Supplementary ESIA for STC Cement Plant & Associated Facilities in Myanmar

Shwe Taung Cement Ltd

Supplementary Environmental and Social Impact Assessment Report

06 April 2017

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CONTENT

1 INTRODUCTION

1.1 PROJECT OVERVIEW

Shwe Taung Cement (STC) is planning a brownfield expansion of cement production, including the extraction of raw materials, at its existing cement plant in Pyi Nyaung Village, Thazi Township in the Mandalay region of Myanmar (the Project). The Project aims to expand STC's clinker production capacity from 1,500 tonnes per day (tpd) to 5,500 tpd and cement capacity from 2,800 tpd to 7,200 tpd.

STC is part of the **Shwe Taung Group** (STG) which owns and operates a variety of businesses across various sectors in Myanmar. A coal mine developed by **Shwe Taung Mining** (STM), another subsidiary of STG, in the Kalaywa township of the Sagaing region of Myanmar, produces coal exclusively for use as fuel for the cement kiln and is therefore considered an associated facility and within the scope of the Project.

1.2 BACKGROUND TO THE ESIA

Three local Environmental and Social Impact Assessment (ESIA) Studies related to the Project have been prepared and submitted to regulatory authorities in Myanmar, which are as follows:

- ESIA for the 1,500 tpd Apache Cement Plant, Thazi Township, Mandalay Region, NEPS, 2014;
- EIA on 3,500 tpd Shwe Taung Cement Factory, at Kubyin Village, Pyi Nyaung Area, Tharzi Township, Mandalay Region, Myanmar Environment Sustainable Conservation (MESC), 2016; and
- EIA on the 100,000 tpa Shwe Taung Coal Mine, at Chaung Sone Village (Paluzawa area), Kalaywa Township, Sagaing Region, MESC, 2016.

The Local ESIAs do not fulfil the requirements of the International Finance Corporation's Performance Standards on Environmental and Social Sustainability, 2012 (IFC PSs). As such, **Environmental Resources Management** (ERM) has been commissioned by STC to undertake a Supplemental ESIA to address gaps with respect to the IFC PSs and other relevant international requirements.

2 PROJECT DESCRIPTION

The Project consists of four main components, namely the cement plant (including ancillary facilities), a mudstone quarry and a limestone quarry located in Thazi township of Mandalay region as well as a coal mine located in the Kalaywa township of the Sagaing region.

An overview of the Project location is shown in *Figure 2.1*. All the areas were leased from the Forest Department. The coal mine covers a leased area of 3,378.2 acres while the cement plant, limestone quarry and mudstone quarry cover leased areas of 455, 600 and 165 acres, respectively. Detailed descriptions of the above Project components are provided below.

2.1 CEMENT PLANT AND ANCILLARY FACILITIES

2.1.1 Cement Plant

The existing STC cement plant and ancillary facilities are located in a brownfield area of 455 acres in Thazi township within the Mandalay Region (*Figures 2.2-3*). It is situated in a valley surrounded by the mudstone quarry to the west and the limestone quarry to the east, both of which fall within the Tha Pyae mountain range.

The clinker production and cement grinding capacity of the existing plant are 1,500 tpd and 2,800 tpd, respectively. A dry process is used for the cement production as shown in the production flow diagram in *Figure 2.4*. Cement production comprises five key steps including raw material crushing, materials handling, clinker production, cement grinding and cement packing and dispatch. Facilities and equipment associated with the cement manufacturing process are presented in *Table 2.1* and the layout is illustrated in *Figure 2.5*.

