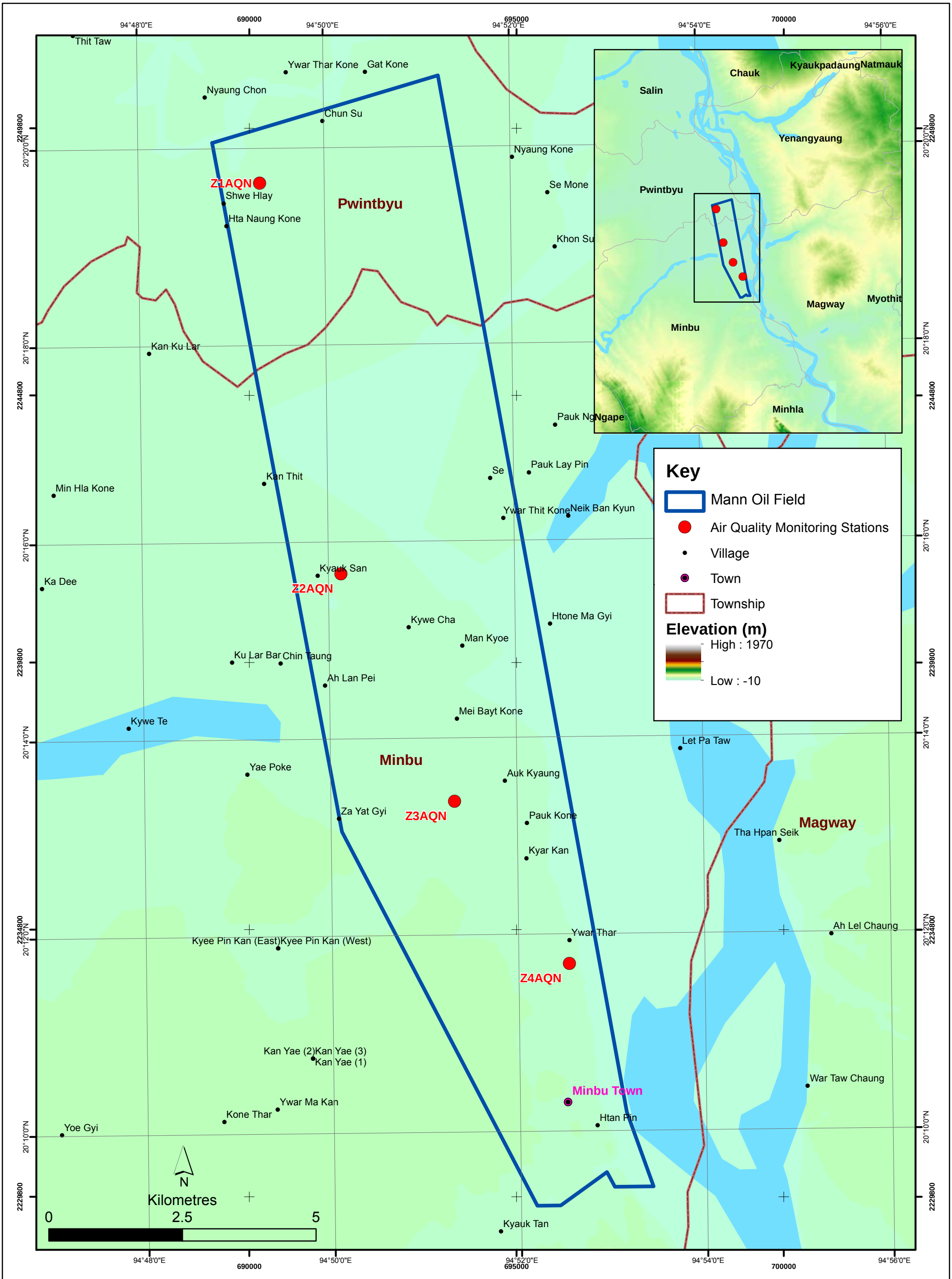

Figure 4.10

Locations of Air and Noise Monitoring Stations

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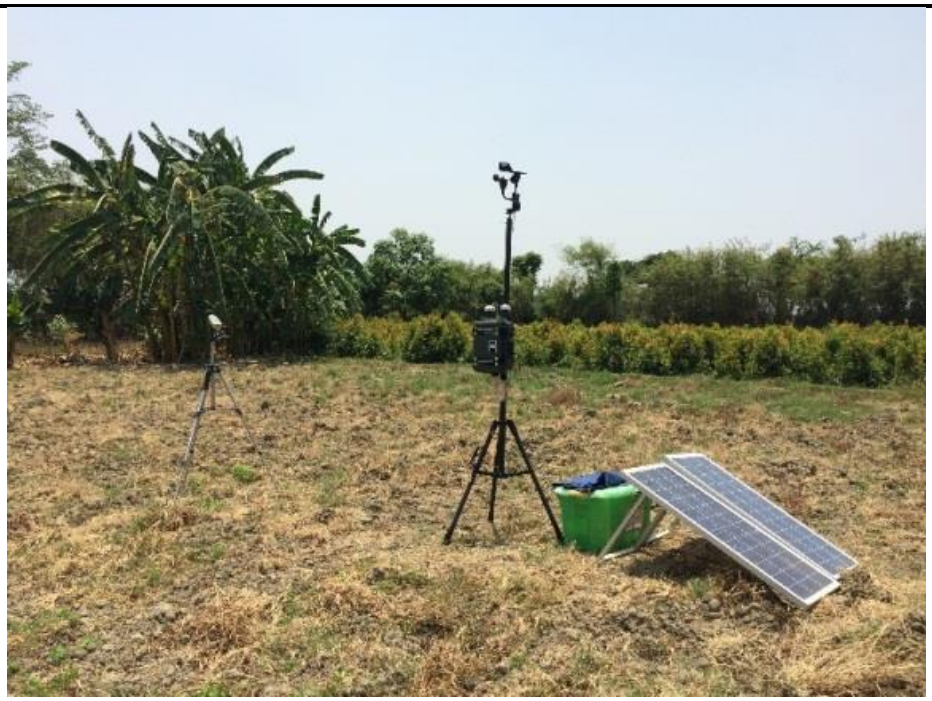
Table 4.1 Ambient Air Quality Monitoring Stations

Sampling Point	GPS Coordinates	Description	Land Use
Z1AQN	20° 19′ 39.0′′ N 94° 49′ 18.4′′ E	Located at southwestern part of Pauk Su village, Pwint Phyu Township.	Residential
Z2AQN	20° 15′ 40.6′′ N 94° 50′ 08.0′′ E	Located at eastern part of Kyauk San village, near monastery compund.	Residential
Z3AQN	20° 13′ 21.5′′ N 94° 51′ 19.6′′ E	In the MPRL office compound, south of staff housing, well No.521 also located nearby.	Commercial
Z4AQN	20° 11′ 41.9′′ N 94° 52′ 32.4′′ E	Located at eastern part of Minbu Town, close to the western bank of Ayeyarwady River	Bare ground

Monitoring Parameters and Equipment

Sampling and analysis of ambient air pollutants was conducted accordingly to the guidelines of United States Environmental Protection Agency (U.S. EPA). The Haz-Scanner EPAS Wireless Environmental Perimeter Air Station was used to collect Ambient Air Monitoring data, which is a portable monitor recorded real time data that directly logged the ambient air quality measurements as well as climatological data. The air quality parameters and meteorological data collected in the current survey are listed in *Table 4.2*.

Figure 4.11a Surrounding Environment of Ambient Air Quality and Noise Monitoring Stations



↑ Station: Z1AQN

↑ Station: Z2AQN

Figure 4.11b Surrounding Environment of Ambient Air Quality and Noise Monitoring Stations

↑ Station: Z3AQN

↑ Station: Z4AQN

Table 4.2 Parameters measured by the Haz-Scanner EPAS Wireless Environmental Perimeter Air Station

Parameters	Unit	Method and Duration
Air Quality		*In situ* reading for 24-hour
Sulfur dioxide (SO_2)	ppm	
Carbon monoxide (CO)	ppm	
Nitric oxide (NO)	ppm	
Nitrogen dioxides (NO_2)	ppm	
Particulate matter < 2.5 µm (PM2.5)	mg/m^3	
Particulate matter < 10 µm (PM10)	mg/m^3	
Meteorological Data		
Relative Humidity (R.H.)	%	
Temperature	°C	
Wind speed	kph	
Wind direction	-	

Monitoring Period and Frequency

The ambient air quality and the meteorological data were collected at the four designated air quality monitoring station for 24-hour in May 2015. The sampling dates and hours are summarised in *Table 4.3*.

Table 4.3 Sampling Dates for Ambient Air Quality and Meteorology

Monitoring Station	Sampling Date
Z1AQN	8 – 9 May, 2015
Z2AQN	7 – 8 May, 2015
Z3AQN	6 - 7 May, 2015
Z4AQN	6 - 7 May, 2015

Baseline Air Quality Results

The monitoring results for air quality and meteorological information are summarized in *Table 4.4*.

The major dust sources in the monitoring period included activities at the existing oil production activities, nearby human activities and traffic emission. Most of the air quality parameters are well below the assessment criteria, except for the mean PM2.5 at Z1AQN, Z2AQN, Z4AQN and SO_2 at Z2AQN which are slightly higher than the IFC's 24-hour average and 1-hour average guideline values respectively in some occasions. It is useful to note that human activities (e.g. traffics, cooking by burning wood) nearby Z1AQN, Z2AQN and Z4AQN may lead to the higher PM2.5 level and SO_2 recorded there.

Table 4.4 Summary of Baseline Air Quality Monitoring Results in May 2015

Station	CO (ppm) (min – max)	NO2 (ppm) (min – max)	NO (ppm). (min – max)	PM2.5 (mg/m³) (min – max)	PM10 (mg/m³) (min – max)	SO2 (ppm) (min – max)	Temperature (°C) (min – max)	Relative Humidity (%) (min – max)	Wind Speed (m/s)	Wind Direction
Z1AQN	0.14	0.10	0.31	0.04	0.05	0.02	30.7	61	0	-
	(0.01- 0.25)	(0.04 – 0.19)	(<0.01 – 2.11)	(0.02 – 0.07)	(0.02 – 0.08)	(<0.01 – 0.1)	(23.3 – 32.3)	(28 – 90)		
Z2AQN	0.11	0.10	0.07	0.03	0.04	0.03	29.0	61	0.015	Southwest
	(<0.01 – 0.22)	(0.01- 0.35)	(<0.01 – 0.29)	(0.02 – 0.09)	(0.02 – 0.10)	(0.01 – 0.19)	(23.8 – 44.0)	(27 – 78)		
Z3AQN	0.05	0.03	< 0.01	0.02	0.04	< 0.01	31.5	56	0.081	Southeast
	(<0.01 – 0.26)	(<0.01 – 0.35)	(<0.01 - <0.01)	(<0.01 – 0.07)	(<0.01 – 0.08)	(<0.01 - <0.01)	(25 – 42.5)	(30 – 78)		
Z4AQN	0.13	0.09	0.14	0.03	0.04	0.01	27.1	55	0.85	Southeast
	(0.01-0.27)	(0.02 – 0.28)	(0.01 < 0.66)	(0.02 – 0.09)	(0.02 – 0.13)	(<0.01 – 0.11)	(24 – 40.5)	(29 – 81)		
Assessment criteria: IFC Guideline Value										
24-hr	-	-	-	0.025	0.05	-	-	-	-	-
1-hr	-	0.2 mg/m³	-	-	-	0.02 mg/m³	-	-	-	-

4.4.2 Noise

The aim of baseline noise monitoring is to establish the background level at nearby Noise Sensitive Receivers (NSRs).

Methodology

Four noise monitors were set up to measure background noise levels for 24 hours at the identified NSRs, which was the same location and monitoring period as per the ASRs. Details are shown in *Table 4.5* and illustrated in *Figure 4.10.* The surrounding environment of the noise quality monitoring stations is showed in *Figure 4.12.*

Table 4.5 Noise Monitoring Stations

Sampling Point	GPS Coordinates	Description	Land use
Z1AQN	20° 19′ 39.0′′ N 94° 49′ 18.4′′ E	Located at southwestern part of Pauk Su village, Pwint Phyu Township.	Residential
Z2AQN	20° 15′ 40.6′′ N 94° 50′ 08.0′′ E	Located at eastern part of Kyauk San village, near monastery compund.	Residential
Z3AQN	20° 13′ 21.5′′ N 94° 51′ 19.6′′ E	In the MPRL office compound, south of staff housing, well No.521 also located nearby.	Commercial
Z4AQN	20° 11′ 41.9′′ N 94° 52′ 32.4′′ E	Located at eastern part of Minbu Town, close to the western bank of Ayeyarwady River	Bare ground

The 24-hour baseline noise monitoring was conducted by using the portable sound meter (Lutron, SL-0423SD, unit: dB). Noise level (L_{Aeq}) were measured and recorded at a ten-minute interval and averaged at an hourly and daily (i.e. 24-hour) interval using the following formula:

$L_{Aeq} = 10*LOG_{10}(AVERGAE(10^((RANGE)/10)))$

Baseline Noise Measurements

The results of baseline noise monitoring are summarized in *Table 4.6*.

Since there is no noise standard of operation activities to receptors in Myanmar, the IFC standards for operational activities were adopted to evaluate the measured noise levels in the area which was in the vicinity of existing oil and gas operations (*Table 4.7*). The results of noise monitoring showed that the hourly and daily noise levels at all monitoring stations were well below the standard as stipulated in the IFC guidelines, and it thus appeared that the existing oil producing facilities were operated in environmentally acceptable manner in relation to noise emissions.

Table 4.6 Hourly L_{Aeq} Values at the Designated Noise Monitoring Stations

Monitoring Time	Stations			
	4N1	4N2	4N3	4N4
6:00-7:00	72	83	58	50
7:00-8:00	48	76	50	46
8:00:9:00	44	74	54	52
9:00-10:00	43	72	53	45
10:00-11:00	68	56	49	45
11:00-12:00	45	68	49	52
12:00-13:00	45	74	55	41
13:00-14:00	45	47	47	39
14:00-15:00	56	47	48	39
15:00-16:00	43	46	63	52
16:00-17:00	47	52	63	45
17:00-18:00	49	50	65	52
18:00-19:00	48	66	66	51
19:00-20:00	50	63	50	54
20:00-21:00	59	52	56	51
21:00-22:00	54	49	47	64
Day L_{Aeq}	51	61	55	49
22:00-23:00	49	50	41	52
23:00-24:00	44	50	75	55
24:00-1:00	42	63	42	53
1:00-2:00	42	59	44	51
2:00-3:00	42	49	41	60
3:00-4:00	43	50	41	60
4:00-5:00	43	60	57	60
5:00-6:00	47	62	58	57
Night L_{Aeq}	44	55	50	56

Table 4.7 IFC Noise standards at Operation Stage

Description	Daytime (Leq, dB) (0700 to 2200, 15 hours)	Nighttime (Leq, dB) (2200 to 0700, 9 hours)
Residential; Institutional; Education	55	45
Industrial; Commercial	70	70

4.4.3 Surface Water Quality

Methodology

Sampling Locations

To characterize the surface water quality within the Project Area, surface water sampling was carried out at four locations in May 2015. Details of sampling locations were presented in *Table 4.8* below and indicated in *Figure 4.13*. The surrounding environment of surface water sampling location is shown in *Figure 4.14*.

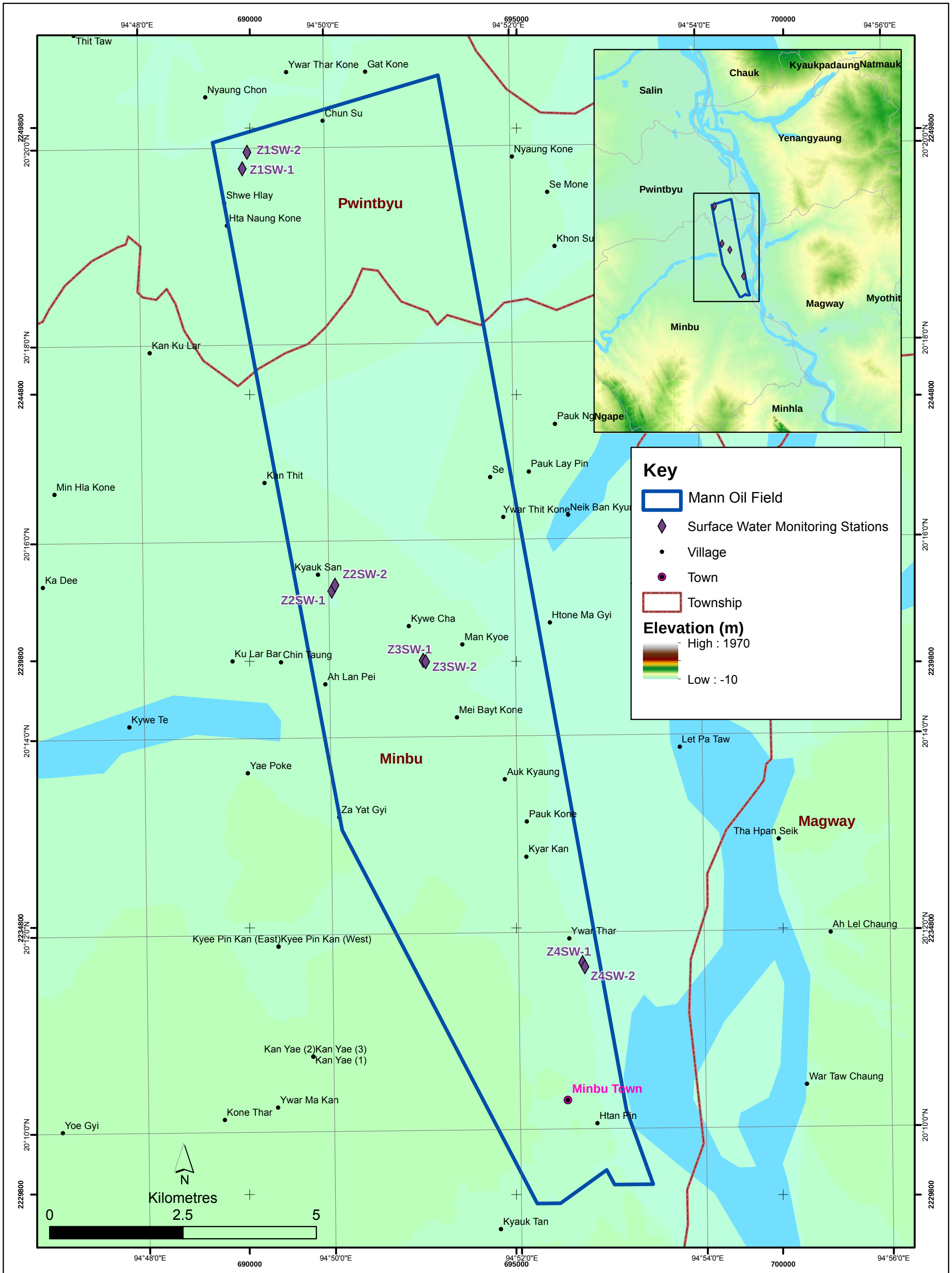


Figure 4.13

Locations of Surface Water Monitoring Stations

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Figure 4.14a Surrounding Environment of Surface Water Sampling Locations

↑ Station: ZAW1-1

↑ Station: ZSW1-2

Figure 4.14b Surrounding Environment of Surface Water Sampling Locations

↑ Station: Z2SW-1

↑ Station: Z2SW-2

Figure 4.14c Surrounding Environment of Surface Water Sampling Locations

↑ Station: Z3SW-1

↑ Station: Z3SW-2

Figure 4.14d Surrounding Environment of Surface Water Sampling Locations

↑ Station: Z4SW-1

↑ Station: Z4SW-2

Table 4.8 Sampling Locations for Surface Water Quality

Sampling Location	Coordinates	Description	Sampling Date
Z1SW-1	20°19'47.67"N 94°49'6.88"E	Mone Chaung, near Pauk Su village .	9 May 2015
Z1SW-2	20°19'57.80"N 94°49'10.19"E	Mone Chaung, about 320 m downstream of Z1SW-1	9 May 2015
Z2SW-1	20°15'29.55"N 94°50'1.86"E	Mann Chaung, near Kyauksan village	7 May 2015
Z2SW-2	20°15'33.13"N 94°50'3.93"E	Mann Chaung, about 120 m downstream of Z2SW-1	7 May 2015
Z3SW-1	20°14'46.51"N 94°51'0.27" E	Mann Chaung, near Kywegya village	6 May 2015
Z3SW-2	20°14'45.74"N 94°51'1.87"E	Mann Chaung, about 50 m downstream of Z3SW-1	6 May 2015
Z4SW-1	20°11'41.31"N 94°52'41.11"E	Near west bank of Ayeyarwady river, Minbu Township.	6 May 2015
Z4SW-2	20°11'38.80"N 94°52'42.50"E	Ayeyarwady river, about 90 m downstream of Z4SW-1	6 May 2015

Sampling Procedures

Water samples were taken by Alpha horizontal water sampler and collected in sterilized sample containers. All sampling was in strict accordance with recognized standard procedures. The parameters for *in situ* measures included pH, temperature, dissolved oxygen (DO), electrical conductivity (EC), and turbidity and surface water samples were concurrently collected. Two samples were taken at each sampling location. Samples were then stored at 4 ^{o}C for transportation to laboratory analyses under chain-of-custody procedures. The parameters for laboratory analyses were listed in *Table 4.9*. Equipment for surface water sampling is showed in *Table 4.10.*

Table 4.9 Parameters for Laboratory Analyses of Baseline Surface Water Monitoring

Parameters	Unit
BOD_5	mg/L
COD	mg/L
Total Suspended Solids	mg/L
Total Nitrogen	mg/L
Total Phosphorous	mg/L
Total Coliform Bacteria	
Oil and Grease	mg/L
Heavy Metals	

Table 4.10 Equipment for Surface Water Sampling

Equipment	Brand	Model
Multiparameter (water quality)	HANNA	-
pH meter	HANNA	HI 98129
Alpha Bottle (Water Sampler)	Wildlife Supply Company®	-

Baseline Surface Water Results

With reference to *Figure 1.1*, Mann Oil Field is located at the northwest of Minbu District, Magway Region. Mann Oil Field Area is elongated which running as north-south, at the west of Ayeyarwady River. The total length of lower Ayeyarwady River Basin is 690 km with a total catchment area of 95,600 km^2 and annual surface water of 85.80 km^3. Results of surface water quality monitoring are summarized in *Table 4.11*.