Figure 2.1 Locations of Cement Plant (with associated Quarries) and Coal Mine

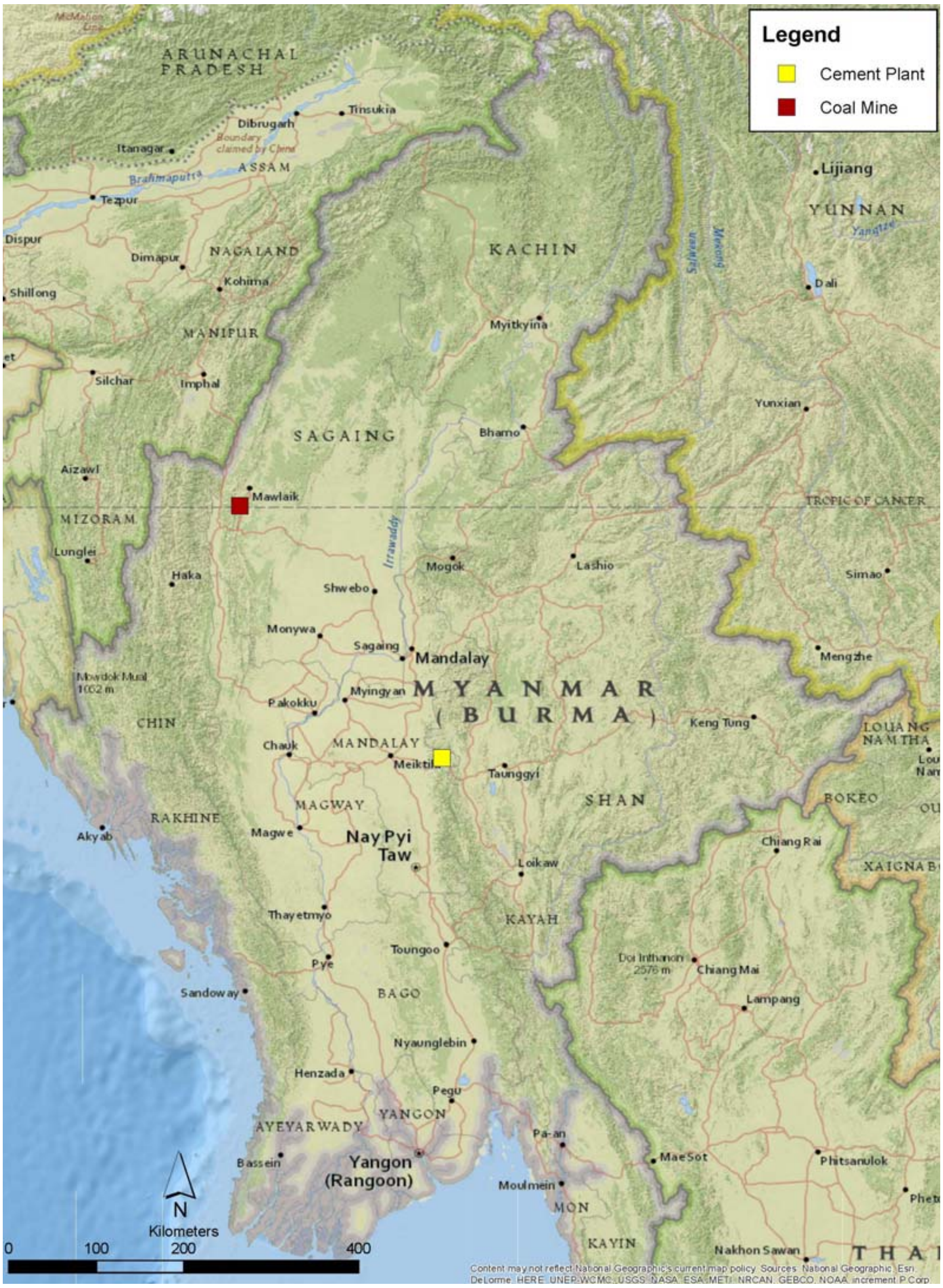


Figure 2.2 Overview of the Existing Cement Plant

Source: ERM, 2016

Figure 2.3 Locations of Cement Plant, Limestone Concession, Mudstone Concession and Ancillaries Facilities