Apart from the total suspended solids (TSS), all the other parameters are complied with the IFC standard. The high TSS is recorded at Z4SW which is located near the village Ywat Thar.

Table 4.11 Result Summary of Surface Water Quality Monitoring

Item/Sample Name	**Z1SW-1**	**Z1SW-2**	**Z2SW-1**	**Z2SW-2**	**Z3SW-1**	**Z3SW-2**	**Z4SW-1**	**Z4SW-2**	***IFC Standard**
Date /Time	9/5/15 09:22	9/5/15 09:45	7/5/15 11:09	7/5/15 11:22	6/5/15 12:08	6/5/15 12:35	6/5/15 15:22	6/5/15 15:51	-
Weather	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	-
Transparency	High	High	High	High	High	High	Medium	Medium	-
Temperature _Water (C)	30.89	30.82	34.72	35.43	37.66	37.62	31.55	31.18	-
pH	7.82	7.82	8.21	8.27	8.1	8.11	7.73	7.65	6 - 9
DO (mg/l)	6.56	6.61	14.6	15.25	11.33	11.52	7.12	7.15	-
EC (µs)	352	350.1	611.2	588.7	711.8	705.7	153	152.5	-
Turbidity (FNU)	16	13.4	18.5	20.9	7.1	7	25	43.7	-
Colour	20	20	Nil	Nil	5	10	45	55	-
Alkalinity	137	136	209	209	238	237	58	58	-
Hardness	127	128	144	133	144	150	58	50	-
BOD5 (mg/l)	14	14	12	12	10	10	14	16	-
COD (mg/l)	32	32	32	32	32	32	32	32	250
Total Nitrogen (mg/l)	<2	<2	11	4	3	9	19	18	-
Total Phosphorus (mg/l)	0.061	0.026	0.039	0.030	0.047	0.051	0.071	0.031	2.0
Oil and grease (mg/l)	<1	<1	<1	2	5	7	<1	<1	10
TSS (mg/l)	40	34	23	18	7	13	124	138	50
*Note:									
http://www.ifc.org/wps/wcm/connect/7dd5798048865849b52ef76a6515bb18/genenv_PPAH.pdf?MOD=AJPERES									

4.4.4 Groundwater

Methodology

To access groundwater quality in the Project Area, a total of four existing residential wells (dug wells and drilled/ tube wells) were sampled. The sampling locations were selected to represent the spatial extent and sensitive receivers in the residential areas of Minbu and Pwint Phyu.

A total of two replicate groundwater samples were collected by Alpha horizontal water sampler at each location. Immediately after collection, the samples were transferred to labelled sample containers containing the necessary preservatives prepared by the laboratory. Samples were then stored at 4 ºC for transportation to laboratory analyses under chain-of-custody procedures. The parameters for assessing the groundwater quality are the same as those for the surface water quality monitoring in *Table 4.9*. Details of groundwater sampling location are presented in *Table 4.12* and indicated on *Figure 4.15*. The surrounding environment of groundwater sampling is presented in *Figure 4.16*.

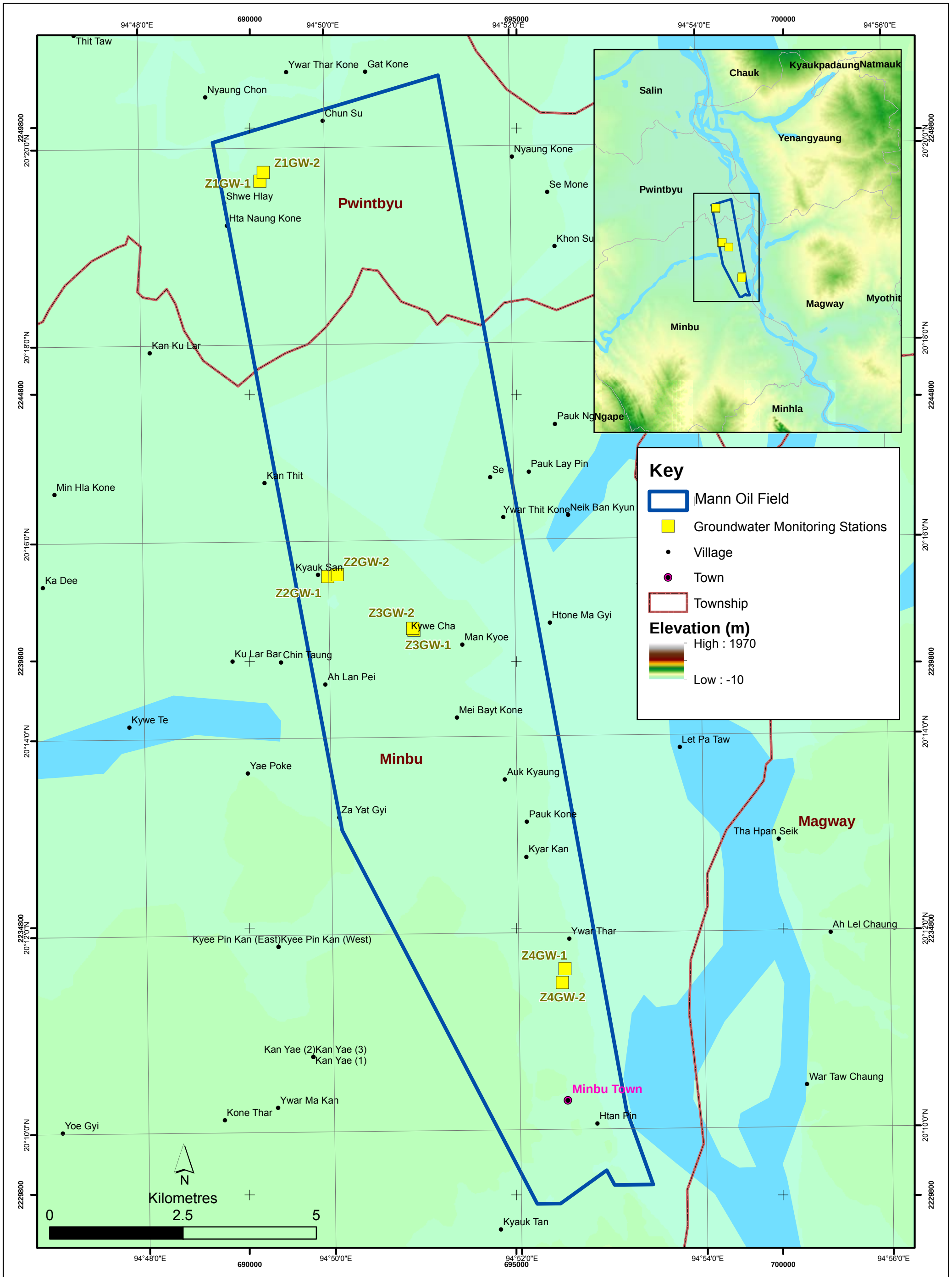

Figure 4.15

Locations of Groundwater Monitoring Stations

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Table 4.12 Groundwater Sampling Locations at Block Mann Oil Field

Sampling Location	Coordinates	Description	Sampling Date
Z1GW-1	20°19'40.01"N 94°49'18.27"E	Tube well in Pauk su village, Pwint Phyu Township	9 May 2015
Z1GW-2	20°19'45.22"N 94°49'20.51"E	Tube well in Pauk su village, Pwint Phyu Township	9 May 2015
Z2GW-1	20°15'38.43"N 94°49'59.29"E	Tube well in Kyauk san village, Minbu Township	7 May 2015
Z2GW-2	20°15'39.50"N 94°50'5.51"E	Tube well in Kyauk san village, Minbu Township	7 May 2015
Z3GW-1	20°15'5.35"N 94°50'54.52"E	Tube well in Kywe gya village, Minbu Township	6 May 2015
Z3GW-2	20°15'6.44"N 94°50'53.77"E	Tube well in Kywe gya village, Minbu Township	6 May 2015
Z4GW-1	20°11'37.92"N 94°52'29.67"E	Well in Shwe war gone ward, Minbu Township.	6 May 2015
Z4GW-2	20°11'29.50"N 94°52'27.85"E	Well in Shwe war gone ward, Minbu Township.	6 May 2015

Baseline Groundwater Quality Monitoring Results

The aquifer within Mann Oil Field is mainly Alluvian aquifer and Irrawaddian Aquifer and Peguan Aquifer (*Figure 4.8*). It is estimated that the groundwater potential in the lower Ayeyarwady region, where Mann Oil Field is situate at, is approximately 153.25 km^3 [(1)] with about 1,298 tube wells within the Magway Division. Results of groundwater quality monitoring are summarized in *Table 4.13*.

(1) http://danishwater.dk/wp-content/uploads/2013/09/Ministry-of-Agriculture-and-Irrigation-Department-of-Water-Resources-Utilization-Sustainable-Development-and-Management-of-Groundwater-in-Myanmar.pdf

Table 4.13 Results Summary of Groundwater Quality Monitoring

Item/Sample Name	Z1GW -1	Z1GW -2	Z2GW -1	Z2GW -2	Z3GW -1	Z3GW -2	Z4GW-1	Z4GW -2
Date /Time	9/5/15 10:49	9/5/15 11:22	7/5/15 10:22	7/5/15 10:40	6/5/15 11:04	6/5/15 11:30	6/5/15 14:32	6/5/15 14:58
Weather	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny
Transparency	High	High	High	High	High	High	Medium	High
Temperature_Water (˚C)	28.78	30.11	33.11	35.03	36.12	37.57	31.77	31.67
pH	6.92	6.93	6.85	7.09	6.68	6.63	6.95	7.22
DO (mg/l)	2.51	2.75	1.1	2.25	2.9	2.29	1.44	3.41
EC (µs)	669	778.1	1097.7	805.3	1498.3	1198.7	5060.4	7740.8
Turbidity (FNU)	0.5	0.3	0.2	0.1	4.9	4.6	0.5	1
Colour	Nil	10	Nil	Nil	5	10	Nil	Nil
Alkalinity	256	296	359	294	354	279	462	624
Hardness	281	316	130	64	246	222	539	639
BOD5 (mg/l)	10	12	8	10	10	14	8	10
COD (mg/l)	32	32	32	32	32	32	32	32
Total Nitrogen (mg/l)	<2	4	4	<2	4	73	4	63
Total Phosphorus (mg/l)	0.038	0.194	0.104	0.245	0.239	0.168	0.251	0.042
Oil and grease (mg/l)	<1	<1	<1	<1	<1	<1	<1	<1
TSS (mg/l)	<5	<5	<5	<5	<5	<5	5	<5

Figure 4.16a Surrounding Environment of Groundwater Sampling Locations

↑ Station: Z1GW-1

↑ Station: Z1GW-2

Figure 4.16b Surrounding Environment of Groundwater Sampling Locations

↑ Station: Z2GW-1

↑ Station: Z2GW-2

Figure 4.16c Surrounding Environment of Groundwater Sampling Locations

↑ Station: Z3GW-1

↑ Station: Z3GW-2

Figure 4.16d Surrounding Environment of Groundwater Sampling Locations

↑ Station: Z4GW-1

↑ Station: Z4GW-2

4.4.5 Soil

Methodology

Soil Sampling Location

The soil sampling locations were chosen as close as practicable to the existing oil wells within Mann Oil Field. For safety reasons, underground utilities inspection was conducted at the proposed borehole location jointly with the staff from MOGE before soil sampling. Details of the monitoring location are shown in *Table 4.14* and illustrated in *Figure 4.17*. The surrounding environment of the soil sampling stations and soil condition are shown in *Figure 4.18*.

Table 4.14 Baseline Soil Sampling Locations in May 2015

Sampling Station	Replicate	Coordinates	Description	Sampling Date
Z1S	1	20°19'45.30"N 94°49'13.99"E	At west of Pauk su village, Pwint Phyu Township	6 – 9 May 2015
	2	20°19'45.38"N 94°49'21.05"E	At Pauk su village, Pwint Phyu Township	6 – 9 May 2015
Z2S	1	20°15'41.70"N 94°50'8.41"E	In the paddy field located at the east of Kauk san village, Minbu Township	6 – 9 May 2015
	2	20°15'40.05"N 94°50'10.40"E	At east of Kauk san village, Minbu Township	6 – 9 May 2015
Z3S	1	20°13'22.04"N 94°51'19.59"E	In the compound of MPRL office, Minbu Township	6 – 9 May 2015
	2	20°13'2.60"N 94°51'14.86"E	In the compound of MPRL office, Minbu Township	6 – 9 May 2015
Z4S	1	20°11'41.31"N 94°52'39.20"E	Near western bank of Ayeyarwady River, north of Minbu Town	6 – 9 May 2015
	2	20°11'45.77"N 94°52'38.30"E	Near western bank of Ayeyarwady River, north of Minbu Town	6 – 9 May 2015

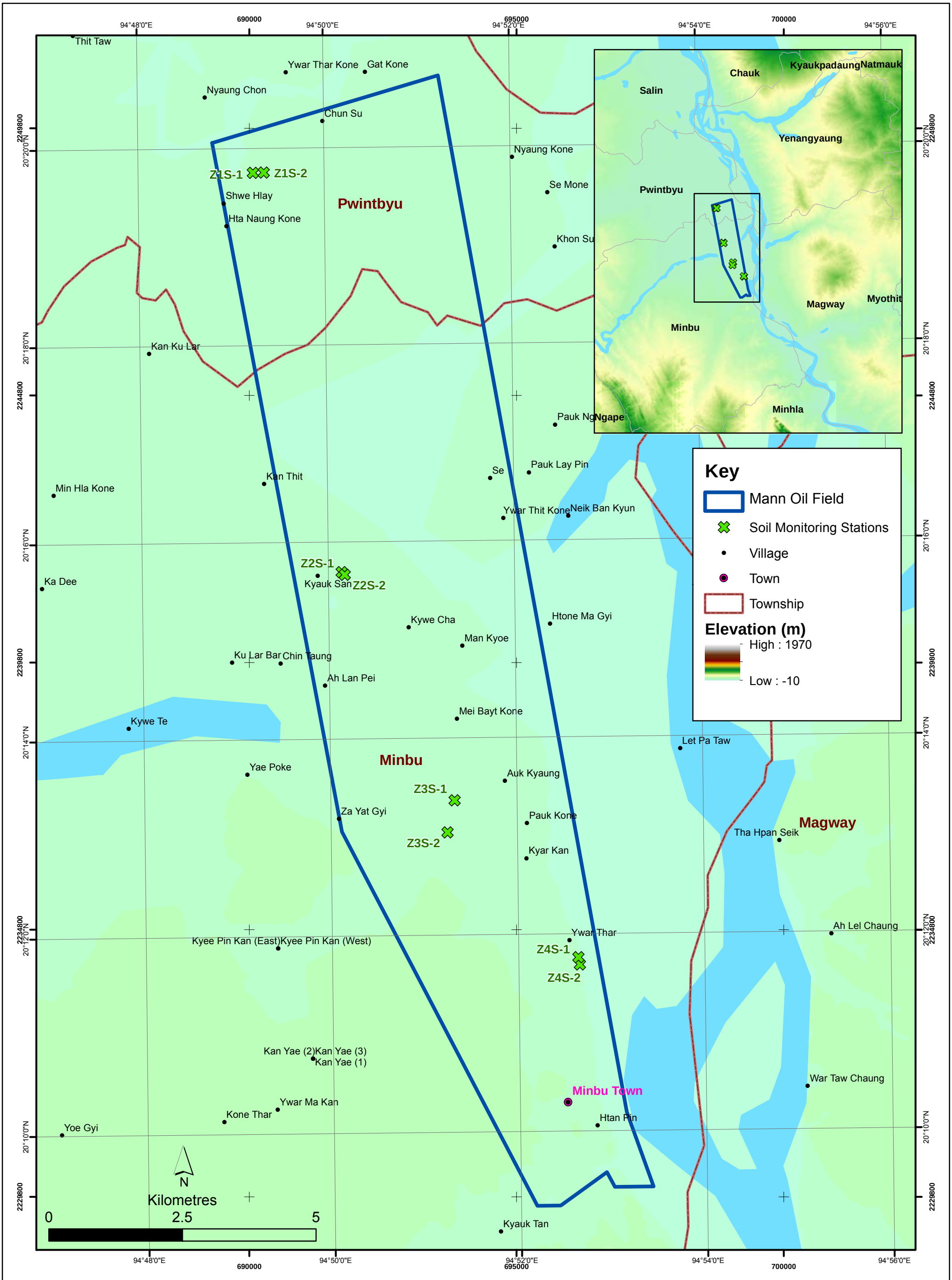

Figure 4.17

Locations of Soil Monitoring Stations

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Date: 16/9/2015

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Figure 4.18a Surrounding Environment of Groundwater Sampling Locations

↑ Station: Z1S-1

↑ Station: Z1S-2

Figure 4.18b Surrounding Environment of Groundwater Sampling Locations

↑ Station: Z2S-1

↑ Station: Z2S-2

Figure 4.18c Surrounding Environment of Groundwater Sampling Locations

↑ Station: Z3S-1

↑ Station: Z3S-2

Figure 4.18d Surrounding Environment of Groundwater Sampling Locations

↑ Station: Z4S-1

↑ Station: Z4S-2

Sampling Methodology and Equipment

All soil boring/ excavation and sampling were undertaken by means of dry rotary drilling method. A total of two (2) replicate samples were collected for laboratory analyses for each sampling area. Parameters for laboratory analyses included:

- pH;
- Arsenic (As);
- Lead (Pb);
- Cadmium (Cd);
- Copper (Cu);
- Zinc (Zn);
- Manganese (Mn); and
- Iron (Fe).

In the course of survey, sampling procedure, sample preservation and sample analysis recommended in standard operating procedure of U.S. EPA (SOP-2013, SOP2016, and SOP 2003) were referred. In soil sampling, the standard agricultural sampler (Soil Auger) was applied. The sampler is a stainless steel tube that is sharpened on one end and fitted with a long, T-shaped handle. This tube is approximately three inches inside diameter. To refrain from contamination, about 20 – 30 cm of top soil was removed by the sampler before sampling. Then sample was taken and collected in cleaned plastic bag. Chemical preservation of samples was not applied because it is generally not recommended by standard method. Samples were cooled in an ice box which temperature was under 4°C. Samples were protected from sunlight to minimize any potential chemical reaction. Soil texture and colour were also recorded upon sampling.

Baseline Soil Quality Results

The results of baseline soil quality monitoring are summarized in *Table 4.15*.

In general, the soil in the sampling locations is sandy in nature and was previously disturbed by agricultural activities. As there is no relevant national guideline or IFC standard to assess the soil quality, the Dutch Standard 2000 is adopted for evaluation, and all the measured parameters meet the assessment criteria.

Table 4.15 Results Summary of Baseline Soil Quality Monitoring in May 2015

Parameter	Unit	Station								Dutch Standard 2000
		Z1S-1	Z1S-2	Z2S-1	Z2S-2	Z3S-1	Z3S-2	Z4S-1	Z4S-2	
pH	-	6.8	6.8	6.7	6.7	6.8	6.8	6.9	6.9	–
As	mg/kg	ND	ND	ND	ND	ND	ND	ND	ND	55
Pb	mg/kg	115	120	135	130	120	124	137	135	530
Cd	mg/kg	0.009	0.008	0.009	0.007	0.007	0.007	0.006	0.007	12
Cu	mg/kg	105	99	110	115	90	95	85	88	800
Zn	mg/kg	75	80	72	69	65	70	75	78	720
Mn	mg/kg	30	32	38	35	28	25	31	30	–
Fe	mg/kg	4850	4790	4900	4930	4870	4950	4700	4690	–
Soil Texture	-	Silty clay	Silty clay	Silty sand	Silty sand	Silty sand	Silty sand	Sandy silt with minor clay	Sandy silt with minor clay	–
Soil Colour	-	Grey	Grey	Yellowish brown	Yellowish brown	Yellowish brown	Yellowish brown	Yellowish grey	Yellowish grey	–

Note:
N.D. = Not Detected

4.5 *BASELINE SURVEYS FOR BIOLOGICAL ENVIRONMENT – TERRESTRIAL ECOLOGY*

This section describes the biological environment of the Project Area for the proposed EOR and redevelopment activities. The baseline information has been gathered by focussed baseline field surveys conducted during the wet season in May 2015. The discussion is limited to those biological components either recorded or likely to be found within the Project Area. These include the following:

- Habitats and Vegetation;
- Avifauna (Birds);
- Herpetofauna (Amphibians and Reptiles);
- Mammals;
- Butterflies; and
- Aquatic fauna.

Each of the above are discussed in turn below.

4.5.1 Habitats and Vegetation

Methodology

Field survey focusing on habitat and vegetation (including trees) within the Project Area was performed in May 2015 to establish the general terrestrial ecological profile of the Project Area. Habitats were mapped based on publicly available aerial photos and field ground-truthing. Representative areas of each habitat type were surveyed on foot. Plant species of each habitat type encountered and their relative abundance were recorded with special attention to rare or protected species.

Results

The area surveyed within the Project Area was found to comprise four (4) key habitat types, including agricultural land, developed area, shrubland and water bodies (including river, channelized watercourse and pond) (*Figure 4.19*). Sizes of these habitats are presented in *Table 4.16*. Agricultural land and developed area were the main habitat types within the Project Area, covering 82% and 12% of the Project Area, respectively. Overall, the main feature of the Project Area was that it was predominantly composed of human-modified habitats (i.e. agricultural land and developed area).

Table 4.16 Areas (Total and Percentage) of Habitat Types recorded within the Project Area during the May 2015 Field Survey

Habitat	Total Area within the Project Area (km²)	Percent of Habitat in the Project Area (%)
Agricultural Land	66.90	82
Developed Area	9.60	12
Water bodies (river, channelized watercourse and pond)	4.22	5
Shrubland	0.94	1
TOTAL	**81.66**	**100**

A total of 60 plant species were recorded within the Project Area in shrubland, agricultural land and developed area (see *Annex A*). No plant species of recognised conservation interest were recorded within the Project Area. The photos of representative plant species recorded in Mann Oil Field are shown in *Figure 4.20.*

The following sections present a description of the vegetation of each habitat type along with representative photos.

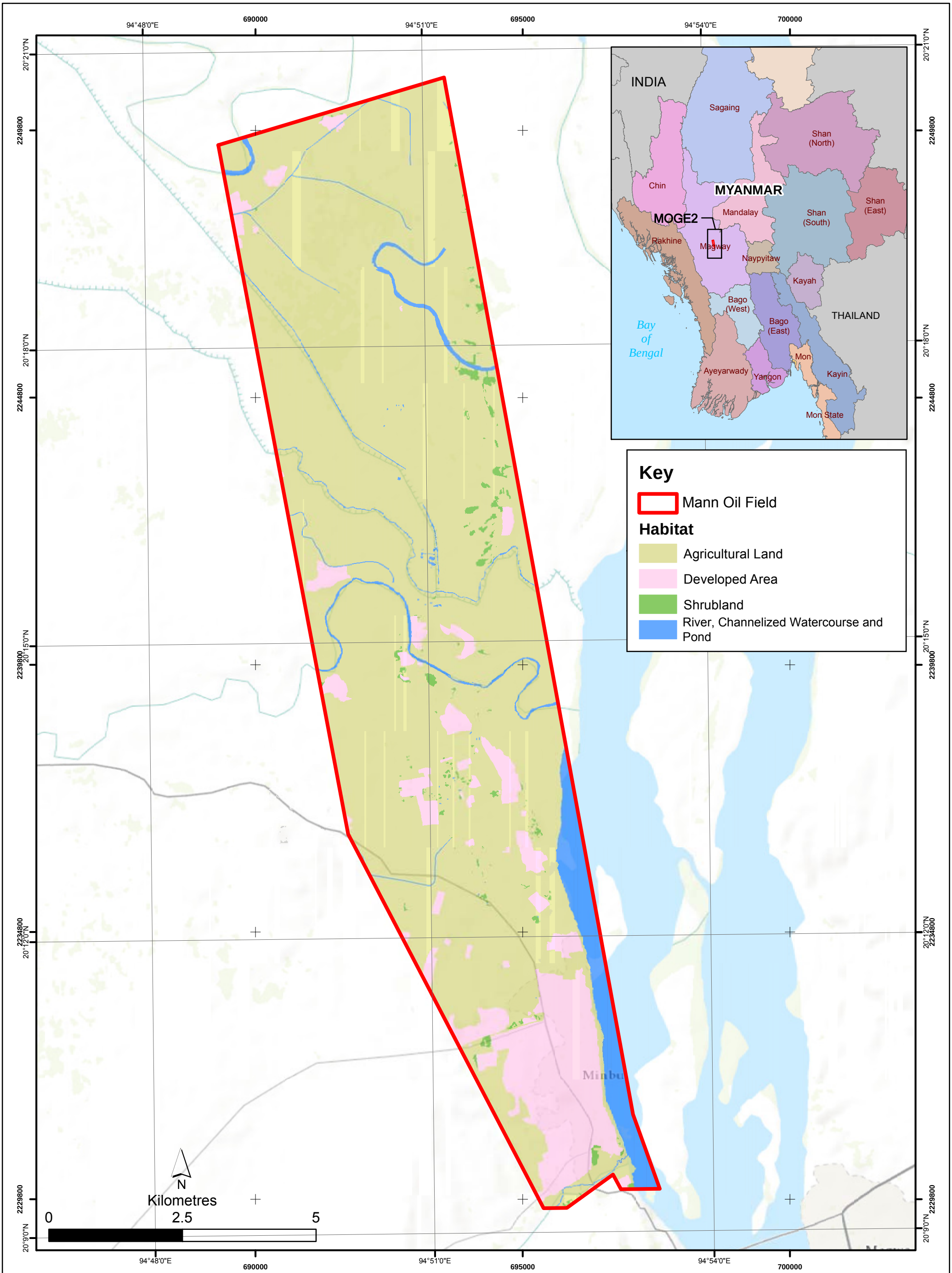

Figure 4.19

Identified habitats at Mann Oil Field

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Date: 17/9/2015

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Figure 4.20a Photos of Representative Plant Species

Acacia chundra

Oryza sativa L.

Figure 4.20b Photos of Representative Plant Species

Carcia papaya L.

Shrubland

Shrubland is the habitat with the largest area within the Project Area which mainly occupied the eastern side (see Habitat Map in *Figure 4.19*). It covered approximately 1% of the Project Area (i.e. 0.94 km^2 within 81.66 km^2 of Project Area). Shrubland habitat was found to be restricted to the areas with high disturbance from human activities and deforestation.

Photographic record of the shrubland is shown in *Figure 4.21*. A total of 35 plant species were recorded in the shrubland, of which 24 were tree species (see *Annex A*). The dominant plant species recorded in the shrubland was *Acacia Chundra* which is a common herb belonging to family Mimosaceae. Plant species of recognised conservation interest was not recorded in the shrubland.

This habitat type is considered as with low ecological value / receptor sensitivity as most of shrubland habitats are already subject to human disturbance, such as cultivation activities and deforestation.

Figure 4.21 Representative Photo of Shrubland Habitat Type

Agricultural Land

Agricultural habitat was the largest habitat type found within the Project Area which occupied approximately 82% of the Project Area (see Habitat Map in *Figure 4.19*). This habitat was mainly restricted to low terrain areas and covered a total area of 66.90 km^2 within 81.66 km^2 of the Project Area. Agricultural land is regarded as modified habitat with low ecological value / receptor sensitivity.

Agricultural land is mainly paddy field cultivated with Asian Rice (*Oryza sativa L;* see *Annex A*). No tree species was found in this habitat. A total of 54 plant species were observed at the agricultural land with no plant species of recognised conservation interest found.

Representative photo of agricultural land is shown in *Figure 4.22* below.

Figure 4.22 Representative Photo of Agricultural Land Habitat Type

Developed Area

Developed area is mainly found in the southern and middle part of the Project Area, where the Mann Oil Field is located. Developed area covered an area of 9.60 km² (see Habitat Map in *Figure 4.19*). The developed area is regarded as man-made, disturbed habitat with low ecological value / receptor sensitivity. A photographic record of developed area is shown in *Figure 4.23*.

A total of 36 plant species was found within the developed area of the Project Area (see *Annex A*). The plant species in the developed area was dominated by flowering tree of *Mangifera indica* L., *Azadirachta indica* A. Juss and herb *Musa sapientum* L. No plant species of recognised conservation interest was recorded within this habitat type.

Figure 4.23 Representative Photo of Developed Area/ Village

Water bodies (river, channelized watercourse and pond)

Water bodies recorded within the Project Area included river, channelized watercourse and pond. The Ayeyarwady River is the main river identified within the Project Area. Apart from Ayeyarwady River, two other rivers, Mann River and Mon River, were also located within the Project Area (*Figure 4.19*). The total area of the waterbodies recorded within the Project Area was estimated to be approximately 4.22 km². Vegetation record was not made for the water bodies as it was included in the record of adjacent habitats. Channelized watercourse and pond are regarded as a man-made habitat with low ecological value / receptor sensitivity. For the river, it is also considered as with low ecological value / receptor sensitivity without any species of

recognised conservation interest recorded (please refer to findings on aquatic fauna species recorded in *Section 4.5.11* below).

A photographic record of river is shown in *Figure 4.24*.

Figure 4.24 Representative Photo of Waterbodies

4.5.2 Avifauna (Bird)

Methodology

The avifauna (bird) communities of each habitat types within the Project Area were surveyed using the qualitative transect count method. During the survey, all birds seen or heard from either sides of the transect were identified to species where possible with their relatively abundance noted. Signs of breeding (eg nests, recently fledged juveniles) within the Project Area were also recorded, if any. Observations were made using binoculars and photographic records were taken, if possible. Special attention was paid to egretry, wetland dependent and migratory birds.

Results

A total of 45 bird species were recorded during the survey period within the Project Area (see *Annex B*). *Passer montanus*, *Passer domesticus*, *Acridotheres tristis*, *Columba livia*, *Hirundo rustica* were common bird species found in the Project Area. The abundance and species richness of bird was noted to be higher in agricultural land.

No bird species of recognised conservation interest was found within the Project Area. Photo records of identified bird species are shown in *Figure 4.25*.

Figure 4.25 Photo Records of Identified Bird Species

Little Egret (*Ardea alba*)

Spotted Dove (*Metopidius indicus*)

4.5.3 Herpetofauna (Amphibians and Reptiles)

Methodology

Herpetofauna survey was conducted through direct observation and active searching in all habitat types in potential hiding places such as amongst leaf litter, inside holes, under stones and logs within the Project Area. Particular attention was given to water bodies. Auditory detection of species-specific calls was also used to survey frogs and toads. During the surveys, all reptiles and amphibians sighted and heard were recorded. Interviews were also conducted with villagers to gather information of the herpetofauna species they found within the Project Area.

Results

During the herpetofauna survey, three (3) amphibian species and nine (9) reptiles species were record within the Project Area through observation and interview (see *Annex C*). It is important to note, however, that data obtained through the interviews has not been verified through observation by the survey team. Photo records of identified herpetofauna are shown in *Figure 4.26*.

The species richness of herpetofauna was the highest in agricultural land within the Project Area. All species recorded are regarded as common and widespread species within no recognised conservation interest.

Figure 4.26 Photo Records of Identified Herpetofauna Species

Common sun skink *Eutropis multifasciata*

Garden lizard *Calotes versicolor*

4.5.4 *Mammals*

Methodology

As most mammals often occur at low densities, all sightings, tracks, and signs of mammals (including droppings) were actively searched along the survey transects during the field survey. Interviews were also conducted with villagers to gather information of the mammal species they found within the Project Area.

Results

Six (6) mammal species were recorded within the Project Area through observation and interview (see *Annex D*). It is important to note, however, that data obtained through the interviews has not been verified through observation by the survey team. Amongst the recorded mammal species, all of them were considered to be common species within the Project Area with no recognised conservation interest. Mammal species was reported within all identified habitats of the Project Area (*Figure 4.27*).

Figure 4.27 Photo Records of Identified Mammal Species

4.5.5 Butterflies

Methodology

Butterflies at different habitats within the Project Area were surveyed using qualitative transect count method. Butterflies from either side of the survey transect were identified with their relatively abundance noted.

Results

In total, 11 butterflies species were recorded within the Project Area (see *Annex E*). It was noted that the relatively abundance of butterfly was higher in developed area and agricultural land while the species richness was the highest at agricultural land. No butterfly species of recognised conservation interest was found within the Project Area. Photo records of identified butterfly species are shown in *Figure 4.28*.

Figure 4.28 Photo Records of Identified Butterflies Species

Danaus chrysippus

Catopsilia pyranthe

4.5.6 Aquatic Fauna

Methodology

Fishes were collected with the help of local fishermen within the Project Area by using local fishing gears (e.g. fish traps, gill nets etc) to obtain a qualitative species list. Fish species which could not be identified in the field were preserved in 10% formalin solution and sent to laboratory for later identification.

Planktonic and benthic species were also collected within the aquatic habitat of the Project Area using plankton nets and by sieving of sediment, respectively, to obtain a qualitative species list (*Figure 4.28*). Planktonic and benthic species which could not be identified in the field were preserved in 10% formalin solution and sent to laboratory for later identification.

Results

A total of 20 fish species were recorded from the aquatic habitats of the Project Area (see *Annex F*). Photo records of identified aquatic fauna species are shown in *Figure 4.29*. Commercially important fish species including Long Whisker Catfish (*Mystus gulio*) and Nile Tilapia (*Oreochromis niloticus*) were recorded within the Project Area. Amongst the recorded species, no species of conservation concern was recorded.

Six (6) zooplankton, 11 phytoplankton and three benthic species were identified from the collected samples (*Annex G*). All plankton and benthic species recorded are considerd as common species and no species of recognised conservation interest was found.

Figure 4.28 Photo Records of Planktonic and Benthic Samplings

Collecting Planktonic sample

Sieving benthic samples

Figure 4.29 Photo Records of Identified Aquatic Fauna Species

Mastacembelus unicolor

Clarias batrachus

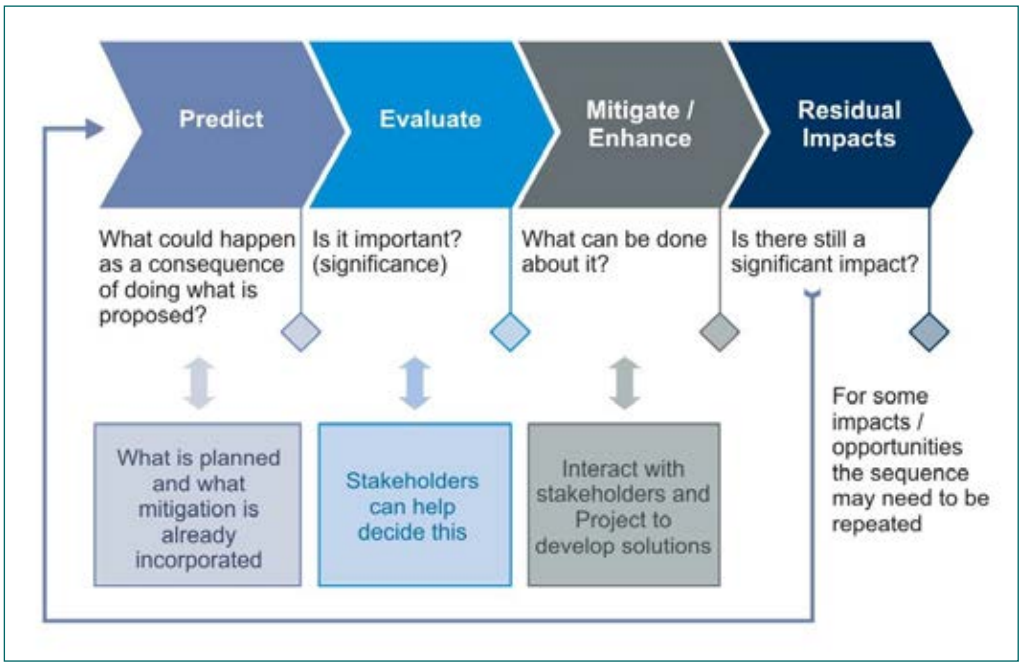
5 IMPACT ASSESSMENT

5.1 IMPACT ASSESSMENT METHODOLOGY AND APPROACH

Impact identification and assessment starts with scoping and continues through the remainder of the impact assessment process (IAP). The principal impact assessment (IA) steps are summarized in *Figure 5.1* and comprise:

- Impact prediction: to determine what could potentially happen to resources/receptors as a consequence of the Project and its associated activities.
- Impact evaluation: to evaluate the significance of the predicted impacts by considering their magnitude and likelihood of occurrence, and the sensitivity, value and/or importance of the affected resource/receptor.
- Mitigation and enhancement: to identify appropriate and justified measures to mitigate negative impacts and enhance positive impacts.
- Residual impact evaluation: to evaluate the significance of impacts assuming effective implementation of mitigation and enhancement measures.

Figure 5.1 Impact Assessment Process



Prediction of Impacts

Prediction of impacts is essentially an objective exercise to determine what could potentially happen to the environment as a consequence of the Project and its associated activities. This is essentially a repeat of the process undertaken in scoping, whereby the potential interactions between the Project

and the baseline environment are identified. In the impact assessment stage, these potential interactions are updated based on additional Project and baseline information. From these potential interactions, the potential impacts to the various resources/receptors are identified, and are elaborated to the extent possible. The diverse range of potential impacts considered in the IA process typically results in a wide range of prediction methods being used including quantitative, semi-quantitative and qualitative techniques.

Evaluation of Impacts

Once the prediction of impacts is complete, each impact is described in terms of its various relevant characteristics (e.g., type, scale, duration, frequency, extent). The terminology used to describe impact characteristics is shown in *Table 5.1.*

Table 5.1 Impact Characteristic Terminology

Characteristic	Definition	Designations
Type	A descriptor indicating the relationship of the impact to the Project (in terms of cause and effect).	Direct Indirect Induced
Extent	The "reach" of the impact (e.g., confined to a small area around the Project Footprint, projected for several kilometres, etc).	Local Regional International
Duration	The time period over which a resource / receptor is affected.	Temporary Short-term Long-term Permanent
Scale	The size of the impact (e.g., the size of the area damaged or impacted, the fraction of a resource that is lost or affected, etc)	[no fixed designations; intended to be a numerical value]
Frequency	A measure of the constancy or periodicity of the impact.	[no fixed designations; intended to be a numerical value]

The definitions for the *type* designations are shown in *Table 5.2.* Definitions for the other designations are resource/receptor-specific, and are discussed in the resource/receptor-specific chapters.

Table 5.2 Impact Type Definitions

Designations (Type)	Definition
Direct	Impacts that result from a direct interaction between the Project and a resource/receptor (e.g., between occupation of a plot of land and the habitats which are affected).
Indirect	Impacts that follow on from the direct interactions between the Project and its environment as a result of subsequent interactions within the environment (e.g., viability of a species population resulting from loss of part of a habitat as a result of the Project occupying a plot of land).
Induced	Impacts that result from other activities (which are not part of the Project) that happen as a consequence of the Project (e.g., influx of camp followers resulting from the importation of a large Project workforce).

The above characteristics and definitions apply to planned and unplanned events. An additional characteristic that pertains only to unplanned events is *likelihood*. The *likelihood* of an unplanned event occurring is designated using a qualitative scale, as described in *Table 5.3*.

Table 5.3 Definitions for Likelihood Designations

Likelihood	Definition
Unlikely	The event is unlikely but may occur at some time during normal operating conditions.
Possible	The event is likely to occur at some time during normal operating conditions.
Likely	The event will occur during normal operating conditions (i.e., it is essentially inevitable).

Once an impact's characteristics are defined, the next step in the impact assessment phase is to assign each impact a 'magnitude'. Magnitude is a function of some combination (depending on the resource/receptor in question) of the following impact characteristics:

- Extent
- Duration
- Scale
- Frequency

Additionally, for unplanned events only, magnitude incorporates the 'likelihood' factor discussed above.

Magnitude essentially describes the intensity of the change that is predicted to occur in the resource/receptor as a result of the impact. As discussed above, the magnitude designations themselves are universally consistent, but the definitions for these designations vary on a resource/receptor-by-resource/receptor basis, as further discussed in each of the resource/receptor-specific chapters. The universal magnitude designations are:

- Positive
- Negligible
- Small
- Medium
- Large

In the case of a *positive* impact, no magnitude designation (aside from 'positive') is assigned. It is considered sufficient for the purpose of the IA to indicate that the Project is expected to result in a *positive* impact, without characterising the exact degree of positive change likely to occur.

In the case of impacts resulting from unplanned events, the same resource/ receptor-specific approach to concluding a magnitude designation is utilised, but the 'likelihood' factor is considered, together with the other impact characteristics, when assigning a magnitude designation.

In addition to characterising the magnitude of impact, the other principal impact evaluation step is definition of the sensitivity / vulnerability / importance of the impacted resource/receptor. There are a range of factors to be taken into account when defining the sensitivity / vulnerability / importance of the resource/receptor, which may be physical, biological, cultural or human. Other factors may also be considered when characterising sensitivity/vulnerability/importance, such as legal protection, government policy, stakeholder views and economic value.

As in the case of magnitude, the sensitivity/vulnerability/importance designations themselves are universally consistent, but the definitions for these designations vary on a resource/receptor basis. The universal sensitivity/vulnerability/importance designations are:

- Low
- Medium
- High

Once magnitude of impact and sensitivity/vulnerability/importance of resource/receptor have been characterised, the significance can be assigned for each impact. Impact significance is designated using the matrix shown in *Figure 5.2.*

Figure 5.2 Impact Significances

		Sensitivity/Vulnerability/Importance of Resource/Receptor		
		Low	Medium	High
Magnitude of Impact	Negligible	Negligible	Negligible	Negligible
	Small	Negligible	Minor	Moderate
	Medium	Minor	Moderate	Major
	Large	Moderate	Major	Major

The matrix applies universally to all resources/receptors, and all impacts to these resources/receptors, as the resource/receptor-specific considerations are factored into the assignment of magnitude and sensitivity/vulnerability/ importance designations that enter into the matrix. *Box 5.1* provides a context for what the various impact significance ratings signify.

It is important to note that impact prediction and evaluation take into account any embedded controls (i.e., physical or procedural controls that are already planned as part of the Project design, regardless of the results of the IA Process). An example of an embedded control is a standard acoustic enclosure that is designed to be installed around a piece of major equipment. The avoids the situation where an impact is assigned a magnitude based on a hypothetical version of the Project that considers none of the embedded controls.

Box 5.1 Context of Impact Significances

An impact of **negligible** significance is one where a resource/receptor (including people) will essentially not be affected in any way by a particular activity or the predicted effect is deemed to be 'imperceptible' or is indistinguishable from natural background variations.

An impact of **minor** significance is one where a resource/receptor will experience a noticeable effect, but the impact magnitude is sufficiently small (with or without mitigation) and/or the resource/receptor is of low sensitivity/ vulnerability/ importance. In either case, the magnitude should be well within applicable standards.