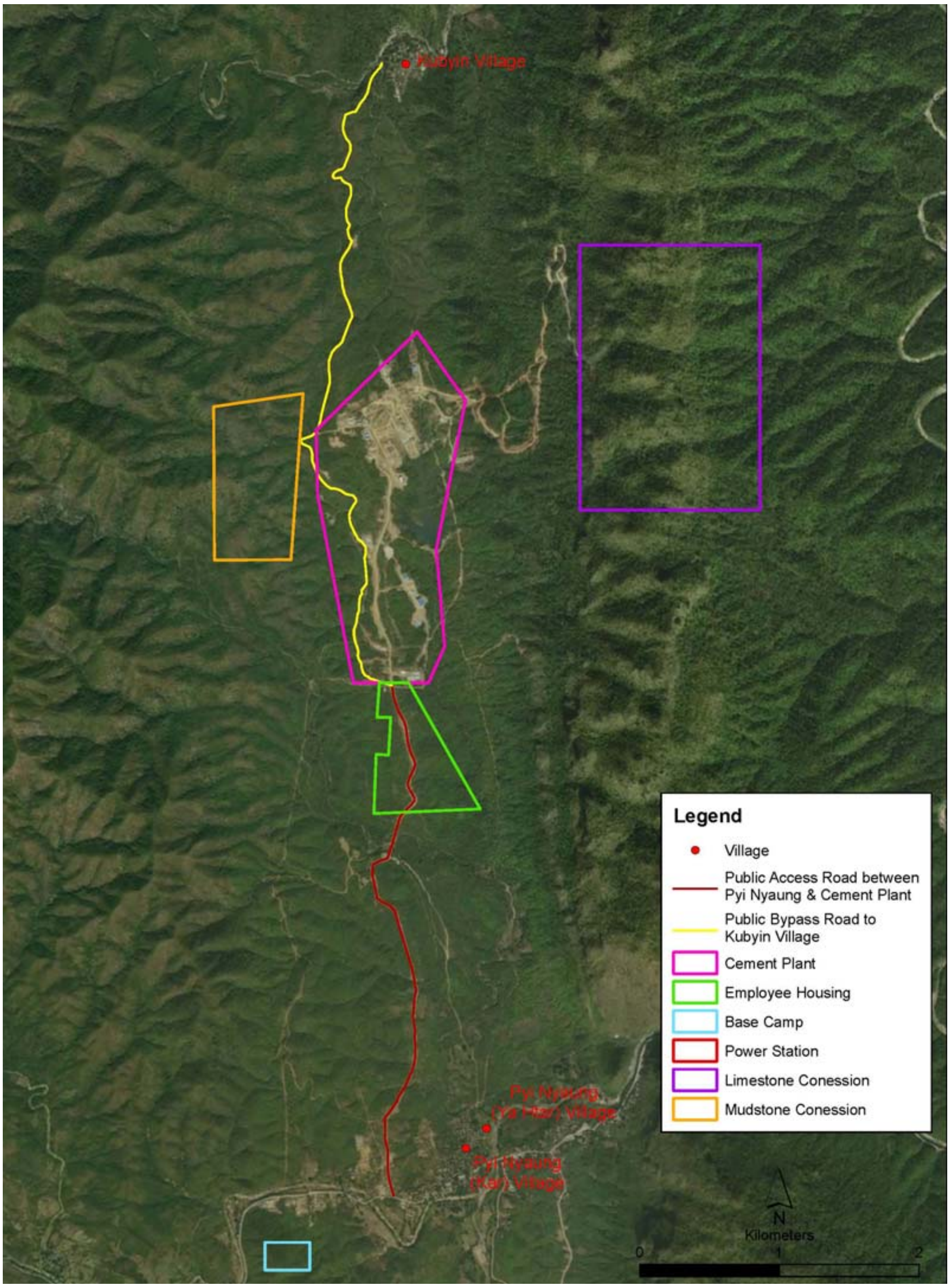


Figure 2.4 Dry Process Flow of the Existing Cement Production Process

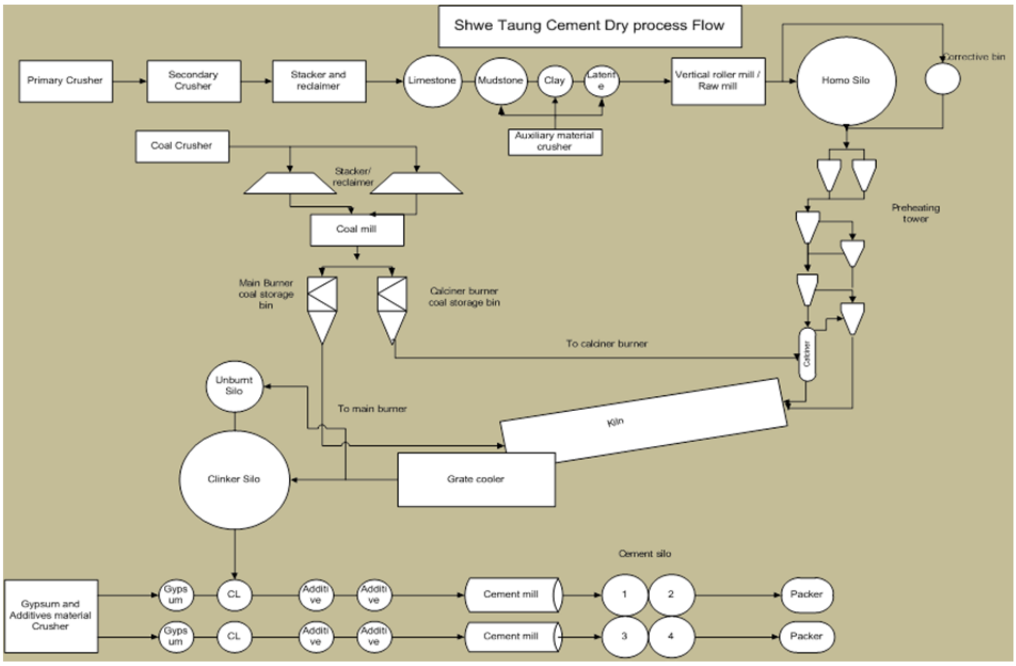
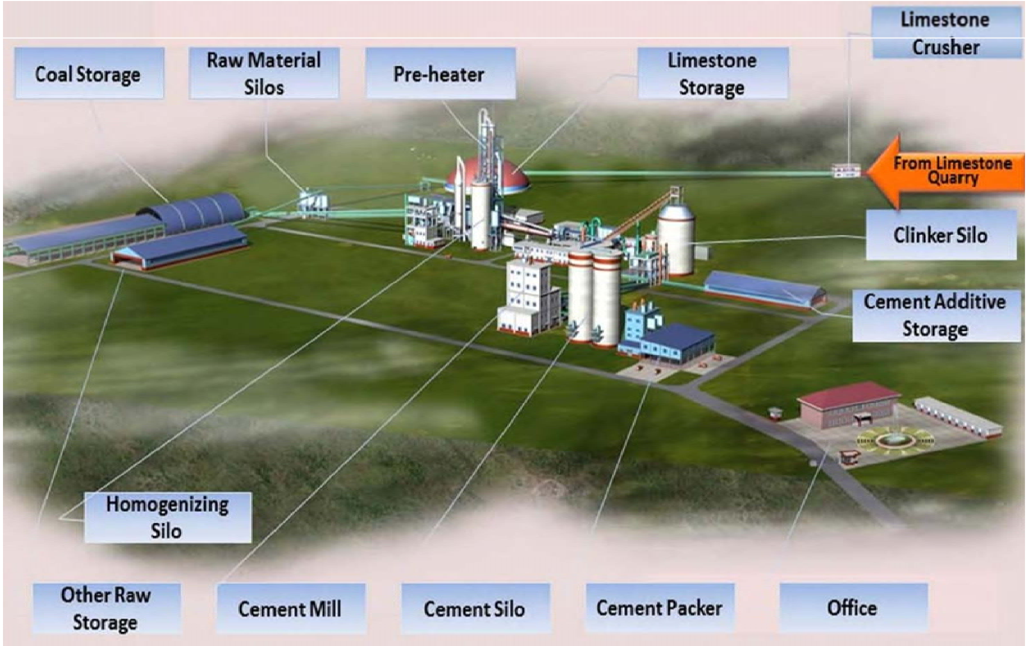


Table 2.1 List of Facility / Equipment for the Existing Cement Production Line

Plant Component	Equipment	Number	Capacity
Limestone crushing	Jaw Crusher	1	400-500 tph
	Hammer crusher	2	400 tph
Limestone storage	Circular yard (Dia 60 m)	1	15,000 Ton
Auxiliary material	Mudstone	1	2,500 Ton
	Laterite	2	650 Ton
	Red Clay	3	650 Ton
	Jaw Crusher	4	40 tph
Raw material grinding	Vertical roller mill	1	130 tph
Homo silo storage	Dai 18 m x Height 47 m	1	7,500 Ton
Kiln middle	Rotary kiln Dia 3.5 X length 54 m	1	1,500 Tpd
Kiln head	Grate Cooler(3 rd generation)	1	1,500 -1800 tpd
Clinker silo storage	Dia 25 m x Height 40.7 m	1	25,000 Ton
Off-spec silo Storage	Dia 9 m x Height 20 m	1	1000 Ton
Cement additive storage	Admixture -1	1	1800 ton
	Admixture -2	2	1800 ton
	Gypsum	3	450 ton
	Jaw Crusher	4	40 tph
Cement grinding	Ball mill (Dia 3.5 X Length 13 m)	2	50 tph
Cement silo storage	Dia 15 m x Height 42 m	1	6,200 Ton (x 4 nos)
Raw coal crushing and storage	Double Teeth Roller Crusher	1	40 tph
	Longitudinal storage	2	2,600 x 2 = 5400 T
Pulverized coal grinding	Vertical roller mill	1	16-18 tph

Figure 2.5 Layout of the Existing Cement Plant



To produce cement, the plant needs four main raw materials: limestone, mudstone, laterite and gypsum. Coal is used as fuel for the cement manufacturing process. The limestone and mudstone quarries as well as the coal mine are solely supplying raw materials to the STC cement plant and are thus considered as associated facilities of the Project and included in the scope of the ESIA. Within the plant, there are designated storage areas for the raw materials / coal crushing, storage and handling before they are fed into the cement manufacturing process. Once produced, the cement is further processed and stored on site prior to onward transportation to market.

The Project involves expanding production capacity of the cement plant to 5,500 tpd for clinker production and 7,200 tpd for cement grinding through the construction of a new rotary kiln and associated facilities. The expansion will adopt the same dry process with additional facilities installed to achieve the increased capacity as indicated in *Table 2.2*. These additional facilities will be installed within the existing 455 acres site and the layout of the expanded plant is shown in *Figure 2.6*. All land leased to date by the company is stated owned forest land. No new land is required to accommodate the expanded facilities and concessions for the mudstone and limestone quarries have already been secured.

Table 2.2 List of Additional Cement Production Equipment

Plant Component	Equipment Name	Number	Capacity
Limestone crushing	Hammer Crusher	1	1,200 tph
Limestone storage	Circular yard (diameter 90 m)	1	45,000 ton
Raw material grinding	Vertical roller mill	1	350 tph
Homo silo storage	Diameter 20 m X Height 56 m	1	15,000 t
Kiln middle	Rotary kiln (Diameter 4.5 m x Length 68 m)	1	4,000 tpd
Kiln head	Grate Cooler (4th generation)	1	4,000-4,500 tpd
Clinker silo storage	Diameter 25 x Height 21 m	1	60,000 ton
Additive crusher	Jaw crusher	1	40 ~ 50 tph
Cement grinding	Ball mill (4.2 m X 13 m)	1	235 ton
	Roller press (Diameter 1800 X Width 1400)	1	7,70-1,080 tph
Cement silo storage	Diameter 18 m x Height 43 m	1	2 x 9,000 ton
Raw Coal Crusher	Double roller crusher	1	150 tph
Raw coal storage	Longitudinal storage	1	2 x 3,600 ton

2.1.2 *Ancillary Facilities*

A concrete access road was constructed by STC from Pyi Nyaung Village to the cement plant, which is a public road accessible to all parties. Previously this was a small dirt track, accessible only by foot or by bullock-cart.

Electricity required for the operation of the existing and expanded cement plant is sourced from the Yay Paung Sone Power Station which is located 11km away from the plant. The cement plant currently consumes 11 MW supplied via a 33kV transmission line. STC will construct a new 66kV transmission line within the existing right of way for the 33kV line and then hand this over to the Ministry of Electric Power and Energy. The new 66kV line will supply the STC cement plant and several other cement plants planned in the broader area; additional supply to STC will be 36 MW and requires a new transformer on-site. A 2,000 kVA backup generator is deployed on site for instances of power outage.

The estimated water requirement of the expanded cement plant is 3,400 m^3 per day taking into account the requirements for the waste heat recovery unit (1,900 m^3 per day).. Water is currently sourced from two reservoirs, with capacities of 6 million gallons and 45 million gallons, respectively. Water is pumped into the reservoirs from Kubyin Stream at Kubyin Village, approximately 4 km north of the cement plant, during the dry season. During the wet season, the reservoirs can be replenished by rain water and there is no need to pump water from the Kubyin Stream. The reservoirs are only supplying water to the cement plant and not to the nearby villages.

The plant includes a refuelling area and maintenance workshop for truck and equipment repair. It also includes various materials handling and storage areas for coal, limestone, mudstone and other raw materials.

During construction, it is estimated that around 500 construction workers will be housed in construction camps within the cement plant. There will be around 460 operational staff who will mainly stay in staff accommodation within the plant. Other ancillary facilities within the plant include the office building, the control centre and laboratory as well as the staff canteen.