An impact of **moderate** significance has an impact magnitude that is within applicable standards, but falls somewhere in the range from a threshold below which the impact is minor, up to a level that might be just short of breaching a legal limit. Clearly, to design an activity so that its effects only just avoid breaking a law and/or cause a major impact is not best practice. The emphasis for moderate impacts is therefore on demonstrating that the impact has been reduced to a level that is as low as reasonably practicable (ALARP). This does not necessarily mean that impacts of moderate significance have to be reduced to minor, but that moderate impacts are being managed effectively and efficiently.

An impact of **major** significance is one where an accepted limit or standard may be exceeded, or large magnitude impacts occur to highly valued/sensitive resource/receptors. An aim of IA is to get to a position where the Project does not have any major residual impacts, certainly not ones that would endure into the long-term or extend over a large area. However, for some aspects there may be major residual impacts after all practicable mitigation options have been exhausted (i.e. ALARP has been applied). An example might be the visual impact of a facility. It is then the function of regulators and stakeholders to weigh such negative factors against the positive ones, such as employment, in coming to a decision on the Project.

Identification of Mitigation and Enhancement Measures

Once the significance of an impact has been characterised, the next step is to evaluate what mitigation and enhancement measures are warranted. For the purposes of this IA, ERM has adopted the following Mitigation Hierarchy:

- **Avoid at Source; Reduce at Source**: avoiding or reducing at source through the design of the Project (e.g., avoiding by siting or re-routing activity away from sensitive areas or reducing by restricting the working area or changing the time of the activity).

- **Abate on Site**: add something to the design to abate the impact (e.g., pollution control equipment, traffic controls, perimeter screening and landscaping).

- **Abate at Receptor**: if an impact cannot be abated on-site then control measures can be implemented off-site (e.g., noise barriers to reduce noise impact at a nearby residence or fencing to prevent animals straying onto the site).

- **Repair or Remedy**: some impacts involve unavoidable damage to a resource (e.g. agricultural land and forestry due to creating access, work camps or materials storage areas) and these impacts can be addressed through repair, restoration or reinstatement measures.

- **Compensate in Kind; Compensate Through Other Means**: where other mitigation approaches are not possible or fully effective, then compensation for loss, damage and disturbance might be appropriate (e.g., planting to replace damaged vegetation, financial compensation for damaged crops or providing community facilities for loss of fisheries access, recreation and amenity space).

The priority in mitigation is to first apply mitigation measures to the source of the impact (i.e., to avoid or reduce the magnitude of the impact from the associated Project activity), and then to address the resultant effect to the resource/receptor via abatement or compensatory measures or offsets (i.e., to reduce the significance of the effect once all reasonably practicable mitigations have been applied to reduce the impact magnitude).

Residual Impact Evaluation

Once mitigation and enhancement measures are declared, the next step in the IA Process is to assign residual impact significance. This is essentially a repeat of the impact assessment steps discussed above, considering the assumed implementation of the additional declared mitigation and enhancement measures.

Management and Monitoring

The final stage in the IA Process is definition of the management and monitoring measures that are needed to identify whether: a) impacts or their associated Project components remain in conformance with applicable standards; and b) mitigation measures are effectively addressing impacts and compensatory measures and offsets are reducing effects to the extent predicted.

A Environmental Management Plan, which is a summary of all actions which the Project Proponent has committed to executing with respect to environmental performance for the Project, is also included as part of the EIA report. The Environmental Management Plan includes mitigation measures, compensatory measures and offsets and management and monitoring activities.

5.2 IDENTIFICATION OF POTENTIAL IMPACTS OF THE PROJECT

For the Project, potential impacts have been identified through a systematic process whereby the activities (both planned and unplanned) associated with the Project have been considered with respect to their potential to interact with environmental resources or receptors.

The results from the scoping process for the Project are presented in the Scoping Matrix in *Table 5.4*. The Scoping Matrix displays Project activities against resources/receptors, and supports a methodological identification of the potential interactions each Project activity may have on the range of resources/receptors within the Area of Influence for the Project. Entries in the matrix cells are coloured to indicate whether:

- An interaction is not reasonably expected (white);
- An interaction is reasonably possible but none of the resulting impacts are likely to lead to significant effects (grey);
- An interaction is reasonably possible and at least one of the resulting impacts is likely to lead to an effect that is significant (black); or
- An interaction will possibly lead to positive impacts (green).

For the purpose of the scoping exercise, Project activities are divided into the following phases:

- Construction phase;
- Operational phase; and
- Accidental events.

Table 5.4 Scoping Matrix for Project Activities

Project Activity/ Hazards \ Resource/ Receptors	Physical						Biological					
	Ambient Air Quality	Ambient Noise	Ground Water Quality	Surface Water Quality	Soil	Landscape and Visual Character	Use of Natural Resources	Terrestrial Habitat	Terrestrial Flora	Terrestrial Fauna	Aquatic Habitat (freshwater)	Aquatic Flora & Fauna (freshwater)
Re-development and EOR activities												
Construction Phase												
Use of PMEs for installation of EOR facilities and re-development activities (General)												
Drilling activities (daylight hours)												
Labour, equipment and services supply												
Mobile Power Generation												
Excavation, site preparation / clearance & creation of additional access routes												
Improper disposal of solid waste												
Improper wastewater discharge												
Operational Phase												
Labour, equipment and services supply												
Mobile power generation												
Use of chemicals for EOR process												
Consumptive use of water resources for EOR process												
Venting												
Improper disposal of solid waste												
Improper disposal of wastewater and slug												
Improved operations after re-development												
Accidental Events												
Chemical spill, well failure, reservoir leakage (include spillage due to flooding)												
Fires and explosions due to accidental events related to re-perforations												

- An interaction is not reasonably expected (white);
- An interaction is reasonably possible but none of the resulting impacts are likely to lead to significant effects (grey);
- An interaction is reasonably possible and at least one of the resulting impacts is likely to lead to an effect that is significant (black); or
- An interaction will possibly lead to positive impacts (green).

5.3 *KEY POTENTIAL IMPACTS*

The prioritisation of impacts indicates that the majority of identified interactions of the re-development and EOR activities and the environment receptors are not expected to be significant. For activities predicted to have no significant impact (ie those in white in the Matrix), no detailed quantification or further assessment will be conducted under the EIA.

For activities where an interaction is reasonably possible but none of the resulting impacts would be considered likely to lead to significant effects, this evaluation recommends that they be reviewed and confirmed within the detailed EIA.

It is important to note that for those issues that have been scoped out of requiring further assessment in this EIA study, it is still essential that they still receive careful planning and consideration in line with international standard management procedures and general good practice for all project stages.

Those interactions which have the potential to generate **significant** impacts are:

Construction Phase

- Impacts from use of PMEs for installation of EOR facilities and re-development activities (general) on ambient air quality, ambient noise as well as terrestrial ecological resources (i.e. habitats and fauna);
- Impacts from drilling activities on ambient air quality, ambient noise, surface water quality, groundwater quality, soil quality as well as terrestrial and aquatic ecological resources (i.e. habitats, flora and fauna);
- Impacts from mobile power generation on terrestrial fauna;
- Impacts from excavation, site preparation / clearance & creation of additional access routes on terrestrial ecological resources (i.e. habitats, flora and fauna);
- Impacts from improper disposal of solid wastes on surface water quality, groundwater quality, soil quality as well as terrestrial and aquatic ecological resources (i.e. habitats, flora and fauna); and
- Impacts from improper wastewater discharge on surface water quality, groundwater quality, soil quality as well as terrestrial and aquatic ecological resources (i.e. habitats, flora and fauna).

Operational Phase

- Impacts from mobile power generation on terrestrial fauna;

- Impacts from consumptive use of surface water resources by EOR process on use of nature resources;

- Impacts from the use of chemicals for EOR process on soil quality, surface water quality, groundwater quality as well as terrestrial and aquatic ecological resources (i.e. habitats, flora and fauna); and,

- Impacts from improper disposal of solid wastes on surface water quality, groundwater quality, soil quality as well as terrestrial and aquatic ecological resources (i.e. habitats, flora and fauna); and

- Impacts from improper disposal of wastewater and slug on surface water quality, groundwater quality, soil quality as well as terrestrial and aquatic ecological resources (i.e. habitats, flora and fauna).

- Impacts from gas venting activities on ambient air condition.

- Positive impacts of improved operations after re-development on all related physical and biological receptors.

Accidental Events

- Impacts from chemical spills, well failure and reservoir leakage on soil quality, surface water quality, groundwater quality as well as terrestrial and aquatic ecological resources (i.e. habitats, flora and fauna).

- Impacts from fires and explosions caused by the accidental events related to the use of explosive materials in re-perforation on air quality, ground water quality, surface water quality, soil quality, use of natural resources, terrestrial habitats and aquatic habitats as well as their associated flora and fauna.

This scoping study recommends that these above activities and potential impacts be given specific attention in the detailed EIA Study, including quantification of predicted impacts where possible. If impacts are confirmed to be of moderate or greater significance, mitigation, management and monitoring measures are required to ensure predicted impacts are maintained within ALARP levels.

It is, however, important to note that the identification of potential environmental impacts should continue throughout the planning and implementation of the Project. As Project concepts are further developed and their implementation planned, activities should continue to be screened to determine whether any change in circumstance (Project or baseline) could constitute a change in this evaluation.

5.4 ENVIRONMENTAL IMPACT ASSESSMENT AND MITIGATION

Drawing on the outcomes of scoping, *Sections 5.5 – 5.30* below present the assessment of the potential impacts to the environment associated with the

EOR and redevelopment activities. The assessment is presented in the order of impacts as identified during scoping.

CONSTRUCTION PHASE

5.5 *IMPACTS FROM USE OF PMES FOR INSTALLATION OF EOR FACILITIES AND RE-DEVELOPMENT ACTIVITIES (GENERAL) ON AMBIENT AIR QUALITY, AMBIENT NOISE AS WELL AS TERRESTRIAL ECOLOGICAL RESOURCES (I.E. HABITATS AND FAUNA)*

5.5.1 *Source of Impact*

During construction phase of the EOR and re-development programme, Powered Mechanical Equipment (PME) would be used to construct the EOR facilities (e.g. injection well) and for the re-development activities (e.g. improvement of pumping units). These PMEs would be the key sources of air emission and noise.

Exact locations where the EOR and re-development activities will be undertaken are not yet determined. It is expected that the construction activities will be carried out at existing facilities (e.g. wells and GOCS) within the Mann Oil Field which are considered as developed area and are mostly remote from sensitive receiver locations. A small proportion of existing facilities are, however, relatively nearby residential area, guesthouse, MPRL E&P office, which are considered NSRs and ASRs of medium sensitivity. For air emission, exhaust gas from vehicles, generator and engines have the potential to affect nearby ASRs. The primary pollutants emitted from engines include Particulate matter (PM), Carbon monoxide, (CO), Nitrogen oxides (NOx), Hydrocarbons (HC), and Volatile organic compounds (VOCs). Combustion of fossil fuels in stationary and mobile combustion sources will produce greenhouse gases (e.g. carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). In addition, noise from the PMEs may affect the NSRs and also lead to indirect impacts to terrestrial ecology due to disturbance of terrestrial habitat and associated fauna. Noise emissions and vibration from PMEs will have the potential to modify the movement and behaviour of terrestrial fauna. The most common response to disturbance is active avoidance of an area with associated ecological effects (e.g. move from an individual's territory, disturbance of breeding activities etc.). Affected fauna are likely to include the six (6) mammal species recorded during the baseline survey such as Gray squirrel and Myanmar hare (Annex A).Existing/ In Place Controls

5.5.2 *Existing / in place Measures to control/ reduce adverse impacts include:*

- Construction activities carried out at existing facilities of the Mann Oil Field which are developed area mostly away from sensitive receptors.
- Construction activities to be limited to daylight working hours.

- Well maintained equipment will be used.
- Noise suppression box will be fabricated over the engine for the PMEs being operated nearby the NSRs (e.g. villages).
- Appropriate PPE e.g. ear protection will be used for MPRL E&P personnel.
- Vegetation cutting by hand to minimise disturbance and degradation of the habitats.
- It is assumed felling of large perennial vegetation (i.e. large trees which typically provide habitat for higher densities of terrestrial fauna) will be avoided.

5.5.3 Significance of Impacts

Noise

For the EOR programme, it is expected that the use of drilling rig for the construction of the injection wells would be the most significant noise source. For the re-development programme, rigid trucks are anticipated to be the key equipment used for improvement of the facilities (e.g. pumping units).

The Government of Myanmar has not yet established numerical standards for noise impact arising from construction noise and operation noise. In the absence of national standards, the MOECAF typically recommends that internationally accepted numerical environmental standards, such as IFC to be adopted for any noise assessment. However, the IFC Guidelines only specified noise limits for operation of a facility while no noise limits are set out for construction noise. In this circumstance, reference has been made to the Ambient Noise Standards in Thailand. A-weighted equivalent continuous sound level (L_{eq}) 24 hours should not exceed 70 dB(A) and the maximum equivalent sound level (L_{eq}) should not exceed 115 dB(A). Ambient noise levels recorded during baseline survey at four representative locations during daytime (LA_{eq}) ranged from 49 dB to 61 dB and are below the standard.

Noise levels associated with EOR and re-development activities at a works area have been calculated to illustrate indicative noise levels at varying distances away from the area (*Table 5.5*).

Table 5.5 Calculated Noise Levels at 50m, 100m, 150m and 200m from EOR and Re-development Activities

Equipment to NSR Separation Distance	Activities	Equipment	Noise Level, dB(A)	Assessment Criteria dB(A)[(a)]	Compliance
50m	Construction of injection well for EOR programme	1 x Tracked hydraulic drilling rig (P100 rig)	72	70	No
	Facilities improvement for the re-development programme	2x rigid trucks	72	70	No
100m	Construction of injection well for EOR programme	1 x Tracked hydraulic drilling rig (P100 rig)	69	70	Yes
	Facilities improvement for the re-development programme	2x rigid trucks	69	70	Yes
150m	Construction of injection well for EOR programme	1 x Tracked hydraulic drilling rig (P100 rig)	65	70	Yes
	Facilities improvement for the re-development programme	2x rigid trucks	65	70	Yes
200m	Construction of injection well for EOR programme	1 x Tracked hydraulic drilling rig (P100 rig)	63	70	Yes
	Facilities improvement for the re-development programme	2x rigid trucks	63	70	Yes

Note:
(a) Ambient Noise Standards in Thailand

Based on the calculations, it is expected there is potential for small magnitude noise exceedance to occur if NSRs are located within about 100 m from the well. The significance of impact to such NSRs with medium sensitivity is assessed as **Minor**. For EOR and redevelopment at wells that are further than 100m from NSRs, noise levels would not be expected to exceed assessment criteria due to activities at the works site. The significance of impacts to NSRs would be considered as **Negligible**.

Table 5.6 ***Assessment of Impacts on Ambient Noise Levels due to the use of PMEs during Construction***

Impact	Noise impact from the use of PMEs during construction phase.				
Impact Type	Direct		Indirect		Induced
Impact Duration	Temporary	Short-term		Long-term	Permanent
Impact Extent	Local		Regional		International
Impact Scale	Noise levels are calculated to comply with noise criteria within about 100 m from the works area.				
Frequency	Daytime only hroughout construction activity period at a works area.				
Impact Magnitude	Positive	Negligible	Small	Medium	Large
Resource Sensitivity	Low		Medium		High
Impact Significance	Negligible	Minor		Moderate	Major

Air

Potential impacts are likely to be small and limited to the works area and hence would be considered to be local, however, winds may potentially carry emissions into surrounding communities, if wells / GOCS selected for the EOR and re-development programme are nearby ASRs. The combination of a medium resource sensitivity and small impact magnitude will result in an overall **Minor** potential impact significance.

Table 5.7 ***Assessment of Impacts on Ambient Air Quality due to the use of PMEs during Construction***

Impact	Air quality impact from the use of PMEs during construction phase.				
Impact Type	Direct		Indirect		Induced
Impact Duration	Temporary	Short-term		Long-term	Permanent
Impact Extent	Local		Regional		International
Impact Scale	Limited to the works area and hence would be considered to be local, however, winds may potentially carry emissions into surrounding communities.				
Frequency	Daytime only throughout construction activity period at a works area.				
Impact Magnitude	Positive	Negligible	Small	Medium	Large
Resource Sensitivity	Low		Medium		High
Impact Significance	Negligible	Minor		Moderate	Major

Terrestrial Ecological Resources

While disturbance effects have the potential to occur due to noise emission from PMEs during construction phase, they will be temporary in nature and local in scale as temporarily displaced terrestrial fauna will be expected to move back into an area once activities at a location have ceased. The impact magnitude is thus expected to be small. The sensitivity of terrestrial habitats and fauna is considered to be low as revealed from the baseline survey findings with no species of recognised conservation interest recorded. In addition, fauna species presented at the works areas, which are mostly

developed area, are expected to be well-adapted to disturbance due to the existing oil and gas operations. As such, provided that the existing/in place controls are followed, the impact of disturbance to terrestrial ecological resources due to noise emission from PMEs is considered as of **Negligible** significance.

Table 5.8 ***Assessment of Impacts on Terrestrial Ecological Resources (Habitat and Associated Fauna) due to the use of PMEs during Construction***

Impact	Disturbances to terrestrial habitat and associated fauna from the use of PMEs during construction phase.				
Impact Nature	Negative		Positive		Neutral
Impact Type	Direct		Indirect		Induced
Impact Duration	Temporary	Short-term		Long-term	Permanent
Impact Extent	Local		Regional		International
Impact Scale	Exact extent of indirect affects unknown but considered local. Also, impact scale is expected to be small to fauna which should have adapted to disturbances by existing oil and gas activities.				
Frequency	Daytime only hroughout construction activity period at a works area.				
Impact Magnitude	Positive	Negligible	Small	Medium	Large
Resource Sensitivity	Low		Medium		High
Impact Significance	Negligible	Minor		Moderate	Major

5.5.4 Additional Mitigation, Management and Monitoring

Since the significance of impacts is considered negligible to minor with exiting control measures, additional measures are not considered necessary. However, as industrial best practices the following mitigation measures are recommended to be implemented:

- Regular maintenance of equipment such as lubricating moving parts, tightening loose parts and replacing worn out components.
- Shut down or throttled down between work periods for machines and construction plant items (eg trucks) that may be in intermittent use.
- Shut down generators, compressors, and other equipment when not in use.
- Reduce the number of equipment operating simultaneously as far as practicable.
- Orientate equipment known to emit noise strongly in one direction so that the noise is directed away from receptors as far as practicable.
- Implement control measures, eg erecting temporary noise barriers and deflectors, whenever applicable.

5.5.5 *Significance of Residual Impacts*

Provided that mitigation measures are followed, the residual impacts of the use of PMEs during construction on ambient noise levels, air quality and terrestrial ecological resources are expected to be **Negligible**.

5.6 *IMPACTS FROM DRILLING ACTIVITIES ON AMBIENT AIR QUALITY, AMBIENT NOISE, SURFACE WATER QUALITY, GROUNDWATER QUALITY, SOIL QUALITY AS WELL AS TERRESTRIAL AND AQUATIC ECOLOGICAL RESOURCES (I.E. HABITATS, FLORA AND FAUNA)*

5.6.1 *Source of Impact*

Drilling activities will be carried out for the installation of the injection wells under the EOR programme. Although exact locations are not yet determined, it is expected that drilling will be carried out at existing well sites within the Mann Oil Field which are considered as developed area and are mostly remote from sensitive receiver locations (please also refer to *Section 5.5* above for the description of the drilling activities). The use of PMEs during drilling activities will lead to potential impacts on air quality, noise and terrestrial ecological resources which have been assessed in *Section 5.5* above and would thus not be further discussed in this section.

Drilling of injection wells will generate cuttings and use drilling muds which are typically the largest waste stream during the construction phase of the EOR programme. Drill muds used for the EOR will be water based mud (WBM) and potassium chloride (KCl) polymer mud. It is estimated that 600 bbl of drilling mud and 18 bbl of cuttings will be generated from drilling of each well. Improper disposal of cuttings and drilling muds has the potential to contaminate surface waters, ground water and soil giving rise to sub lethal or lethal effects to exposed aquatic organism or terrestrial fauna due to exposure to elevated salinity, total suspended solid and sedimentation levels as well as toxicity effects (i.e. such as from hydrocarbons and chemical additives). These potential impacts to surface water, ground water and soil quality as well as the terrestrial and aquatic resources are further assessed below.

5.6.2 *Existing/ In Place Controls*

Measures to control/ minimise adverse impacts from drilling muds and cuttings include:

- Proper implementation of MPRL E&P's Waste Management Plan (WMP) for the Mann Oil Field.

- Drill muds used will be WBM and KCl polymer mud with negligible toxicity which will be recycled and treated for future use as far as possible. If disposal is required, the cuttings and muds will be dewatered with the residual solid contained in plastic liner and buried underground and residual water injected into dumping wells.

5.6.3 *Significance of Impacts*

The sensitivity of surface water, groundwater and soil quality is considered to be medium within the Mann Oil Field as these resources are used by the community for drinking, irrigation and cultivation activities. Terrestrial and aquatic habitats as well as the associated flora and fauna are considered as of low sensitivity as revealed by the baseline survey findings.

On the assumption that the WMP will be properly implemented and WBM and KCl polymer mud with negligible toxicity will be used, the impact magnitude associated with the improper disposal of drilling muds and cuttings is considered to be small. The significance of impacts is thus ranked as **Minor** for surface water, groundwater and soil quality and **Negligible** for terrestrial and aquatic ecological resources.

Table 5.9 ***Impacts from Drilling Activities (Drilling Muds and Cuttings) on Surface Water Quality, Ground Water Quality, Soil Quality, Terrestrial and Aquatic Habitats as well as their Associated Flora and Fauna***

Impact	Impacts on surface water quality, ground water quality, soil quality, terrestrial and aquatic habitats as well as their associated flora and fauna.				
Impact Nature	Negative	Positive	Neutral		
Impact Type	Direct	Indirect	Induced		
Impact Duration	Temporary	Short-term	Long-term	Permanent	
Impact Extent	Local	Regional	International		
Impact Scale	Impact scale is expected to be small with negligible toxicity of the drilling muds and cuttings and their proper treatment and disposal under the WMP.				
Frequency	Occurred when there is drilling activity.				
Impact Magnitude	Positive	Negligible	Small	Medium	Large
Resource Sensitivity	Low	Medium	High		
Impact Significance	Negligible	Minor	Moderate	Major	

5.6.4 *Additional Mitigation, Management and Monitoring*

Since the significance of impacts is considered negligible to minor with exiting control measures, additional measures are not considered necessary. However, as industrial best practices the following mitigation measures are recommended to be implemented:

- Careful selection of the fluid system. When selecting chemical additives, technical requirements, additive concentration, toxicity, bioavailability and bioaccumulation potential should be taken into account to minimize environmental hazards to their use and disposal.

- Monitoring the concentration of heavy metal impurities (mainly mercury and cadmium) in barite stock in the fluid formulation, if used.

5.6.5 Significance of Residual Impacts

Provided that mitigation measures are followed, the residual impacts are expected to be Negligible.

5.7 IMPACTS FROM MOBILE POWER GENERATION ON TERRESTRIAL FAUNA

5.7.1 Source of Impact

Mobile power generators will be used during the construction phase of the EOR and re-development programme. These generators, which may present in nearby all works areas, will give rise to noise emissions and vibration which in turn will have the potential to modify the movement and behaviour of terrestrial fauna. The most common response to disturbance is active avoidance of an area with associated ecological effects (e.g. move from an individual's territory, disturbance of breeding activities etc.). Affected fauna are likely to include the six (6) mammal species recorded during the baseline survey, such as Gray squirrel and Myanmar hare.

5.7.2 Existing/ In Place Controls

Measures to control/ minimise adverse impacts will include:

- Specifications of power generator.
- Project activities limited to daylight hours.

5.7.3 Significance of Impacts

While disturbance effects have the potential to occur, they will be temporary in nature and local in scale as temporarily displaced terrestrial fauna will be expected to move back into an area once activities at a location have ceased. In addition, fauna species presented at the works areas, which are mostly developed area, are expected to be well-adapted to disturbance due to the existing oil and gas operations. The impact magnitude is thus expected to be small. The sensitivity of terrestrial fauna is considered to be low as species of recognised conservation interest was not recorded during the baseline survey. Provided that the existing/in place controls are followed, the impact of disturbance to terrestrial fauna due to mobile power generation is ranked of **Negligible** significance.

Table 5.10 Assessment of Impacts on Terrestrial Fauna due to Mobile Power Generation

Impact	Impacts on terrestrial faun due to mobile power generation.			
Impact Nature	Negative	Positive	Neutral	
Impact Type	Direct	Indirect	Induced	
Impact Duration	Temporary	Short-term	Long-term	Permanent
Impact Extent	Local	Regional	International	
Impact Scale	Exact extent of indirect affects unknown but considered local. Also, impact scale is expected to be small to fauna which should have adapted to disturbances by existing oil and gas activities.			
Frequency	During daylight operation of generators.			
Impact Magnitude	Positive	Negligible	Small	Medium	Large
Resource Sensitivity	Low	Medium	High	
Impact Significance	Negligible	Minor	Moderate	Major

5.7.4 *Additional Mitigation, Management and Monitoring*

The assessment indicates potential impacts associated with mobile power generations are expected to be negligible and hence no further mitigations are required.

5.7.5 *Significance of Residual Impacts*

The residual impact of mobile power generation to terrestrial fauna is expected to be **Negligible.**

5.8 *IMPACTS FROM EXCAVATION, SITE PREPARATION / CLEARANCE & CREATION OF ADDITIONAL ACCESS ROUTES ON TERRESTRIAL ECOLOGICAL RESOURCES (I.E. HABITATS, FLORA AND FAUNA)*

5.8.1 *Source of Impact*

Development of access routes for equipment and workforce may be required during construction phase of the Project to undertake the EOR and re-development activities at the works areas. The Project team may also need to undertake excavation and site clearance at the works areas. Direct impacts to terrestrial ecology associated with these activities will include habitat and vegetation loss within the footprint of the associated works area as well as potential loss of inactive or less mobile wildlife (e.g. herpetofauna) that are nesting in or inhabiting the affected area.

Apart from the above direct impacts, indirect impacts to terrestrial fauna may occur as a result of the linear constructions of access routes within forest habitat, such as shrubland of the Project Area. The linear construction of access routes can lead to detrimental ecological effects on wildlife populations due to creation of fragmentation and edge effects [1]. For instance, due to predator avoidance behaviours, some terrestrial fauna may have a tendency to

[1] Laurance, W., Goosem, M. and Laurance, S. (2009) Impacts of roads and linear clearings on tropical forests. Elsevier Ltd, doi:10.1016/j.tree.2009.06.009

stay away from access routes / works area which may impede movements across areas. On the other hand, linear constructions can facilitate movements of predators across areas which could change predator-prey relationships.

5.8.2 Existing/ In Place Controls

Measures to control/ minimise adverse impacts will include:

- On the basis that vegetation clearance for access routes will be undertaken using hand tools, it is assumed that felling of large perennial vegetation (i.e. large trees) will be avoided.

- Minimize footprint of access roads at the design stage (width of any new road should be less than 5 m).

- Induction training for personnel is recommended to include a mandatory segment on biodiversity. In this induction details of key requirements will be provided to include:

    - Outline vegetation clearance procedures including species and upper size limit of tree that can be felled.

    - What to do in the advent of disturbing fauna species (eg snakes) (both from an occupational safety and biodiversity perspective).

5.8.3 Significance of Impacts

Provided that the EOR and re-development programme will mostly be implemented at existing facilities which are developed area typically with low density of vegetation and fauna, direct impacts on terrestrial habitat and the associated fauna and flora are expected to be of small magnitude. Given that sensitivity of potentially affected habitats, fauna and flora are considered low with no species of recognised conservation interest recorded, the significance of impacts is ranked as **Minor**.

Works areas of the Project will mostly be located near / at existing facilities (i.e. developed area) with established access routes. As such, it is expected that construction of access routes for the Project would not be extensive and is not anticipated to affect fauna within the shrubland which are more susceptible to fragmentation and edging effects. In addition, fauna species presented at the works areas, which are mostly developed area, are expected to be well-adapted to disturbance due to the existing oil and gas operations. The potential indirect impacts to fauna as a result of fragmentation and edging effects would thus be of small magnitude. Sensitivity of terrestrial fauna is considered low with no species of recognised conservation interest recorded. Significance of potential indirect impacts to fauna is thus ranked as **Negligible**.

Table 5.11 ***Assessment of Impacts of Direct Loss of Terrestrial Habitat, Flora and Fauna due to Excavation, Site Preparation / Clearance & Creation of Additional Access Routes.***

Impact	Impacts of direct loss of terrestrial habitat, flora and fauna.				
Impact Type	Direct		Indirect		Induced
Impact Duration	Temporary	Short-term		Long-term	Permanent
Impact Extent	Local		Regional		International
Impact Scale	Small as EOR and re-development programme will mostly be implemented at existing facilities which are developed area typically with low density of vegetation and fauna.				
Frequency	Occur only during the construction phase.				
Impact Magnitude	Positive	Negligible	Small	Medium	Large
Resource Sensitivity	Low		Medium		High
Impact Significance	Negligible	Minor		Moderate	Major

Table 5.12 ***Assessment of Indirect Impacts on Terrestrial Fauna due to Excavation, Site Preparation / Clearance & Creation of Additional Access Routes.***

Impact	Indirect impacts to terrestrial fauna.				
Impact Nature	Negative		Positive		Neutral
Impact Type	Direct		Indirect		Induced
Impact Duration	Temporary	Short-term		Long-term	Permanent
Impact Extent	Local		Regional		International
Impact Scale	Fragmentation and edging effects would be of small scale as construction of access routes for the Project would not be extensive and is not anticipated to affect fauna within the shrubland which are more susceptible to fragmentation and edging effects. In addition, fauna are expected to be adapted to disturbance due to existing oil and gas operations.				
Frequency	Occur only during the construction phase.				
Impact Magnitude	Positive	Negligible	Small	Medium	Large
Resource Sensitivity	Low		Medium		High
Impact Significance	Negligible	Minor		Moderate	Major

5.8.4 Additional Mitigation, Management and Monitoring

The assessment indicates potential impacts are expected to be negligible and hence no further mitigations are required.

5.8.5 Significance of Residual Impacts

Provided that the mitigations are followed, the residual impact is expected to be **Negligible**.

5.9 *IMPACTS FROM IMPROPER DISPOSAL OF SOLID WASTES ON SURFACE WATER QUALITY, GROUNDWATER QUALITY, SOIL QUALITY AS WELL AS TERRESTRIAL AND AQUATIC ECOLOGICAL RESOURCES (I.E. HABITATS, FLORA AND FAUNA)*

5.9.1 *Source of Impact*

Activities during the construction phase will include structure assembly, transportation, temporary storage and civil construction. These construction activities will generate a variety of solid wastes which can be categorized based on their nature and the options for disposal, such as general construction waste (inert wastes, scrap metals/metal off-cuts, wood, cardboard, paper and some plastics) and general refuse (food residues, paper, used bottles and cans, packaging and broken furniture). The handling, storage, transport and disposal of these wastes has the potential to result in impacts to quality of surface water, groundwater, soil as well as terrestrial and aquatic ecological sources in the event of inappropriate waste management.

Construction of the EOR facilities and the re-development activities may also generate hazardous waste such as oily rags, paints and chemicals. Hazardous wastes can pose serious environmental hazards without proper management plan during handling, storage, transportation and disposal. Potential impacts may include:

- Water quality impact if hazardous wastes are discharged to watercourses or from runoff from inappropriately stored hazardous waste;
- Soil quality impact in the form of contamination and impact to groundwater quality if hazardous wastes are disposed of to land or containers leak; and
- Indirect impacts to terrestrial and aquatic ecological sources due to deterioration of surface water, groundwater and soil quality.

5.9.2 *Existing/ In Place Controls*

Measures to control/ minimise adverse impacts will include those specified in MPRL E&P WMP for the Mann Oil Field:

- Waste materials will be segregated at source of generation and properly stored in labelled color bins assigned for general waste, recyclable waste, hazardous waste and organic waste.
- The segregated wastes will be transported to the waste management compound daily for proper temporary storage. The waste management compound will be managed by an experienced environmental team.
- Recyclable wastes will be collected by an approved third party contractor.
- Compostable organic wastes will be treated by composting and the products will be used to fertilize and condition soil.

- Non-compostable wastes will be incinerated in properly designed mobile incinerator. The residual solids from incineration will be used for composting.

- Hazardous wastes will be collected for proper disposal by approved third party contractor. Hazardous wastes which cannot be collected by the contractor will be buried underground in concrete bunker.

5.9.3 *Significance of Impacts*

The impact magnitude is expected to be small given propoer implementation of the wastes management measures. The resource/receptor sensitivity is considered medium for surface water, groundwater and soil quality and low for terrestrial and aquatic ecological resources. The impact significance is thus considered **Minor** for surface water, groundwater and soil quality and **Negligible** for terrestrial and aquatic ecological resources.

Table 5.13 ***Assessment of Impacts from Solid Waste Disposal on Surface Water Quality, Ground Water Quality, Soil Quality, Terrestrial and Aquatic Habitats as well as their Associated Flora and Fauna***

Impact	Impacts on surface water quality, ground water quality, soil quality, terrestrial and aquatic habitats as well as their associated flora and fauna.				
Impact Nature	Negative	Positive	Neutral		
Impact Type	Direct	Indirect	Induced		
Impact Duration	Temporary	Short-term	Long-term	Permanent	
Impact Extent	Local	Regional	International		
Impact Scale	Impact scale is expected to be small with proper WMP implementation.				
Frequency	Continuous during the construction phase				
Impact Magnitude	Positive	Negligible	Small	Medium	Large
Resource Sensitivity	Low	Medium	High		
Impact Significance	Negligible	Minor	Moderate	Major	

5.9.4 *Additional Mitigation, Management and Monitoring*

Since the significance of impacts is considered negligible to minor with exiting control measures, additional measures are not considered necessary. However, as industrial best practices it is recommended that induction training for Project personnel should include the waste management system.

5.9.5 *Significance of Residual Impacts*

Provided the mitigations are followed, the residual impact of surface water quality, ground water quality, soil, terrestrial habitats and aquatic habitats and their associated flora and fauna in the Project Area is ranked as **Negligible**.

5.10 IMPACTS FROM IMPROPER WASTEWATER DISCHARGE ON SURFACE WATER QUALITY, GROUND WATER QUALITY, SOIL, TERRESTRIAL HABITATS AND AQUATIC HABITATS AS WELL AS THEIR ASSOCIATED FLORA AND FAUNA

5.10.1 Source of Impact

Domestic-type wastewater and sewage will arise from the construction workforce. With an assumed sewage generation rate of 0.19m^3 per worker per day [1] , up to about 14 m^3 of sanitary wastewater will be generated per day from the camp site within the Mann Oil Field which can accommodate 70 workers. Discharged wastewater is generally characterized as having a high concentration of solids (suspended and dissolved), BOD and COD, nutrients (ammonia) and faecal coliform counts. Mis-management of sewage and wastewaters would have the potential to result in contamination of surface water, ground water and soil, which may result in localized ecological contamination and impacts to terrestrial and aquatic ecological resources.

Surface run-off from the construction site, particularly following heavy rains and during flooding, could have potential impacts on water quality of surface waters. Surface run-off from the site could contain high levels of SS. It may also contain contaminants washed out during rainstorms such as from accidentally spilled fuels (eg petroleum, gasoline and waste oil) or leaks from machinery (eg lubricants).

5.10.2 Existing/ In Place Controls

Measures to control/ minimise adverse impacts from wastewater discharge will include:

- Sanitary wastewater will be collected in the septic holding tanks to be located at the construction camp and a retained licensed firm will periodically clean and service the septic holding tanks.

- The discharge of treated sanitary wastewater should meet guideline levels in *IFC General EHS Guidelines* as shown in *Table 5.14* as far as possible.

Table 5.14 Indicative Values for Treated Sanitary Sewage Discharges

Pollutants	Guideline Values
pH	6-9
BOD (mg/L)	30
COD (mg/L)	125
Total Nitrogen (mg/L)	10
Total Phosphorus (mg/L)	2
Oil and Grease (mg/L)	10
Total Suspended Solids (mg/L)	50
Total Coliform Bacteria MPN / 100 mL	400

Note: *Table 1.3.1* in *IFC EHS General Guidelines.*

(1) EPD Hong Kong 2005. Technical Paper Guidelines for Estimating Sewage Flows for Sewage Infrastructure Planning. Available at: http://www.epd.gov.hk/epd/sites/default/files/epd/english/environmentinhk/water/guide_ref/files/gesf.pdf

Measures to control/ minimise adverse impacts from surface run-off discharge will include:

- Storm water run-off will be routed to a pond to remove silt particles before discharge via storm drain.
- Earthworks to form the final surfaces will be followed up with surface protection and drainage works to prevent erosion caused by rainstorms.
- Appropriate surface drainage will be designed and provided where necessary.
- Surface runoff from potential sources of contamination will be prevented.
- All drainage facilities and sediment control structures will be inspected on a regular basis and maintained to confirm proper and efficient operation at all times and particularly during rainstorms. Deposited silt and grit will be removed regularly.
- Runoff from areas without potential sources of contamination will be minimized (e.g. by minimizing the area of impermeable surfaces) and the peak discharge rate will be reduced (e.g. by using vegetated swales and retention ponds).
- Oil water separators and grease traps will be installed and maintained as appropriate at refueling facilities, workshops, parking areas, fuel storage and containment areas, if any.
- The discharge point of treated sewage effluent to surface water (location not confirmed based on existing project design) will be located where there is adequate assimilative capacity of the surface waters.

5.10.3 Significance of Impacts

Provided that the the existing mitigation meausres are properly implemented, it is expected that impacts from wastewater discharge and surface run-off on surface water, groundwater and soil quality as well as terrestrial and aquatic ecological resources would be of **Negligible** to **Minor** significance.

Table 5.15 ***Significance of Impacts on Water and Soil Quality and associated Terrestrial and Aquatic Ecological Resources from Wastewater Discharge and Surface Run-off***

Impact	Impacts from wastewater discharge and surface run-off on water and soil quality as well as the associated terrestrial and aquatic ecological resources.				
Impact Nature	Negative	Positive	Neutral		
Impact Type	Direct	Indirect	Induced		
Impact Duration	Temporary	Short-term	Long-term	Permanent	
Impact Extent	Local	Regional	International		
Impact Scale	The impact is estimated to be point-based source from the Project Area.				
Frequency	Throughout the construction phase				
Impact Magnitude	Positive	Negligible	Small	Medium	Large
Resource Sensitivity	Low	Medium	High		
Impact Significance	Negligible	Minor	Moderate	Major	

5.10.4 Additional Mitigation, Management and Monitoring

The assessment indicates impacts from wastewater and sewage are expected to be negligible to minor, hence additional mitigation measures are not recommended.

5.10.5 Significance of Residual Impacts

With the implementation of in place controls, the residual impact of wastewater discharge is ranked as **Negligible** to **Minor**.

OPERATIONAL PHASE

5.11 IMPACTS FROM MOBILE POWER GENERATION ON TERRESTRIAL FAUNA

5.11.1 Source of Impact

During operation phase of the Project, mobile power generators will be used at the EOR and re-developed areas. The generators will give rise to noise emissions and vibration which in turn will have the potential to modify the movement and behavior of terrestrial fauna.

5.11.2 Significance of Residual Impacts

The mitigation measures and residual impact significance of mobile power generation to terrestrial fauna are as previously discussed in *Section 5.7.* The residual impact is expected to be of **Negligible** significance.

5.12 IMPACTS FROM CONSUMPTIVE USE OF SURFACE WATER AND GROUNDWATER RESOURCES ON USE OF NATURE RESOURCES

5.12.1 Source of Impact

EOR will require significant quantities of water over and above primary recovery methods and it has been estimated by other study that one (1) to six (6) barrels of fresh water is needed for each barrel of oil recovered [1] . Of the available EOR methods, chemical method adopted for the Project has generally been considered as having the greatest potential for adverse impacts on surface water and groundwater resources due to consumptive use because water consumed would be equal to or greater than other methods, such as thermal EOR method. The consumptive use of surface water and groundwater during the EOR process may result in a water shortage in the area for the local community. Due the site visit in May 2015, it is observed the well sites are generally closer to the groundwater wells than the rivers. As such, it is assumed that the consumptive use will mostly be on groundwater within the Mann Oil Field.

5.12.2 Existing/ In Place Controls

No existing / in place controls have been identified for the consumptive use of surface water for the EOR process.

5.12.3 Significance of Impacts

As discussed in *Section 4.3.1, t*he Mann Oil Field is located on the eastern boundary of the Ayeyarwady River which is the largest river in Myanmar. Other tributaries flowing from west to east within the Mann Oil Field included Yaw, Salin and Mann. The river and tributaries are the key source of surface water in the Mann Oil Field. For groundwater the Mann Oil Field is located within the Ayeyarwady River Basin which has the highest groundwater potential in Myanmar. Water supply from the surface water and groundwater appeared to be sufficient, however, considering that large volume of surface water may be required of the EOR process using chemical injection as well as the sensitive use of water by the local community for drinking and agricultural purpose, the significance of the impacts is considered to be **Moderate**.

[1] Mansoor Zeveidavianpoor and Madjid Jalilavi (2014) Qualitative Analysis of enhanced oil recovery: impacts on air, surface water and groundwater. International Conference on Checmial, Environment and Biological Sciences (CEBS-2014).

Table 5.16 Assessment of Impacts due to Consumptive Use of Surface Water Resources

Impact	Impacts due to consumptive use of surface water resources.				
Impact Type	Direct		Indirect		Induced
Impact Duration	Temporary	Short-term		Long-term	Permanent
Impact Extent	Local		Regional		International
Impact Scale	local community in the Project Area				
Frequency	Through the life of the project				
Impact Magnitude	Positive	Negligible	Small	Medium	Large
Resource Sensitivity	Low		Medium		High
Impact Significance	Negligible	Minor		Moderate	Major

5.12.4 *Additional Mitigation, Management and Monitoring*

For the purpose of minimizing the impacts on the surface water and groundwater due to consumptive use by the Project, the local community will be engaged and a water use agreement will be formulated, which would minimize the pressure on the source water and ensure adequate water availability for the community.

5.12.5 *Significance of Residual Impacts*

The potential impacts on the source water for the project are likely to be **Minor**.

5.13 *IMPACTS FROM THE USE OF CHEMICALS FOR EOR PROCESS ON GROUNDWATER QUALITY*

5.13.1 *Source of Impact*

During the EOR operation, chemicals will be injected to the wells to alter the property of oil for enhanced recovery. The chemicals that may be used for the Project included paraffin dissolvent, paraffin inhibitor, pore point depressant and GreenZyme and their Material Safety Data Sheet (MSDS) are shown in *Annex A*. The injection of chemicals into the well may cause groundwater contamination and information regarding application and toxicity of these chemicals are shown in *Table 3.2* in *Section 3.2.3*.

5.13.2 *Existing/ In Place Controls*

Measures to control/ minimise adverse impacts from use of chemicals on groundwater contamination include:

- The amount of chemical injected in a chemical flood would be as low as practicable and designed to be retained by adsorption, channelling and dilution in the petroleum reservoir.

- Precautionary measures should be developed and implemented to prevent loss of chemical fluids during the EOR process.