Figure 2.6 Layout of the Expanded Cement Plant

No.	Item No.	Item name
30	052	Circulating water cooling tower
29	051	Chemical water treatment room
28	012	Turbo-generators room
27	216	2#SP waste heat boiler
26	215	2#AQC waste heat boiler
25	116	1#SP waste heat boiler
24	115	1#AQC waste heat boiler
23	902	Water purifying station
22	901	Circulation water pump house
21	701	Master power distribution station
20	601	Compressor station
19	502	Pulverized coal preparation
18	501	Coal crushing and conveying
17	405	Cement packing
16	404	Cement silos and cement bulking
15	403	Cement grinding
14	402	Cement blending station
13	401	Mixed materials store and conveying
12	304	Clinker silo
11	303	Kiln head and clinker conveying
10	302	Kiln middle
09	301	Kiln inlet
08	203	Raw meal homogenizing silo
07	202	Raw meal grinding and treatment of waste gas at kiln inlet
06	201	Raw material blending station
05	105	Auxiliary material prehomogenizing shed (The use of the original 102)
04	104	Auxiliary material crushing (The use of the original 101.103)
03	103	Limestone prehomogenizing shed
02	102	Limestone conveying
01	101	Limestone crushing

2.2 *LIMESTONE QUARRY*

A concession of 600 acres in size has been allocated to STC for limestone extraction. It is located approximately 800m to the east of the cement plant within the forest area on the ridge of the Tha Pyae mountain range (*Figure 2.3*). Limestone extraction is undertaken using a drill and blast method. The extracted limestone is transported by truck to the limestone crusher where it is crushed and stored prior to use (*Figure 2.5*). Approximately 715,000 tonnes of limestone per year is required for the current production of the cement plant.

For the Project expansion, a conveyor will be built to transport the limestone from the quarry to the limestone crusher in place of trucks (*Figure 2.6*). The new production line will require an additional ~1.6 million tonnes of limestone per year. The concession, which has estimated limestone reserves of 110 million tonnes, is expected to be mined down from ~750 m to 550 m above sea level with further clearance of forest required. A detailed mining schedule to accommodate the expanded cement plant is not currently available.

2.3 *MUDSTONE QUARRY*

As shown in *Figure 2.3*, one mudstone quarry of a total size of 165 acres is located west of the cement plant. Mudstone excavation is currently undertaken by open excavation at ~500 m above sea level to provide raw material for the existing plant. The extracted mudstone is transported by truck to the cement plant (*Figure 2.5*), which requires ~97,500 tonnes of mudstone per annum to meet the current production capacity.

The new kiln will require an additional ~262,260 tonnes of mudstone per year. Further habitat clearance will be required at the mudstone quarry within the existing concession.

2.4 *COAL MINE*

The coal mine is located on the western side of the Chindwin River in the Kalaywa township of Sagaing region (*Figure 2.7*). Annual production is currently approximately 00,000 tonnes which may increase to up to 150,000 tonnes per annum in the future. The coal mine is approximately 3,378 acres, measuring 15 km long and 0.9 km wide (*Figure 2.7*). Coal extraction is open-cast. The extracted coal is transported down from the mine, past base camp to Paluzawa Village, via a 15 km access road built by STM, and then to the coal staging area and barging point on the bank of the Chindwin River (see *Figure 2.8* for current 15 km haul road). The access road is seasonal and is rebuilt each November. It follows the Paluzawa stream for much of its path with numerous stream crossings control. A new 10 km access road is currently being constructed by STC between the coal mine and coal staging area no.2 at Namwake Village (see *Figure 2.8* for new 10 km life-of-mine approach road). Both the existing and new access roads are under the operational control of STC and are not intended to be used by the public.

Coal is stockpiled at the staging area, from where it is taken to the barging point and loaded onto barges for transport to Mandalay and Pakokko. At Mandalay and Pakokko, the coal is transported to the STC Plant by road.

Mine preparation begins each November for coal production from December through to May during the dry season. The key preparatory work is the re-building of the access road. An additional access road is currently under construction and will be completed during the wet season (June to October) of 2017.

Coal is delivered to Mandalay using barges all year around. However, in the dry season, only small barges are able to travel up the Chindwin River.

Accommodation for staff, fuel storage and machinery / truck staging area are located at the base camp next to Paluzawa Village.