5.13.3 Significance of Impacts

Potential for ground water contamination resulting from chemical injections associated with EOR operations appears minimal which is supported by the lack of groundwater contamination problems associated with conventional water floods [1]. According to Zeveidavianpoor and Jalilavi (2014), only 74 groundwater injection problems resulted from operating 44,000 injection wells in Texas between 1960 and 1975 and only three (3) of these occurred during the last decade. Because EOR injection operations are similar to water floods, generally using the same injection wells in the same formations, an increase in the rate of ground water contamination is not expected for EOR injection using chemicals. However, given that chemical injections may occur daily during EOR operation, impacts from use of chemicals on groundwater quality are considered to be of **Moderate** significance.

(1) Mansoor Zeveidavianpoor and Madjid Jalilavi (2014) Qualitative Analysis of enhanced oil recovery: impacts on air, surface water and groundwater. International Conference on Checmial, Environment and Biological Sciences (CEBS-2014).

Table 5.17 Assessment of Impacts on Water, Soil, Habitats, Flora and Fauna (Accidental Spillage and Leaks)

Impact	Impacts from spills/leaks on water, soil, habitats, flora and fauna.				
Impact Type	Direct		Indirect		Induced
Impact Duration	Temporary	Short-term		Long-term	Permanent
Impact Extent	Local		Regional		International
Impact Scale	Impact scale is expected to be medium considering that groundwater contamination appears to be minimal from historical records and daily occurrence of chemical injections.				
Frequency	Daily throughout the EOR activities				
Impact Magnitude	Positive	Negligible	Small	Medium	Large
Resource Sensitivity	Low		Medium		High
Impact Significance	Negligible	Minor		Moderate	Major

5.13.4 *Additional Mitigation, Management and Monitoring*

As an addition measures, it is recommended that a groundwater monitoring programme should be developed to monitor groundwater quality before, during the after the EOR activities. Should significant groundwater contamination be detected, appropriate remedial measures should be developed to mitigate such impact.

5.13.5 *Significance of Residual Impacts*

Provided that mitigations are in place, the residual impact is ranked as **Minor**.

5.14 *IMPACTS FROM IMPROPER DISPOSAL OF SOLID WASTES ON SURFACE WATER QUALITY, GROUNDWATER QUALITY, SOIL QUALITY AS WELL AS TERRESTRIAL AND AQUATIC ECOLOGICAL RESOURCES (I.E. HABITATS, FLORA AND FAUNA)*

5.14.1 *Source of Impact*

During the operation phase, the EOR activities and the operational workforce will generate a variety of solid wastes such as general refuse (food residues, paper, used bottles and cans, packaging and broken furniture) which is non-hazardous in nature. In addition, hazardous waste such as oily rags, paints and used chemicals may also be generated. Improper disposal of hazardous and non-hazardous wastes has the potential to contaminate surface water, ground water and soil with hydrocarbons or chemicals and indirectly affecting the associated aquatic or terrestrial fauna.

5.14.2 *Significance of Residual Impacts*

The mitigation measures and residual impact significance of improper disposal of solid wastes are as previously discussed in *Section 5.9*. The residual impact is expected to be of **Negligible** significance.

5.15 IMPACTS FROM IMPROPER DISPOSAL OF WASTEWATER AND SLUG ON SURFACE WATER QUALITY, GROUND WATER QUALITY, SOIL, TERRESTRIAL HABITATS AND AQUATIC HABITATS AS WELL AS THEIR ASSOCIATED FLORA AND FAUNA

5.15.1 *Source of Impact*

Domestic-type wastewater and sewage will arise from the operational workforce. With an assumed sewage generation rate of 0.19m^3 per worker per day [1], up to about 14 m^3 of sanitary wastewater will be generated per day from the camp site within the Mann Oil Field which can accommodate 70 workers. Surface run-off from the EOR and re-developed area, particularly following heavy rains and during flooding, could have potential impacts on water quality of surface waters through contamination. Please refer to *Section 5.10.1* for detailed discussion regarding potential impacts to wastewater discharge and surface run-off.

In addition to the above, produced water will be generated from the EOR activities. Produced water typically contains a mixture of inorganic (dissolved salts, trace metals, suspended particles) and organic (dispersed and dissolved hydrocarbons, organic acids) compounds and for the case of EOR residual chemical additives (e.g. scale and corrosion inhibitors). Treatment of the produced water will also produce slug. Improper discharge of produced water and disposal of slug may cause potential impacts on the receiving environment (i.e. soil, surface water and ground water) as well as terrestrial and aquatic ecological resources.

5.15.2 *Existing/ In Place Controls*

Please refer to *Section 5.10.2* for measures to control/ minimise adverse impacts from wastewater discharge and surface run-off.

For the produced water and slug, existing / in place controls include:

- In order to reduce the concentration of chemicals in produced water, the amount of chemical injected in a chemical flood would be designed to be retained by adsorption, channelling and dilution in the petroleum reservoir. Chemicals dissolved in the produced brines will be recycled through the brine treatment system and reinjected into the reservoir. Chemicals dissolved in the oil will be transported to the refinery to be processed as a part of the crude oil.

- A proper produced water treatment system will be installed. Oil recovered from the produced water will be collected and pumped back to process tank. Slug from the treatment process will be buried underground and enclosed in appropriate plastic liner. Treated

(1) EPD Hong Kong 2005. Technical Paper Guidelines for Estimating Sewage Flows for Sewage Infrastructure Planning. Available at: http://www.epd.gov.hk/epd/sites/default/files/epd/english/environmentinhk/water/guide_ref/files/gesf.pdf

wastewater, with oil and slug content reduced and has undergone biological treatment as needed, will be dumped in dumping wells.

5.15.3 *Significance of Impacts*

As discussed in *Section 5.10.3,* it is expected that impacts from wastewater discharge and surface run-off on surface water, groundwater and soil quality as well as terrestrial and aquatic ecological resources would be of **Negligible** to **Minor** significance provided that the existing mitigation measures are properly implemented.

Produced water and slug will be produced daily during operation of the Project and would be one of the largest waste products by volume. It is expected that with proper design on the use of chemicals for the EOR process and appropriate treatment and disposal of the produced water and slug, impacts from produced water and slug would also be of **Minor to Moderate** significance on surface water, groundwater and soil quality as well as terrestrial and aquatic ecological resources.

Table 5.18 ***Significance of Impacts on Water and Soil Quality and associated Terrestrial and Aquatic Ecological Resources from Wastewater Discharge and Disposal of Slug***

Impact	Impacts from wastewater discharge, surface run-off and slug disposal on water and soil quality as well as the associated terrestrial and aquatic ecological resources.				
Impact Nature	Negative		Positive		Neutral
Impact Type	Direct		Indirect		Induced
Impact Duration	Temporary	Short-term		Long-term	Permanent
Impact Extent	Local		Regional		International
Impact Scale	The impact scale is expected to be medium for produced water and slug due to the large volume generated daily.				
Frequency	Throughout the operation phase				
Impact Magnitude	Positive	Negligible	Small	Medium	Large
Resource Sensitivity	Low		Medium		High
Impact Significance	Negligible	Minor		Moderate	Major

5.15.4 *Additional Mitigation, Management and Monitoring*

Regarding produced water, it is recommended that produced water to be discharged should meet guideline levels in *IFC EHS Guidelines for Onshore Oil and Gas Development* as shown in *Table 5.19* as far as possible.

Table 5.19 Indicative Values for Produced Water Discharges

Pollutants	Guideline Values
Total hydrocarbon content (mg/L)	10
pH	6-9
BOD (mg/L)	25
COD (mg/L)	125
Phenols (mg/L)	0.5
Sulfides (mg/L)	1
Heavy metals (total) (mg/L)	5
Chlorides (average) (mg/L)	600
Chlorides (maximum) (mg/L)	1,200

Note: *Table 1.1.1* in *IFC EHS Guidelines for Onshore Oil and Gas Development (2007)*

5.15.5 Significance of Residual Impacts

With the implementation of addition mitigation, the residual impact of is ranked as **Negligible** to **Minor**.

5.16 IMPACTS FROM GAS VENTING ACTIVITIES ON AMBIENT AIR CONDITION

5.16.1 Source of Impact

During operation, gas venting will be undertaken at approximately 80 wells in the Mann Oil Field. In venting, the natural gases associated with the oil and gas production are released directly to the atmosphere and not burned. According to data on gas composition provided by MPRL E&P, gas vented from the well will comprise mostly of methane (CH_4) with negligible content of hydrogen sulfide (H_2S). Methane is non-toxic in nature. For H_2S, it is toxic, flammable, explosive and corrosive. These gaseous emissions have the potential to affect sensitive residential receptors.

The existing wells are located at various locations across the Mann Oil Field in agricultural land or shrubland and are mostly remote from sensitive receiver locations. A small proportion of wells are relatively nearby existing MPRL office, which is considered as ASR of medium sensitivity. The wells that selected for venting will be planned based on the outcome of the geological studies, and good maintenance and operating strategies will be taking into account to keep gas venting volume as low as practicable.

5.16.2 Existing/ In Place Controls

Measures to control/ minimise adverse impacts on air.

- Activities carried out at existing well sites in the oil field which are mostly remoted from the ASRs.
- Good maintenance and operating strategies will be taking into account to keep gas venting volume as low as practicable
- SMART Jack will be considered to install to further reduce gaseous emissions from the vents.

5.16.3 *Significance of Impacts*

According to data provided by MPRL E&P, gas venting will be undertaken at a total of 80 wells. The estimated rate of gaseous emission is ~0.001 MMcfd per day from each well and thus only a small amount of ~0.08 MMcfd of gases will be emitted from venting per day from the 80 wells. Methane is the major component of the emissions which is non-toxic in nature. The amount of hydrogen sulfide, which is toxic, is negligible according to gas composition data provided by MPRL E&P. As such, the magnitude of impact is considered as small. The existing wells are located at various locations across the Mann Oil Field and are mostly remote from sensitive receiver locations. A small proportion of wells are relatively nearby existing MPRL office, which is considered as ASR of medium sensitivity.

The combination of a medium receptor sensitivity and small impact magnitude will result in an overall **Minor** potential impact.

Table 5.20 Assessment of Impacts on Ambient Air Conditions during Venting

Impact	Air impact from venting				
Impact Type	Direct	Indirect	Induced		
Impact Duration	Temporary	Short-term	Long-term	Permanent	
Impact Extent	Local	Regional	International		
Impact Scale	Limited to the Project Area and hence would be considered to be local, however, winds may potentially carry emissions into surrounding communities.				
Frequency	Well venting period.				
Impact Magnitude	Positive	Negligible	Small	Medium	Large
Resource Sensitivity	Low	Medium	High		
Impact Significance	Negligible	Minor	Moderate	Major	

5.16.4 *Additional Mitigation, Management and Monitoring*

Since the significance of impacts is considered minor with exiting control measures, additional measures are not considered necessary. However, as industrial best practices the following mitigation measures are recommended to be implemented:

- Measures related to fire control should be strictly followed.
- Avoid venting or reduce the number of venting well as far as practicable.
- When new vents are to be installed, consideration should be given on toxic gas composition, wind direction, design of venting as well as location and distance from the ASRs to reduce the potential of pollutant dispersal to ASRs.
- Consider flaring instead of venting as far as possible.

- Implement a programme of regular monitoring of gaseous composition of the vented gas and regular air quality monitoring at selected ASRs to identify and properly respond to any unacceptable air quality impacts caused by the venting.

5.16.5 Significance of Residual Impacts

Provided that mitigation measures are followed, the residual impact of gas venting activities on air quality is expected to be **Minor**.

5.17 POSITIVE IMPACTS OF IMPROVED OPERATIONS AFTER RE-DEVELOPMENT ON ALL RELATED PHYSICAL AND BIOLOGICAL RECEPTORS

5.17.1 Source of Impact

As presented in *Section 3.3,* MPRL E&P is undertaking a re-development programme of the Mann Oil Field to improve the environmental performance of the operations. This programme involves iimprovement of pumping unit, refurbishments of the GOCS, flow pipes and drain pits, rehabilitation of shut-in wells and development of produced water treatment system.

It is expected that after the re-development activities, positive impacts would occur to all related physical and biological receptors through reduction of risk of spill, reduction of gaseous and noise emissions, reinstatement of terrestrial habitats and proper waste management within the Mann Oil Field (please refer to *Section 3.3* for detailed discussion regarding the potential positive impacts).

5.17.2 Existing/ In Place Controls

There is no existing / in place controls for the potential positive impacts from the re-development activities.

5.17.3 Significance of Residual Impacts

Residual impact to the environment is expected to be **Positive** after the re-development activities.

ACCIDENTAL EVENTS

5.18 IMPACTS FROM CHEMICAL SPILLS, WELL FAILURE AND RESERVOIR LEAKAGE ON SOIL QUALITY, SURFACE WATER QUALITY, GROUNDWATER QUALITY AS WELL AS TERRESTRIAL AND AQUATIC ECOLOGICAL RESOURCES (I.E. HABITATS, FLORA AND FAUNA).

5.18.1 Source of Impact

During construction of the Project, the key source of accidental spills is expected to be accidental spillage from refuelling of machinery. Spills may also occur at fuel storage compound.

During operation of the EOR, accidental spillage of chemicals may occur at the point of storage (i.e. in chemical storage compound) or application (i.e. at injection wells). Accidental spillage of fuel may also occur from refuelling of machinery at the works area or at fuel storage compound.

Other than operational error, spillage of fuel and chemicals during both construction and operation may be caused by surface run-off from the EOR and re-developed area, particularly following heavy rains and during flooding.

In addition to the above, blowout is another potential accidental spillage event associated with the construction and operation of the Project at the well site. Blowout is regarded as a loss of well control due to kicks with potential for large volume well fluid release volumes to occur at the surface. Well fluids may be hydrocarbons but can also be formation (fresh or salty) water.

The above accidental events have the potential to contaminate surface water, ground water and soil. Exposure to terrestrial and aquatic fauna or uptake of contaminants through plant roots could occur and could lead to direct lethal/non-lethal effects on vegetation and organisms.

5.18.2 Existing/ In Place Controls

Measures to control/ minimise adverse impacts of spills/leaks include:

- Refueling will be carried out in designated areas on hard standing ground to prevent seepage of any spillages to ground. Collection systems will be installed in these areas to manage any spills, fuels will be collected and either reused, treated by incineration or removed by a local contractor. Drip trays must be used when refueling and servicing vehicles or equipment, where it is not on a hard standing.

- Avoid construction of facilities (e.g. chemical storage compound) in a floodplain, whenever practical, and within a distance of 100 m of the normal high-water mark of a water body or a water well used for drinking or domestic purposes.

- Evaluating the risk of existing Underground Storage Tank (UST) to determine if upgrades are required for UST that will be continued to be used, including replacement with new systems or permanent closure of abandoned USTs. Ensuring that new USTs are sited away, as far as practicable, from groundwater wells, reservoirs and other source water protection areas and floodplains, and maintained so as to prevent corrosion.

- Incorporation of siting and safety engineering criteria to prevent failures due to risks posed by flooding. All Project structures should be designed in accordance with engineering and design criteria mandated by site-specific flooding risks.

- Facilities, buildings, plants, and structures should be situated to minimize potential risks from flooding.

- Maintaining a list of external equipment, personnel, facilities, funding, expert knowledge, and materials that may be required to respond to emergencies. The list should include personnel with specialized expertise for spill clean-up, flood control and water treatment.

- The use of competent and well-trained workers for construction and operation.

- Well-planned, well-supervised and standard procedures will be used at the wells to maintain well control (eg management of mud weight).

- Implementation of maintenance and inspection procedures.

5.18.3 Significance of Impacts

Incidental small spills of fuels and chemicals are infrequent but do occur. Malfunction of handling systems and poor handling practices during transfers / refuelling / injection are the most common causes of small spills. These small spills are, however, rare due to the careful handling practices that will be implemented.

Large releases of hazardous materials from process equipment and storage compound are rare because those are designed and built specifically to prevent release. A major spill from well blowout is also unlikely with the in-place controls.

Overall, it is unlikely that a spill would occur and this has thus been factored into the assessment of impact significance.

Soil Quality

The potential of hazardous materials accidentally released to soil at the Project Area is low as the Project will be mostly constructed and operated on developed area. As such, soil exposure will be very limited during both construction and operation of the Project. If spill occurs on soil, the spread would be limited in spatial extent to the immediate surrounding. The overall magnitude of the impact is, however, considered to be medium in case of large scale spillage caused by blowout or flooding. Since the potentially affected soils would be within the Project Area which is intended for industrial activities (e.g. not for agricultural use), sensitivity of the soil is considered to be Low.

The overall significance of potential negative impacts of spill on soil quality is considered to be **Minor.**

Surface Water and Groundwater Quality

Project activities with the potential to lead to accidental spills will generally be limited within the Project Site. The risk of a direct release to the surface water and groundwater is thus very unlikely. It is, however, possible that run-off from the Project Site could transport spilled materials on the ground to the surface water and groundwater depending on spill location and drainage patterns. The concentration of spilled materials released to surface water and groundwater is expected to be very low given the existing mitigation measures such as spill containment provided by bunded area at places where spills are more likely to occur (e.g. storage and handling areas of hazardous materials). The overall magnitude of the impact is, however, considered to be medium in case of large scale spillage caused by blowout or flooding. The sensitivity of surface water and groundwater quality is considered to be Medium due to the use of water by local community for drinking and irrigation.

The overall significance of potential negative impacts of spill on water quality is considered to be **Moderate.**

Terrestrial and Aquatic Habitats and associated Flora and Fauna

Sensitivity of terrestrial and aquatic habitats and their associated flora and fauna is considered low. Given that impacts of spills to soil and water quality are considered to be minor to moderate, the magnitude of indirect impacts to terrestrial and aquatic ecological resources is considered medium.

The overall significance of potential negative impacts of spill on terrestrial and aquatic ecological resources is considered to be **Minor.**

Table 5.21 Assessment of Impacts on Water, Soil, Habitats, Flora and Fauna (Accidental Spillage and Leaks)

Impact	Impacts from spills/leaks on water, soil, habitats, flora and fauna.				
Impact Type	Direct		Indirect		Induced
Impact Duration	Temporary	Short-term		Long-term	Permanent
Impact Extent	Local		Regional		International
Impact Scale	Potentially large for spills caused by flooding and well blowout.				
Frequency	Throughout the construction and operation period.				
Likelihood	Unlikely for large and small spills				
Impact Magnitude	Positive	Negligible	Small	Medium	Large
Resource Sensitivity	Low		Medium		High
Impact Significance	Negligible	Minor		Moderate	Major

5.18.4 Additional Mitigation, Management and Monitoring

- The Project will develop a detailed Spill Response Plan including community sensitization/notifications when required. The Project will maintain spill clean-up and response capability adequate for addressing spills for all phases of the Project. All spills will be immediately

contained and cleaned up. Contaminated areas will be remediated and post remediation verification will be carried out.

- Carefully plan of drilling operation by identifying shallow hazards, using standard materials for well construction/modification, using standard drilling and well control standard operating procedures, and using proper drilling mud formulation with additives if necessary (well kill fluids, loss control and weighting agents).

- Undertake drilling with international best practice safety procedures.

- Test safety devices prior to start-up for function and integrity.

- Continuously monitor pressure in the well and recycled mud during drilling.

- Train employees on emergency procedures.

- Spill kits and shovels at well sites or appropriate locations for any accidental leakage of fuel or other hazardous substances during Project activities. It must be ensured that no such substance enters into groundwater or surface water resources.

- If emergency servicing of equipment is required in the field, spill kits and drip trays will be available.

- Any contaminated soil will be removed from site and disposed of in accordance with the WMP.

- The location, type and quantity of any fuel or chemical or mud spill will be reported to HSE coordinator immediately.

- Improve cellars with double cellars for new and reactivated wells.

5.18.5 Significance of Residual Impacts

With measures to manage accidental spill and leaks associated, it is considered the residual risk can be reduced to **Minor**.

5.19 *IMPACTS FROM FIRES AND EXPLOSIONS CAUSED BY THE ACCIDENTAL EVENTS RELATED TO THE USE OF EXPLOSIVE MATERIALS IN RE-PERFORATION ON AIR QUALITY, GROUND WATER QUALITY, SURFACE WATER QUALITY, SOIL QUALITY, LANDSCAPE AND VISUAL CHARACTER, USE OF NATURAL RESOURCES, TERRESTRIAL HABITATS AND AQUATIC HABITATS AS WELL AS THEIR ASSOCIATED FLORA AND FAUNA.*

5.19.1 *Source of Impact*

Accidental events related to the use of explosive materials in re-perforation may lead to fire and explosions, potentially causing wide scale significant detrimental impacts. In addition, an increase in the number of people who smoke (ie workers) could increase the potential for ignition and uncontrolled fires in the Project Area. Due to the hot and dry climatic conditions that are prevalent in the year, vegetative habitat is dry and therefore fire hazard will typically be significant.

5.19.2 *Existing/ In Place Controls*

Measures to control/ minimise adverse impacts of impacts include:

- Assign designated smoking areas.
- Smoking is only allowed away from the well head of more than 100 feet, up wind, with appropriate ash trays to contain any hot ashes.

5.19.3 *Significance of Impacts*

Impacts from fire outbreaks have been evaluated to result in impacts of up to **Major** significance. This is mostly due to the fact that large habitat area could be lost and crops will be adversely impacted by such events if the event occurs in or in close proximity of agricultural habitat.

Table 5.22 ***Assessment of Impacts on Air, Visual Character, Water, Soil, Habitats, Flora and Fauna (Fire)***

Impact	Impacts from fire and explosions on air, water, soil, habitats, flora and fauna.				
Impact Type	Direct		Indirect		Induced
Impact Duration	Temporary	Short-term		Long-term	Permanent
Impact Extent	Local		Regional		International
Impact Scale	Potentially wide scale within the Project Area.				
Frequency	Could occur during period of re-perforation activity.				
Likelihood	Unlikely				
Impact Magnitude	Positive	Negligible	Small	Medium	Large
Resource Sensitivity	Low		Medium		High
Impact Significance	Negligible	Minor		Moderate	Major

5.19.4 Additional Mitigation, Management and Monitoring

- As administered under the Emergency Preparedness Plan, a Fire Risk Management Plan will be developed including communications protocols and measures to control any fires that do arise.

- Fire control equipment should be located at the well site or appropriate locations.

- Induction training for personnel is recommended to include a mandatory segment on fire safety and actions in the event of a fire.

- It will be of key importance that explosives used for re-perforation activities are kept in a safe manner and no uncontrolled explosions occur. Implement all required safety and management requirements relating to the transportation, storage and handling of explosives

- Misfired charges from re-perforation activities will be disabled and destroyed.

- Conduct fire training and response drills.

5.19.5 Significance of Residual Impacts

With measures to manage fire risk, it is considered the residual risk can be reduced to **Minor**.

Cumulative impacts encompasses impacts that result from the incremental impact, on areas or resources used or directly impacted by the project, from other existing, planned or reasonably defined developments at the time the risks and impacts identification process is conducted. The IFC (2012) defines cumulative impacts as those generally recognised as important on the basis of scientific concerns and or concerns from Affected Communities [1]. Examples given include reduction of water flows in a watershed due to multiple withdrawals, increases in sediment load, increases in traffic congestion and accidents due to increases in vehicular traffic.

Cumulative impacts summarised in this section refer to the additional impacts that may be generated by other developments or activities in the vicinity of the Project Area that when added to the impacts of the proposed EOR and redevelopment activities combine to cause a greater impact. Such impacts may arise due to spatial overlap in an impact (eg overlap in spatial extent of air or water quality changes) or temporal overlap (eg noise impacts caused by construction activities at the same time from different sources).

Within the Mann Oil Field, according to publicly available information no other projects will be constructed or operated concurrently with the proposed EOR and re-development programme. As such, cumulative impacts with other concurrent projects are not expected to occur.

(1) IFC Performance Standards on Environmental and Social Sustainability, January 2012, International Finance Corporation, World Bank Group

7 ENVIRONMENTAL AND MANAGEMENT PLAN

This section provides the Environmental Management Plan (EMP) for the planning, construction and operation of the Project. This EMP provides the procedures and processes which will be applied to the Project activities to check and monitor compliance and effectiveness of the mitigation measures to which MPRL E&P has committed. F In addition, this EMP is used to ensure compliance with statutory requirements and corporate safety and environmental policies.

The remainder of this EMP is structured as follows:

- *Section 7.1* defines the environmental policies of the Project as well as the related legal requirements and institutional arrangements.
- *Section 7.2* presents a summary of environmental impacts associated with the Project, the recommended mitigation measures and the key elements related to the implementation of these measures as well as the overall HSE system of the Project.
- *Section 7.3* presents other detailed management and monitoring plans which are related to this EMP.
- *Section 7.4* presents the emergency response plan for the Project.

7.1 PROJECT ENVIRONMENTAL POLICY AND INSTITUTIONAL ARRANGEMENT

This section sets out the environmental policies which are relevant to the Project as well as the institutional arrangement.

7.1.1 Corporate Environmental Policy

MPRL E&P has adopted a comprehensive HSE Management System. This system is an important and integral part of the company's overall management system and is shown in *Figure 7.1* below. The Project will be required to follow the fundamental goals of::

- Zero accidents;
- No harm to people; and
- No damage to environment.

Figure 7.1 MPRL E&P's HSE Policy

MPRL E&P HSE Policy

MPRL E&P is committed to continuous improvement in Health, Safety and Environmental performance, consistent with our fundamental goals of:

- Zero accidents,
- No harm to people,
- No damage to the environment.

MPRL E&P adheres to and strives to meet the following principles throughout its operations:

- All accidents are preventable.
- No activity is so important that it cannot be done safely.
- Minimize the environmental impact our activities may cause.
- Meet or exceed the requirements of applicable HSE legislation, regulations and Company HSE expectations.
- HSE performance depends on all employees and Contractor personnel working with MPRL E&P. Everyone is responsible for working safely.
- Continually strive to reduce the impact of our business on health, safety and the environment by applying safe work practices, reducing waste, and using energy efficiently.
- Eliminate injuries by rectifying and reporting all actions and conditions, which could result in an accident / incident.
- Conduct appropriate training to ensure all our personnel are competent in their respective jobs and understand and adhere to this policy.
- Ensure business plans and personal objectives include measurable HSE targets, which are established annually and reviewed regularly.

Responsibilities for HSE performance are visible throughout the organization, with clarity for line management accountability. The MPRL E&P Health, Safety and Environment Management System , is fundamental to our business and is applicable to all areas of our operations.

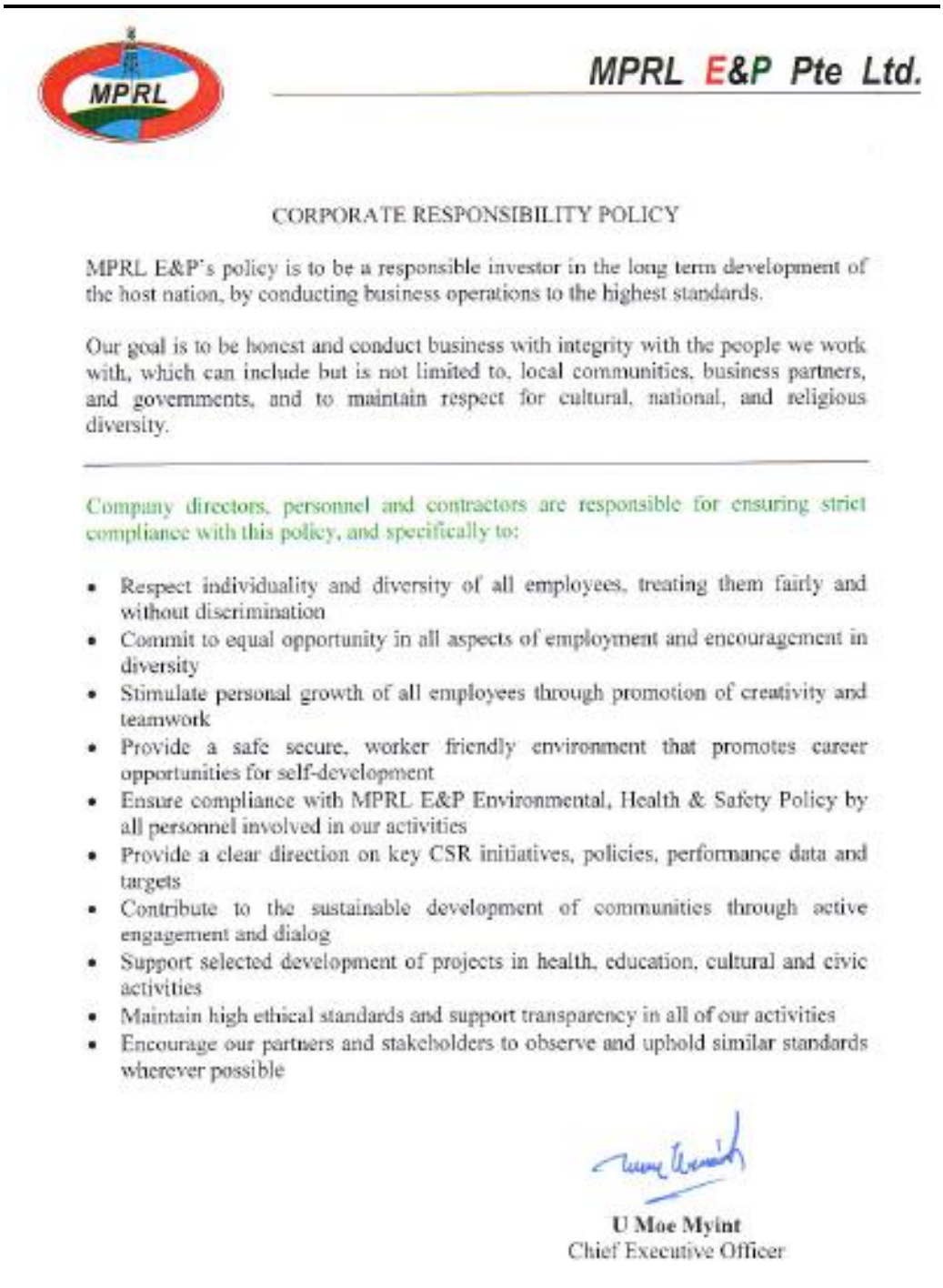
MPRL E&P Senior Management is accountable for implementation of this policy. Implementation is achieved by adhering to our management systems, and where appropriate the management systems used by those who work with us.

U Myo Tin
General Manager
MPRL E&P Pte Ltd.

Date of revision : 13-May-2013

Apart from the HSE policy, MPRL E&P also has in place a corporate responsibility policy and a human rights policy, as can be seen in the following figures

Figure 7.2 MPRL E&P Corporate Responsibility Policy



MPRL E&P Pte Ltd.

CORPORATE RESPONSIBILITY POLICY

MPRL E&P's policy is to be a responsible investor in the long term development of the host nation, by conducting business operations to the highest standards.

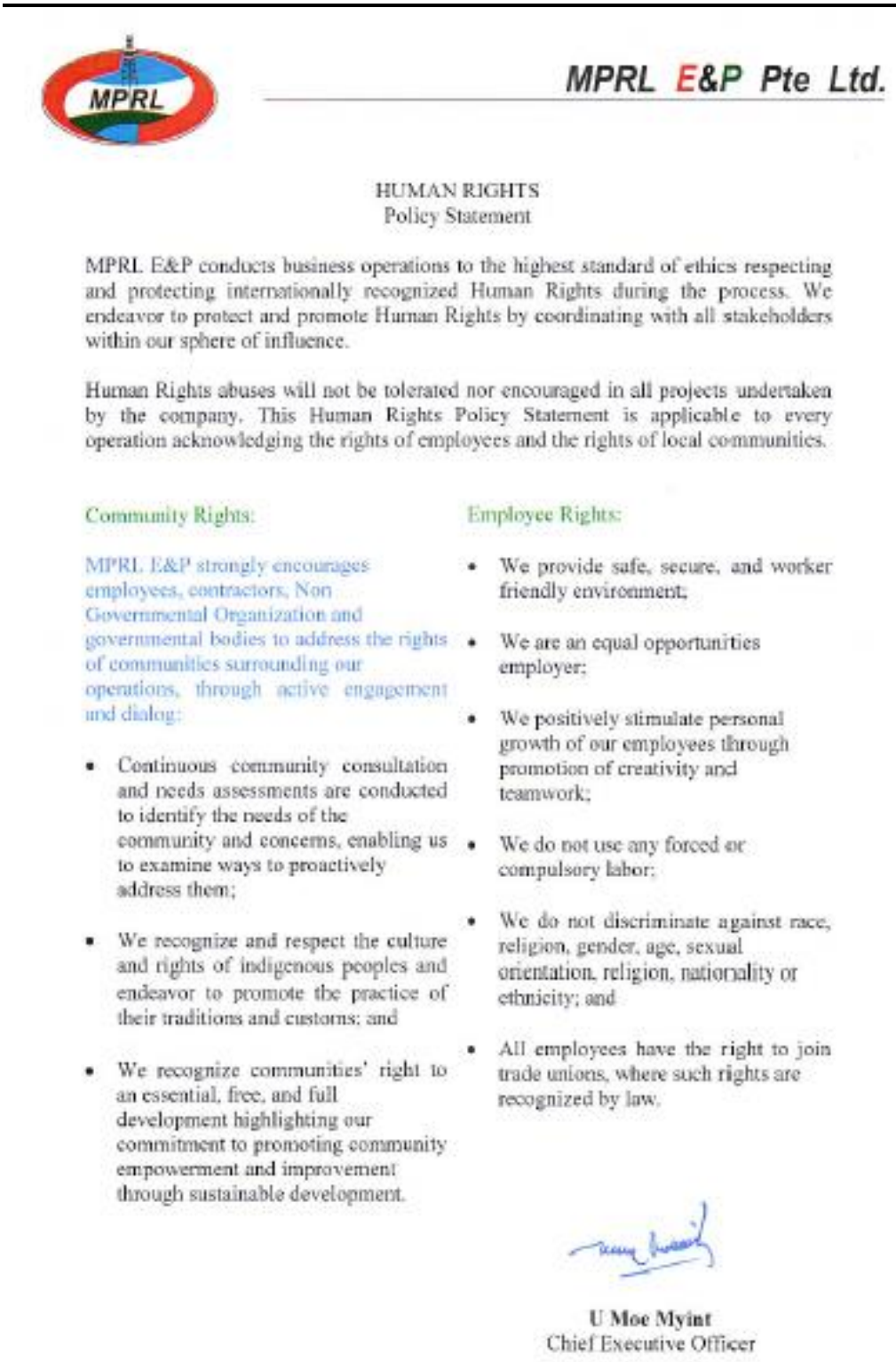
Our goal is to be honest and conduct business with integrity with the people we work with, which can include but is not limited to, local communities, business partners, and governments, and to maintain respect for cultural, national, and religious diversity.

Company directors, personnel and contractors are responsible for ensuring strict compliance with this policy, and specifically to:

- Respect individuality and diversity of all employees, treating them fairly and without discrimination
- Commit to equal opportunity in all aspects of employment and encouragement in diversity
- Stimulate personal growth of all employees through promotion of creativity and teamwork
- Provide a safe secure, worker friendly environment that promotes career opportunities for self-development
- Ensure compliance with MPRL E&P Environmental, Health & Safety Policy by all personnel involved in our activities
- Provide a clear direction on key CSR initiatives, policies, performance data and targets
- Contribute to the sustainable development of communities through active engagement and dialog
- Support selected development of projects in health, education, cultural and civic activities
- Maintain high ethical standards and support transparency in all of our activities
- Encourage our partners and stakeholders to observe and uphold similar standards wherever possible

U Moe Myint
Chief Executive Officer

Figure 7.3 MPRL E&P Human Rights Policy



MPRL E&P Pte Ltd.

HUMAN RIGHTS
Policy Statement

MPRL E&P conducts business operations to the highest standard of ethics respecting and protecting internationally recognized Human Rights during the process. We endeavor to protect and promote Human Rights by coordinating with all stakeholders within our sphere of influence.

Human Rights abuses will not be tolerated nor encouraged in all projects undertaken by the company. This Human Rights Policy Statement is applicable to every operation acknowledging the rights of employees and the rights of local communities.

Community Rights:

MPRL E&P strongly encourages employees, contractors, Non Governmental Organization and governmental bodies to address the rights of communities surrounding our operations, through active engagement and dialog:

- Continuous community consultation and needs assessments are conducted to identify the needs of the community and concerns, enabling us to examine ways to proactively address them;
- We recognize and respect the culture and rights of indigenous peoples and endeavor to promote the practice of their traditions and customs; and
- We recognize communities' right to an essential, free, and full development highlighting our commitment to promoting community empowerment and improvement through sustainable development.

Employee Rights:

- We provide safe, secure, and worker friendly environment;
- We are an equal opportunities employer;
- We positively stimulate personal growth of our employees through promotion of creativity and teamwork;
- We do not use any forced or compulsory labor;
- We do not discriminate against race, religion, gender, age, sexual orientation, religion, nationality or ethnicity; and
- All employees have the right to join trade unions, where such rights are recognized by law.

U Moe Myint
Chief Executive Officer

7.1.2 *Myanmar Regulatory Requirements*

Table 7.1 provides a list of existing laws relevant to environmental aspects of the proposed Project.

Table 7.1 List of Existing Sectorial Laws in Myanmar related to Environmental Issues as of September 2015

Sector	Relevant Laws in Myanmar
Culture	The Protection and Preservation of Cultural Heritage Region Law, 1998
Forestry, Environmental and Natural Resources	The Protection of Wild Life, Wild Plants and Conservation of Natural Areas Law, 1994
	Burma Wild Life Protection Rules, 1941
	The Protection of Wildlife and Conservation of Natural Areas Law - SLORC Law No. 6/94
	The Forest Department Notification No. 583/94
	Environmental Impact Assessment Rules – Draft
	Environmental Conservation Law (March 2012)
	Environmental Conservation Rules (June 2014)
	National Environmental Policy (1994)
	The Conservation of Water Resources and Rivers Law, 2006
Industrial	The Petroleum Act, 1934
Fisheries, Aquaculture and Water	The Underground Water Act (1931)
	The Law Relating to Aquaculture, 1989

In addition to the above existing laws, it is understood that the MOECAF is currently formulating various environmental guidelines and standards, in consultation with financial institution such as the Asian Development Bank (ADB). References to "*Environmental Quality Standards*" *in Article 10, Section 6* of the *Environmental Conservation Law (2012)* are prescribed as follow:

"*The Ministry may stipulate the following* ***environmental quality standards:***

1. *Suitable* ***surface water quality standards*** *in the usage in rivers, streams, canals, springs, marshes, swamps, lakes, reservoirs and other inland water sources of the public;*

2. ***Water quality standards*** *for coastal and estuarine areas;*

3. ***Underground*** *water quality standards;*

4. ***Atmospheric*** *quality standards;*

5. ***Noise and vibration*** *standards;*

6. ***Emissions*** *standards;*

7. ***Effluent*** *standards;*

8. ***Solid wastes*** *standards; and*

9. ***Other*** *environmental quality standards."*

Based on the contents of above Article, it is expected that MOECAF will announce the environmental quality standards for various sectors upon the time that the EIA Regulation or Ordinance comes into force. The Project may

then be required to follow those national standards when they are being announced and enforced.

7.2 *SUMMARY OF IMPACTS AND MITIGATION MEASURES*

Through the Project development and the EIA process, MPRL E&P has made commitments to actions to ensure or improve environmental performance. These commitments are not recommendations, but are binding commitments on the part of the Project.

A summary of the Project impacts and the committed mitigation measures are presented in *Table 7. 2*below. Schedule and responsibility of implementation of these mitigation measures are identified as necessary. Additional details on the key elements for the overall environmental management of the Project are also presented below.

Table 7.2 Summary of the Key Impacts and Control/Mitigation Measures

Potential Impact/Issue	Control / Mitigation Measures	Significance of Residual Impacts	Monitoring	Timing/Frequency	Responsible Party	Related Plans
Environmental Impacts						
CONSTRUCTION PHASE						
Impacts from use of PMEs for installation of EOR facilities and re-development activities (general) on ambient air quality, ambient noise as well as terrestrial ecological resources (i.e. habitats and fauna)	• Construction activities carried out at existing facilities of the Mann Oil Field which are developed area mostly away from sensitive receptors. • Construction activities to be limited to daylight working hours. • Well maintained equipment will be used. • Noise suppression box will be fabricated over the engine for the PMEs being operated nearby the NSRs (e.g. villages). • Appropriate PPE e.g. ear protection will be used for MPRL E&P personnel. • Vegetation cutting by hand to minimise disturbance and degradation of the habitats. • It is assumed felling of large perennial vegetation (i.e. large trees which typically provide habitat for higher densities of terrestrial fauna) will be avoided. • Regular maintenance of equipment such as lubricating moving parts, tightening loose parts and replacing worn out components. • Shut down or throttled down between work periods for machines and construction plant items (eg trucks) that may be in intermittent use. • Shut down generators, compressors, and other equipment when not in use. • Reduce the number of equipment operating simultaneously as far as practicable. • Orientate equipment known to emit noise strongly in one direction so that the noise is directed away from receptors as far as practicable. • Implement control measures, eg erecting temporary noise barriers and deflectors, whenever applicable.	Negligible	Inspection & Compliance Audit	Design Phase & Implementation Phase	MPRL E&P Project Team; MPRL E&P HSE Team	N/A
Impacts from drilling activities on ambient air quality, ambient noise, surface water quality, groundwater quality, soil quality as well as terrestrial and Aquatic ecological resources (i.e. habitats, flora and fauna)	• Proper implementation of MPRL E&P's Waste Management Plan (WMP) for the Mann Oil Field. • Drill muds used will be WBM and KCl polymer mud with negligible toxicity which will be recycled and treated for future use as far as possible. If disposal is required, the cuttings and muds will be dewatered with the residual solid contained in plastic liner and buried underground and residual water injected into dumping wells. • Careful selection of the fluid system. When selecting chemical additives, technical requirements, additive concentration, toxicity, bioavailability and bioaccumulation potential should be taken into account to minimize environmental hazards to their use and disposal. • Monitoring the concentration of heavy metal impurities (mainly mercury and cadmium) in barite stock in the fluid formulation, if used.	Negligible	Compliance Audit	Design Phase	MPRL E&P Project Team; MPRL E&P HSE Team	Waste Management Plan
			Inspection & Compliance Audit	Implementation Phase	MPRL E&P HSE Team	Waste Management Plan; Environmental Monitoring Plan
Impacts from mobile power generation on terrestrial fauna	• Specifications of power generator. • Project activities limited to daylight hours.	Negligible	Compliance Audit	Implementation Phase	MPRL E&P HSE	N/A