Figure 2.7 Location of Coal Mine

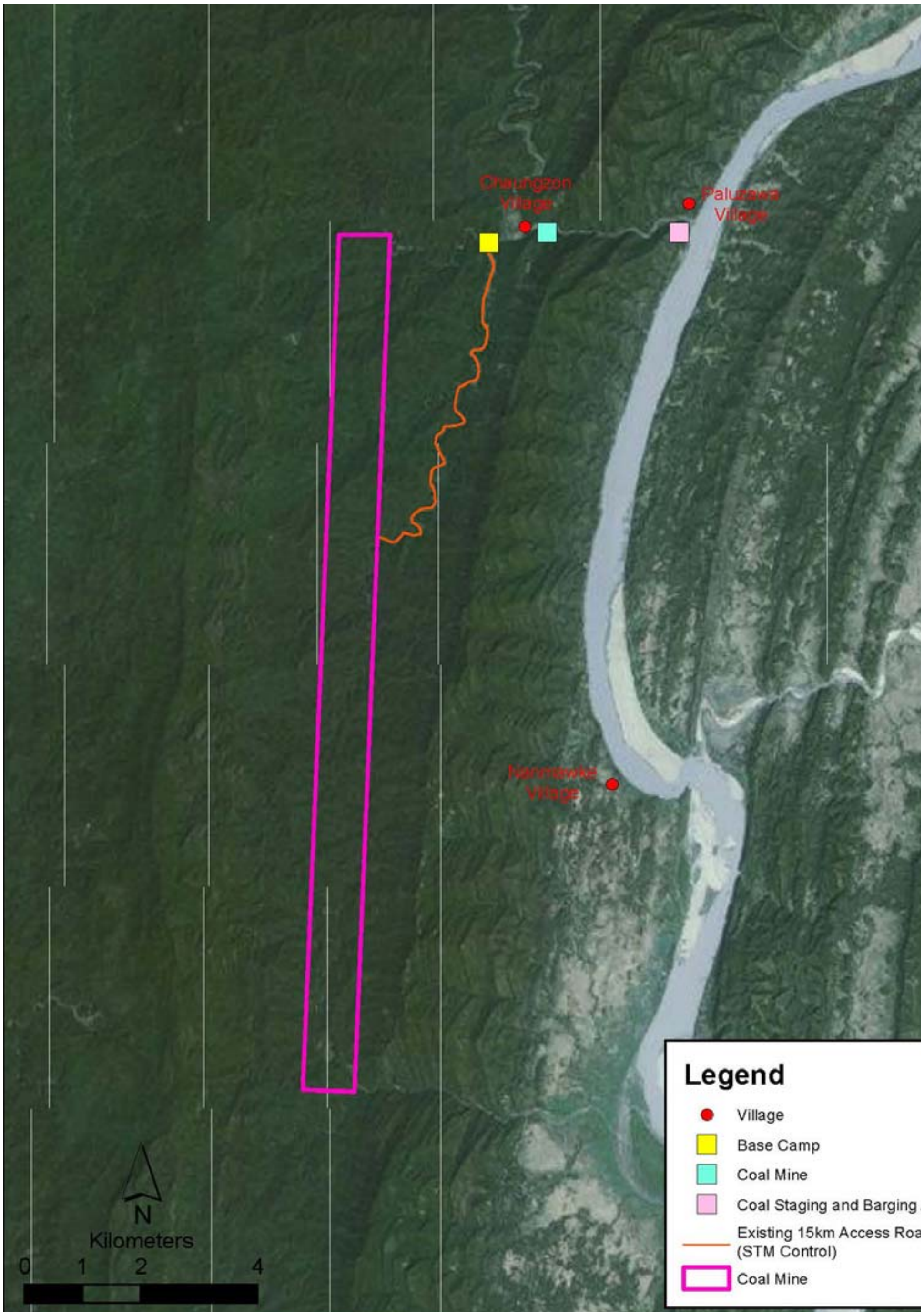
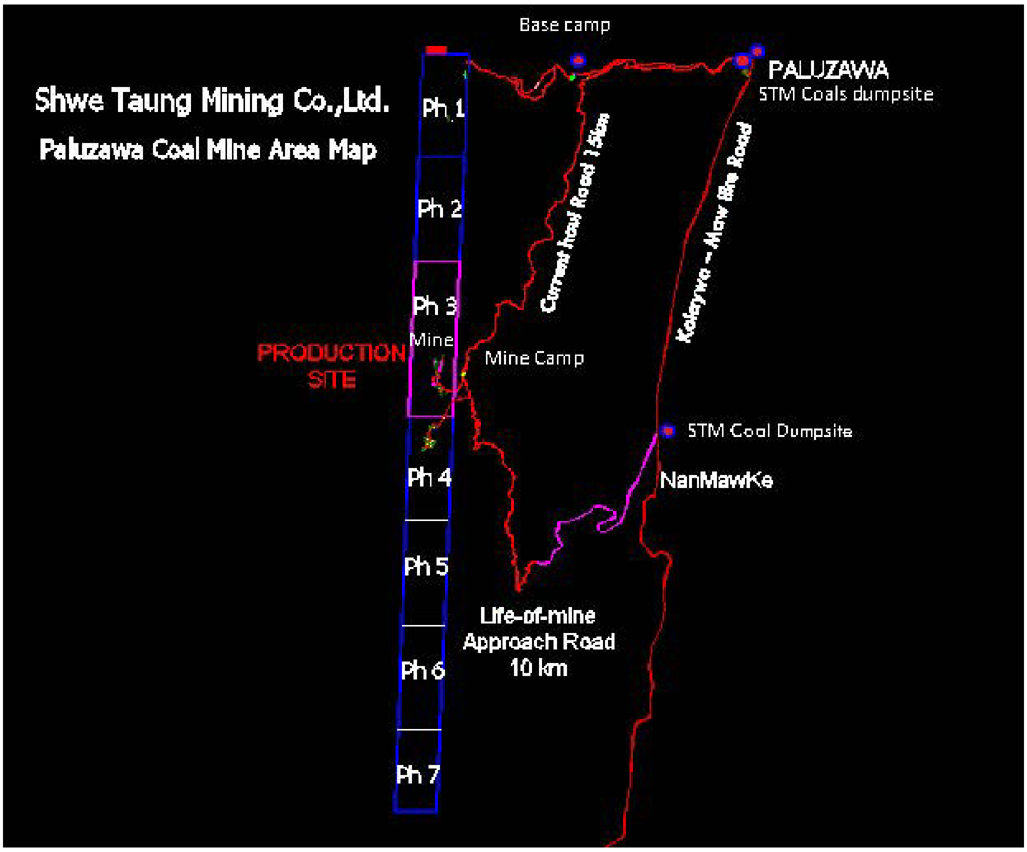


Figure 2.8 Approximate Layout of the Access Roads



3 ADMINISTRATIVE FRAMEWORK

This section sets out the relevant international standards that the Project will follow, including:

- IFC Performance Standards (IFC PS) (2012);
- World Bank Group (WBG) Environmental Health and Safety (EHS) General Guidelines (2007);
- WBG EHS Guidelines for Cement and Lime Manufacturing (2007); and
- WBG EHS Guidelines for Mining (2007).

The local Myanmar requirements on emissions from the Project (for cement manufacturing and mining) are specified in the National Environmental Quality (Emissions) Guidelines which are noted to be the same as those recommended by the relevant WBG EHS Guidelines. As such, local emissions requirements are not presented separately and only international ESIA requirements are presented in this section.