Potential Impact/Issue	Control / Mitigation Measures	Significance of Residual Impacts	Monitoring	Timing/Frequency	Responsible Party	Related Plans
Impacts from excavation, site preparation / clearance & creation of additional access routes on terrestrial ecological resources (i.e. habitats, flora and fauna)	• On the basis that vegetation clearance for access routes will be undertaken using hand tools, it is assumed that felling of large perennial vegetation (i.e. large trees) will be avoided. • Minimize footprint of access roads at the design stage (width of any new road should be less than 5 m). • Induction training for personnel is recommended to include a mandatory segment on biodiversity. In this induction details of key requirements will be provided to include: o Outline vegetation clearance procedures including species and upper size limit of tree that can be felled. o What to do in the advent of disturbing fauna species (eg snakes) (both from an occupational safety and biodiversity perspective).	Negligible	Compliance Audit	Implementation Phase	MPRL E&P HSE Team	N/A
Impacts from improper disposal of solid wastes on surface water quality, groundwater quality, soil quality as well as terrestrial and aquatic ecological resources (i.e. habitats, flora and fauna)	• Waste materials will be segregated at source of generation and properly stored in labelled color bins assigned for general waste, recyclable waste, hazardous waste and organic waste. • The segregated wastes will be transported to the waste management compound daily for proper temporary storage. The waste management compound will be managed by an experienced environmental team. • Recyclable wastes will be collected by an approved third party contractor. • Compostable organic wastes will be treated by composting and the products will be used to fertilize and condition soil. • Non-compostable wastes will be incinerated in properly designed mobile incinerator. The residual solids from incineration will be used for composting. • Hazardous wastes will be collected for proper disposal by approved third party contractor. Hazardous wastes which cannot be collected by the contractor will be buried underground in concrete bunker. • Induction training for Project personnel should include the waste management system.	Negligible	Compliance Audit	Implementation Phase	MPRL E&P HSE Team	Waste Management Plan

Potential Impact/Issue	Control / Mitigation Measures	Significance of Residual Impacts	Monitoring	Timing/Frequency	Responsible Party	Related Plans
Impacts from Improper Wastewater Discharge on Surface Water Quality, Ground Water Quality, Soil, Terrestrial Habitats and Aquatic Habitats as well as their Associated Flora and Fauna	• Sanitary wastewater will be collected in the septic holding tanks to be located at the construction camp and a retained licensed firm will periodically clean and service the septic holding tanks. • The discharge of treated sanitary wastewater should meet guideline levels in IFC General EHS Guidelines. • Storm water run-off will be routed to a pond to remove silt particles before discharge via storm drain. • Earthworks to form the final surfaces will be followed up with surface protection and drainage works to prevent erosion caused by rainstorms. • Appropriate surface drainage will be designed and provided where necessary. • Surface runoff from potential sources of contamination will be prevented. • All drainage facilities and sediment control structures will be inspected on a regular basis and maintained to confirm proper and efficient operation at all times and particularly during rainstorms. Deposited silt and grit will be removed regularly. • Runoff from areas without potential sources of contamination will be minimized (e.g. by minimizing the area of impermeable surfaces) and the peak discharge rate will be reduced (e.g. by using vegetated swales and retention ponds). • Oil water separators and grease traps will be installed and maintained as appropriate at refueling facilities, workshops, parking areas, fuel storage and containment areas, if any. • The discharge point of treated sewage effluent to surface water (location not confirmed based on existing project design) will be located where there is adequate assimilative capacity of the surface waters.	Negligible to Minor	Compliance Audit	Design and Implementation Phase	MPRL E&P Project Team; MPRL E&P HSE Team	Waste Management Plan
OPERATIONAL PHASE						
Impacts from Mobile Power Generation on Terrestrial Fauna	• Specifications of power generator • Project activities limited to day light hours	Negligible	Inspection & Compliance Audit	Implementation Phase	MPRL E&P HSE Team	N/A
Impacts from consumptive use of surface water and Groundwater resources on use of nature resources	• For the purpose of minimizing the impacts on the surface water and groundwater due to consumptive use by the Project, the local community will be engaged and a water use agreement will be formulated, which would minimize the pressure on the source water and ensure adequate water availability for the community.	Minor	Compliance Audit	Design Phase AND Implementation Phase	MPRL E&P HSE and Communications Teams	N/A
Impacts from the use of chemicals for EOR process on groundwater quality	• The amount of chemical injected in a chemical flood would be as low as practicable and designed to be retained by adsorption, channelling and dilution in the petroleum reservoir. • Precautionary measures should be developed and implemented to prevent loss of chemical fluids during the EOR process. • As an addition measures, it is recommended that a groundwater monitoring programme should be developed to monitor groundwater quality before, during the after the EOR activities. Should significant groundwater contamination be detected, appropriate remedial measures should be developed to mitigate such impact.	Minor	Inspection & Compliance Audit	Design Phase	MPRL E&P Project Team and MPRL E&P HSE Team	N/A
			Inspection & Compliance Audit	Implementation Phase	MPRL E&P HSE Team	Environmental Monitoring Plan

Potential Impact/Issue	Control / Mitigation Measures	Significance of Residual Impacts	Monitoring	Timing/Frequency	Responsible Party	Related Plans
Impacts from improper disposal of solid wastes on surface water quality, groundwater quality, soil quality as well as terrestrial and aquatic ecological resources (i.e. habitats, flora and fauna)	• Waste materials will be segregated at source of generation and properly stored in labelled color bins assigned for general waste, recyclable waste, hazardous waste and organic waste. • The segregated wastes will be transported to the waste management compound daily for proper temporary storage. The waste management compound will be managed by an experienced environmental team. • Recyclable wastes will be collected by an approved third party contractor. • Compostable organic wastes will be treated by composting and the products will be used to fertilize and condition soil. • Non-compostable wastes will be incinerated in properly designed mobile incinerator. The residual solids from incineration will be used for composting. • Hazardous wastes will be collected for proper disposal by approved third party contractor. Hazardous wastes which cannot be collected by the contractor will be buried underground in concrete bunker. • Induction training for Project personnel should include the waste management system.	Negligible	Compliance Audit	Implementation Phase	MPRL E&P HSE Team	Waste Management Plan
Impacts from Improper Disposal of Wastewater and Slug on Surface Water Quality, Ground Water Quality, Soil, Terrestrial Habitats and Aquatic Habitats as well as their Associated Flora and Fauna	• Sanitary wastewater will be collected in the septic holding tanks to be located at the construction camp and a retained licensed firm will periodically clean and service the septic holding tanks. • The discharge of treated sanitary wastewater should meet guideline levels in IFC General EHS Guidelines • In order to reduce the concentration of chemicals in produced water, the amount of chemical injected in a chemical flood would be designed to be retained by adsorption, channelling and dilution in the petroleum reservoir. Chemicals dissolved in the produced brines will be recycled through the brine treatment system and reinjected into the reservoir. Chemicals dissolved in the oil will be transported to the refinery to be processed as a part of the crude oil. • A proper produced water treatment system will be installed. Oil recovered from the produced water will be collected and pumped back to process tank. Slug from the treatment process will be buried underground and enclosed in appropriate plastic liner. Treated wastewater, with oil and slug content reduced and has undergone biological treatment as needed, will be dumped in dumping wells.	Negligible to Minor	Compliance Audit	Implementation Phase	MPRL E&P HSE Team	Waste Management Plan
Impacts from Gas Venting on Ambient Air Condition	• Avoid venting or reduce the number of venting well as far as practicable. • When new vents are to be installed, consideration should be given on toxic gas composition, wind direction, design of venting as well as location and distance from the ASRs to reduce the potential of pollutant dispersal to ASRs. • Consider flaring instead of venting as far as possible.	Minor	Compliance Audit	Design Phase	MPRL E&P HSE Team	
	• Activities carried out at existing well sites in the oil field which are mostly remoted from the ASRs. • Good maintenance and operating strategies will be taking into account to keep gas venting volume as low as practicable • Measures related to fire control should be strictly followed. • SMART Jack will be considered to install to further reduce gaseous emissions from the vents. • Implement a programme of regular monitoring of gaseous composition of the vented gas and regular air quality monitoring at selected ASRs to identify and properly respond to any unacceptable air quality impacts caused by the venting.		Inspection & Compliance Audit	Implementation Phase	MPRL E&P HSE Team	Environmental Monitoring Plan
ACCIDENTAL EVENTS						

Potential Impact/Issue	Control / Mitigation Measures	Significance of Residual Impacts	Monitoring	Timing/Frequency	Responsible Party	Related Plans
Impacts from chemical spills, well failure and reservoir leakage on soil quality, surface water quality, groundwater quality as well as terrestrial and aquatic ecological resources (i.e. habitats, flora and fauna).	• Refueling will be carried out in designated areas on hard standing ground to prevent seepage of any spillages to ground. Collection systems will be installed in these areas to manage any spills, fuels will be collected and either reused, treated by incineration or removed by a local contractor. Drip trays must be used when refueling and servicing vehicles or equipment, where it is not on a hard standing. • Avoid construction of facilities (e.g. chemical storage compound) in a floodplain, whenever practical, and within a distance of 100 m of the normal high-water mark of a water body or a water well used for drinking or domestic purposes. • Evaluating the risk of existing Underground Storage Tank (UST) to determine if upgrades are required for UST that will be continued to be used, including replacement with new systems or permanent closure of abandoned USTs. Ensuring that new USTs are sited away, as far as practicable, from groundwater wells, reservoirs and other source water protection areas and floodplains, and maintained so as to prevent corrosion. • Incorporation of siting and safety engineering criteria to prevent failures due to risks posed by flooding. All Project structures should be designed in accordance with engineering and design criteria mandated by site-specific flooding risks. • Facilities, buildings, plants, and structures should be situated to minimize potential risks from flooding. • Maintaining a list of external equipment, personnel, facilities, funding, expert knowledge, and materials that may be required to respond to emergencies. The list should include personnel with specialized expertise for spill clean-up, flood control and water treatment. • The use of competent and well-trained workers for construction and operation. • Well-planned, well-supervised and standard procedures will be used at the wells to maintain well control (eg management of mud weight). • Implementation of maintenance and inspection procedures. • The Project will develop a detailed Spill Response Plan including community sensitization/notifications when required. The Project will maintain spill clean-up and response capability adequate for addressing spills for all phases of the Project. All spills will be immediately contained and cleaned up. Contaminated areas will be remediated and post remediation verification will be carried out. • Carefully plan of drilling operation by identifying shallow hazards, using standard materials for well construction/modification, using standard drilling and well control standard operating procedures, and using proper drilling mud formulation with additives if necessary (well kill fluids, loss control and weighting agents). • Undertake drilling with international best practice safety procedures. • Test safety devices prior to start-up for function and integrity. • Continuously monitor pressure in the well and recycled mud during drilling. • Train employees on emergency procedures. • Spill kits and shovels at well sites or appropriate locations for any accidental leakage of fuel or other hazardous substances during Project activities. It must be ensured that no such substance enters into groundwater or surface water resources. • If emergency servicing of equipment is required in the field, spill kits and drip trays will be available. • Any contaminated soil will be removed from site and disposed of in accordance with the WMP. • The location, type and quantity of any fuel or chemical or mud spill will be reported to HSE coordinator immediately. Improve cellars with double cellars for new and reactivated wells.	Minor	Compliance Audit	Implementation Phase	MPRL E&P HSE Team	Emergency Preparedness Plan ; Spill Response Plan; Waste Management Plan

Potential Impact/Issue	Control / Mitigation Measures	Significance of Residual Impacts	Monitoring	Timing/Frequency	Responsible Party	Related Plans
Impacts from fires and explosions caused by the accidental events related to the use of explosive materials in re-perforation on air quality, ground water quality, surface water quality, Soil Quality, landscape and visual character, use of natural resources, terrestrial habitats and aquatic habitats as well as their associated flora and fauna.	• Assign designated smoking areas. • Smoking is only allowed away from the well head of more than 100 feet, up wind, with appropriate ash trays to contain any hot ashes. • As administered under the Emergency Preparedness Plan, a Fire Risk Management Plan will be developed including communications protocols and measures to control any fires that do arise. • Fire control equipment should be located at the well site or appropriate locations. • Induction training for personnel is recommended to include a mandatory segment on fire safety and actions in the event of a fire. • It will be of key importance that explosives used for re-perforation activities are kept in a safe manner and no uncontrolled explosions occur. Implement all required safety and management requirements relating to the transportation, storage and handling of explosives • Misfired charges from re-perforation activities will be disabled and destroyed. • Conduct fire training and response drills.	Minor	Inspection & Compliance Audit	Implementation Phase	MPRL E&P HSE Team	Emergency Preparedness Plan; Fire Risk Management Plan

7.2.1 Environmental Management Organisation

MPRL E&P is committed to providing resources essential to the implementation and control of the EMP. Resources include the appropriate human resources and specialised skills. The structure for the organisation responsible for environmental management and implementation of the EMP is depicted in *Table 7.3*.

Table 7.3 Environmental Management Organisation Roles and Responsibilities

Position	Responsibility
MPRL E&P	
General Manager	Oversee and coordinate all activities pertaining to the Project; ultimately responsible for environmental issues. Ensure delivery by the asset of its environmental, and operational targets. Ensure effective communication with all stakeholders.
Operations Manager	Technical aspects of the Project including contractor supervision during operations. Responsible for the execution of Emergency Response Plan including Oil Spill Contingency Plan.
Construction Manager	Technical aspects of the Project including subcontractor supervision during Project implementation.
HSE Coordinator	Ensuring that the Project and subcontractors operate in accordance with applicable regulatory environmental requirements and plans. Monitor implementation of environmental protection measures, and assist with technical input into oil spill response requirements.
Community Liaison Officer	Liaise with local communities, farmer and government regulators on the Project's behalf. Implement environmental awareness and education programmes with communities.
Contractor	
Project Manager	Responsible for subcontractor technical performance and compliance.
HSE Manager	Ensure that environment regulatory requirements are met and that EMP requirements are properly implemented.

Supervision of subcontractor activities will be conducted by MPRL E&P General Manager and Operations Manager. This will be accomplished through management controls over strategic project aspects and interaction with subcontractor staff where project activities take place. The MPRL E&P organisation will be staffed at a level to allow for continuous effective supervision of subcontractor activities and work products.

The construction manager and HSE Coordinator will be placed locally at the Project site to supervise contractors during construction while the Operation Manager and HSE Coordinator will supervise contractors during operational activities. The organisation includes a Community Liaison Officer (CLO)

whose role is crucial to the successful implementation of the EMP and the continuation of liaison with the local community.

7.2.2 Training and Awareness

MPRL E&P will identify, plan, monitor, and record training needs for personnel whose work may have a significant adverse impact upon the environment conditions. The Project recognises that it is important that employees at each relevant function and level are aware of the Project's environmental policy; potential impacts of their activities; and roles and responsibilities in achieving conformance with the policy and procedures.

This will be achieved through a formal training process. Employee training will include awareness and competency with respect to:

- Environmental impacts that could potentially arise from their activities;
- Necessity of conforming to the requirements of the EIA and EMP, in order to avoid or reduce those impacts; and
- Roles and responsibilities to achieve that conformity, including with regard to change management and emergency response.

The HSE Coordinator is responsible for coordinating training, maintaining employee-training records, and ensuring that these are monitored and reviewed on a regular basis. The HSE Manager will also periodically verify that staffs are performing competently through discussion and observation.

Employees responsible for performing site inspections will receive training by drawing on external resources as necessary. Training will be coordinated by the HSE Coordinator prior to Project's implementation. Upon completion of training and once deemed competent by management, staff will be ready to train other people.

Similarly the Project will require that each of the contractors institute training programmes for its personnel. Each contractor is responsible for site HSE awareness training for personnel working on the job sites. The contractors are also responsible for identification of any additional training requirements to maintain required competency levels.

The contractor training program will be subject to approval by the Project and it will be audited to ensure that:

- Training programs are adequate;
- All personnel requiring training have been trained; and
- Competency is being verified.

7.2.3 Inspection

HSE inspections will be conducted by subcontractors on a daily basis. The results of the inspection and monitoring activities will be reported to MPRL E&P on a weekly basis or more frequently if requested by the HSE coordinator or the Operations Manager.

7.2.4 Monitoring

Monitoring will be conducted to ensure compliance with regulatory requirements as well as to evaluate the effectiveness of operational controls and other measures intended to mitigate potential impacts.

As a minimum, the following monitoring on physical environment should be undertaken:

Physical Environment Monitoring

- Ambient air quality;
- Acoustic environment;
- Groundwater quality;
- Surface water quality; and
- Soil quality.

The monitoring methodology should follow that adopted for the EIA Study.

Monitoring should be undertaken during the following periods of the EOR and re-development programme activities:

- At least two weeks before the construction activities for baseline data collection.
- Weekly monitoring during the construction and operation phase.

In addition, a programme of regular monitoring of gaseous composition of the vented gas and regular air quality monitoring at selected ASRs should also be implemented to identify and properly respond to any unacceptable air quality impacts caused by the venting which is an existing operation in the Mann Oil Field.

A detailed Environmental Monitoring Plan should be developed to present the background, objective, methodology and reporting requirements of the monitoring programme.

7.2.5 Compliance Auditing

Beyond the routine inspection and monitoring activities conducted, compliance audits will be carried out internally by MPRL E&P to ensure

compliance with regulatory requirements as well as their own HSE standards and policies. Audits to be conducted will also cover the subcontractor self-reported monitoring and inspection activities. The audit shall be performed by qualified staff and the results shall be communicated to the General Manager and management board.

The audit will include a review of compliance with the requirements of the EIA and of this EMP and include, at minimum, the following:

- Completeness of EHS documentation, including planning documents and inspection records;
- Conformance with monitoring requirements;
- Efficacy of activities to address any non-conformance with monitoring requirements; and
- Training activities and record keeping.

There will be a cycle of audits into specific areas of the Project such as waste management, and effectiveness of local content plans and discharge controls. The frequency of audits will be risk based and will vary with the stage of the Project (more frequent during construction and in the early stages of the Project operation) and will depend on the results of previous audits.

7.2.6 Corrective Action

Impacts will be identified and associated risks addressed before an incident occurs. Investigating a 'near miss' or actual incident after it occurs can be used to obtain valuable lessons and information that can be used to prevent similar or more serious occurrences in the future.

MPRL E&P will implement a formal non-compliance and corrective action tracking procedure for investigating cause and identifying corrective actions in response to accidents or environmental non-compliances. This will ensure coordinated action between MPRL E&P and its subcontractors. The HSE Coordinator will be responsible for keeping records of corrective actions and for overseeing the modification of environmental protection procedures and/or training programs to avoid repetition of non-conformances and non-compliances.

7.3 MANAGEMENT PLANS

The goal of this EMP is to ensure full compliance with the Project's policies and with mitigation, monitoring and other commitments made in the EIA Report. While this EMP should also be treated as a high-level, framework document, it is linked to a number of detailed management plans as described below which will be developed to lay out the specifications for compliance with specific environmental elements.

7.3.1 Related Management Plans

A range of management plans will be developed to provide assurances that the outcomes of the EIA are able to be implemented. These management plans will detail the management and mitigation measures required to be implemented, the time frame and responsibilities for their implementation, detailed training requirements, inspections/audits to check implementation, and reporting requirements. Where responsibilities will lay with bodies external to MPRL E&P (e.g. Contractors) the invitations to tender and contracts will contain specific clauses that bind contractors and sub-contractors. This will apply to all tiers of contractors, with penalties for non-compliance also set out in the contracts and rigorously enforced by MPRL E&P.

The key management plans are outlined in *Table 7.4* with information on how these relate to the activities and impacts being discussed in the EIA Report, including reference to who has lead responsibility.

Table 7.4 EMP Hierarchy of Key Plans

Plan Name	Includes	Plan Owner
EMP	Overarching plan linking to other Management Plan	MPRL E&P
Waste Management Plan	Project-related waste handling procedures for hazardous and non-hazardous wastes.	MPRL E&P
Emergency Preparedness Plan	Administration (policy, purpose, distribution, definitions, etc), organization of emergency areas (command centres, medical stations, etc), roles and responsibilities, communication systems, emergency response procedures, emergency resources, training and updating, checklists (role and action list and equipment checklist) and business continuity and contingency.	MPRL E&P
Spill Response Plan	Describes the spill preventative measures and spill response procedures	MPRL E&P
Fire Risk Management Plan	As part of the ERP, including communications protocols and measures to control any fires that do arise and as well as identify where fire control measures should be located.	MPRL E&P
Environmental Monitoring Plan	Groundwater monitoring, surface water monitoring, soil monitoring, routine effluent and discharge monitoring, air quality monitoring, noise monitoring, etc.	MPRL E&P or a third party administered under the Environmental Management Plan

7.3.2 Contractor Environmental Management Plan(s)

The Project will engage contractors to carry out Project activities. The contractors are responsible for performing all work:

- In compliance with relevant national and international HSE legislation and regulations, and with other requirements to which the project subscribes;
- In conformance with the Project's EMP; and
- In accordance with contractual technical and quality specifications.

The Project will also provide specifications for environmental compliance and performance (through this EIA and EMP and the associated plans) and, as a contractual requirement, the contractor will develop and provide to the Project its own specific management plans demonstrating how they intend to comply with the stipulated requirements.

Contractors must also provide documentation detailing their plans for:

- Implementing the measures required in the EIA and this EMP;
- Local content;
- Logistics; and
- Community relations.

The contractor management plans must conform to the requirements of the Project's overarching plans. Contractor plans will be reviewed and approved by MPRL E&P and incorporated into, and form part of, the Project's overall EMP.

Contractors will be required to self-monitor against their plan and the contractor's compliance with the plan will be routinely monitored by MPRL E&P directly or by third-parties. Contractors will be required to submit regular reports of monitoring activities and the Project will review these on a regular basis. An external assurance process will be conducted on an annual basis the results of which will be disclosed at completion of the process.

As a contractual requirement, the subcontractors are required to provide sufficient resources to manage HSE aspects of the work to be performed. This includes providing resources to ensure compliance of next tier subcontractors and a process for emergency stop-work orders in response to monitoring triggers.

7.4 EMERGENCY PREPAREDNESS AND RESPONSE

MPRL E&P has developed plans and procedures to identify the potential for and response to environmental accidents and health and safety emergency situations and for preventing and mitigating potentially adverse environmental impacts that may be associated with them.

Emergency preparedness and response will be reviewed by MPRL E&P on at least an annual basis and after the occurrence of any accidents or emergency situations to ensure that lessons learnt inform continuous improvement. Emergency exercises will be undertaken on a regular basis to confirm adequacy of response strategies. Investigations of accidents or incidents will follow formal documented procedures.

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