3.1 INTERNATIONAL FINANCE CORPORATION PERFORMANCE STANDARDS

The IFC PS represent the 'policy framework' for the ESIA and sustainable social and environmental management for the Project [(1)], 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. The IFC PS include:

- PS1 - Assessment and Management of Environmental and Social Risks and Impacts
- PS 2 - Labour and Working Conditions
- PS 3 - Resource Efficiency and Pollution Prevention
- PS 4 - Community Health, Safety and Security
- PS 5 - Land Acquisition and Involuntary Resettlement
- PS 6 - Biodiversity Conservation and Sustainable Management of Natural Resources
- PS 7 - Indigenous Peoples

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

- P8 8 - Cultural Heritage

PS 1-6 are considered by ERM to be relevant to the Project, while PS 7 and PS8 are not considered relevant.

3.2 *WORLD BANK GROUP EHS GUIDELINES*

The WBG 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 and the contents.

Levels of noise, air emissions and effluent recommended by the relevant WBG Guidelines are summarised in *Tables 3.1-6* below. The Project should achieve compliance with these recommended levels.

Table 3.1 Noise Level Guidelines outside the Project Site Boundary

Receptor	One Hour LAeq (dBA)[a]	
	Daytime 07:00 – 2:00 (10:00 – 22:00 for Public holidays)	**Nighttime 22:00 -07:00 (22:00 – 10:00 for Public holidays)**
Residential, institutional, educational	55	45
Industrial, commercial	70	70

Source: WBG EHS General Guidelines (2007)

Note: [a] Equivalent continuous sound level in decibels

Table 3.2 Air Emission Levels for Cement Manufacturing

Pollutants	Units	Guideline Value
Particulate Matter (new kiln system)	mg/Nm^3	30
Dust	mg/Nm^3	50
SO_2	mg/Nm^3	400
NOx	mg/Nm^3	600
HCl	mg/Nm^3	10
Hydrogen fluoride	mg/Nm^3	1
Total Organic Carbon	mg/Nm^3	10
Dioxins-furans	$mg\ TEQ/Nm^3$	0.1
Cadmium + Thallium	mg/Nm^3	0.05
Mercury (Hg)	mg/Nm^3	0.05
Total Metals [a]	mg/Nm^3	0.5

Source: WBG EHS Guidelines for Cement and Lime Manufacturing (2007

Note:
1. Emissions from the kiln stack unless otherwise noted. Daily average values corrected to 273 K, 101.3 kPa, 10 percent O_2, and dry gas, unless otherwise noted.
2. Total Metals = Arsenic (As), Lead (Pb), Cobalt (Co), Chromium (Cr), Copper (Cu), Manganese (Mn), Nickel (Ni), Vanadium (V), and Antimony (Sb)

Table 3.3 ***Ambient Air Quality Guidelines***

Parameter	Averaging Period	Guideline Value in µg/m³
Nitrogen dioxide	1-year 1-hour	40 200
Ozone	8-hour daily maximum	100
Particulate matter PM_{10} (a)	1-year 24-hour	20 50
Particulate matter $PM_{2.5}$ (b)	1-year 24-hour	10 25
Sulphur dioxide	24-hour 10-minute	20 500

a) $PM_{2.5}$ = Particulate matter 2.5 micrometers or less in diameter
b) PM_{10} = Particulate matter 10 micrometers or less in diameter

Source: WBG EHS General Guidelines (2007)

Table 3.4 ***Effluent Levels from Cement Manufacturing***

Pollutants	Unit	IFC Guideline
pH	S.U.	6-9
Total Suspended Solids	mg/L	50
Temperature increase	°C	<3*

Source: WBG EHS Guidelines for Cement and Lime Manufacturing (2007)

Table 3.5 ***Effluent Levels from Mining***

Pollutants	Unit	IFC Guideline
Arsenic	mg/l	0.1
Cadmium	mg/l	0.05
Chemical oxygen demand	mg/l	150
Chromium (hexavalent)	mg/l	0.1
Copper	mg/l	0.3
Cyanide	mg/l	1
Cyanide (free)	mg/l	0.1
Cyanide (weak acid dissociable)	mg/l	0.5
Iron (total)	mg/l	2
Lead	mg/l	0.2
Mercury	mg/l	0.002
Nickel	mg/l	0.5
pH	S.U.a	6-9
Temperature	°C	<3 degree differential
Total suspended solids	mg/l	50
Zinc	mg/l	0.5

Source: WBG EHS Guidelines for Mining (2007)

Table 3.6 Guideline Values for Treated Sanitary Sewage Discharge and Site Runoff

Parameter	Unit	Maximum Concentration
Biological oxygen demand	mg/L	30
Chemical oxygen demand	mg/L	125
Oil and grease	mg/L	10
pH	S.U.	6-9
Total coliform bacteria	MPN/100 ml	400
Total nitrogen	mg/L	10
Total phosphorus	mg/L	2
Total suspended solids	mg/L	50

Source: WBG EHS General Guidelines (2007)

3.3 OTHER RELEVANT AIR QUALITY GUIDELINES

3.3.1 *Air Quality Criteria for Impact Assessment on Sensitive Ecological and Agricultural Receptors*

The impacts relating directly to air quality (i.e. NO_x) are not habitat or species specific and are the same for all sites. NO_x is especially relevant in this context as it plays a role in the acidification of water and soil and contributes to eutrophication. Air quality critical levels for the protection of sensitive ecological areas and agriculture and presented below in *Table 3.7.*

Table 3.7 Air Quality Critical Levels used for the Assessment of Impacts on Sensitive Ecological and Agricultural Receptors

Pollutant	Averaging Period and Statistic	Assessment Criterion (µg/m^3)
NO_x	24-hour mean	75
	Annual mean	30

Source: Air quality guidelines for Europe, 2nd ed. Copenhagen, WHO Regional Office for Europe, 2000 (WHO Regional Publications, European Series, No. 91).

3.3.2 *Dust Deposition Nuisance Criteria*

Dust emissions from the Project site may result in nuisance issues when depositing onto surfaces, for example, property, vehicles and washing. In addition, dust deposition can affect sensitive vegetation due to the soiling of leaves hindering photosynthesis and the blockage of leaf pores. There is very little information available on the sensitivity of specific plants to dust soiling, however, the information that is available suggests that the guidelines for identifying the deposition rate at which nuisance at human sensitive receptors may occur is also appropriate for use as a metric for assessing the point at which significant impacts on plants may arise (1).

Dust generally does not pose a specific risk to human health and as such the IFC and WHO guidelines (which are focussed on human health) do not

(1) Farmer, A, M. (1993). The Effects of Dust on Vegetation – A Review. Environmental Pollution. 79, 63-75.

include guidelines for nuisance dust. A number of organisations have set guidelines for dust deposition and these are set out in *Table 3.8.*

Table 3.8 ***Dust Deposition Nuisance Criteria***

Criteria definition	Measure of soiling ($mg/m^2/day$)	Data source
National Guidelines		
Possible Nuisance	350 (monthly mean)	TA-Luft (Germany)
Very Likely Nuisance	650	TA-Luft (Germany)
First Loss of Amenity	133 (monthly mean)	West Australia Nuisance Standard
Unacceptable reduction in air quality	333	West Australia Nuisance Standard
Serious nuisance	200	UK recommended nuisance dust deposition rate
Nuisance dust deposition	133	Malaysia air quality standard
Evidence based guidelines		
Noticeable (urban)	95	Source 1
Possible complaint (rural)	119	Source 1
Objectionable	167	Source 1
Probable complaint	476	Source 1
Serious complaint	1191	Source 1

Note:
Source 1: Cites:
Hancock, R. P., Esmen, N. A., and Furber, C. P. (1976) "Visual Response to Dustiness", Journal of the Air Pollution Control Association, 26 (1), 1976, pp54 -57;
Beaman, A. L. and Kingsbury, R. W. S. M. (1981) "Assessment of Nuisance from Deposited Particles Using a Simple and Inexpensive Measuring System". Clean Air, 11, 1981;
Bate, K. J. and Coppin, N. J. (1991) "Dust impacts from mineral workings", Mine and Quarry, 20 (3), 1991, pp31 – 35;
Hofschreuder, P. and Vrins, E. L. M. (1992) "Nuisance from coarse dust", Journal of Aerosol Science, 23 (S1), 1992, pp691 - S694;
Quality of Urban Air Research Group. (1996) "Airborne Particulate Matter in the United Kingdom: Third Report of the Quality of Urban Air Review Group", prepared at the request of the Department of the Environment. University of Birmingham, Birmingham.

There is no clear consensus as to the level of dust deposition that is likely to result in nuisance issues as nuisance is around perception rather than health based impacts. Dust deposition nuisance thresholds have been developed for the AQIA as presented in *Annex C1.*

3.3.3 Relevant Biodiversity Legislation, Policies and Programs

National Biodiversity Strategy and Action Plan (NBSAP)

Myanmar has developed two NBSAPs to date, the first in 2011 and the second in 2015 to span 2015 to 2020. The 2015 NBSAP is structured around the 20 Aichi Biodiversity Targets, and was designed to be achieved realistically within the 5-year timeframe. The goal of the NBSAP is to 'establish a strategic planning framework, identify concrete actions, and ensure effective management and conservation of Myanmar's diverse ecosystems, species, and natural resources'.

One of the Aichi Targets outlined in the NBSAP states that 'by 2020, governments, business and stakeholders at all levels have taken steps to achieve or have implemented plans for sustainable production and consumption and have kept the impacts of use of natural resources well within safe ecological limits'. Under this goal, Myanmar has enacted an Environmental Conservation Law and an EIA Procedure.

The NBSAP has highlighted limestone quarrying as a threat to karst ecosystems, and unregulated gold mining in the Sagaing Region as a major cause of forest loss and pollution of the Chindwin River. These concerns are relevant to the Project as the former is an activity undertaken at the Apache Cement Plant site, and the latter has a potential to result in cumulative impacts to the Coal Mine site.

Global Tiger Recovery Program

The Global Tiger Initiative (GTI) seeks to empower tiger range countries to manage the range of threats facing the species. The goal is to double the number of wild tigers globally by 2022 through a mix of conservation, education and enforcement initiatives. Myanmar is one of 13 countries that fall within the range of the wild tiger, and thus plays a role in the program. The GTI has placed tiger habitats in Myanmar as a global management priority as tiger populations have the highest probability of persistence in these areas. In 2007, Myanmar established a National Wildlife Enforcement Task force to control illegal trade in wildlife within the country and at its borders. It collaborates with CITES, ASEAN-Wildlife Enforcement Network (WEN), TRAFFIC and InterPol.

The estimated numbers of adult tigers within Myanmar is 85. Priority initiatives identified by GTI for Myanmar are '(i) improved legal protection of critical tiger habitats and/or increasing penalties for wildlife crime, (ii) improved inter-sectoral coordination and establishment of best management practices for industry and infrastructure development in buffer zones, and (iii) providing support for front-line staff with equipment, infrastructure, training, incentives and insurance.'

Whilst the Project Area may not support tiger populations, the broader landscape, including protected areas, are relevant to this initiative. The Project area of the coal mine is located within a Tiger Conservation Landscape (TCL). The location of the Project area in relation to the TCL is shown in *Figure 3.1*.

Species and Habitat Management

There are several efforts by both government and non-governmental organisations (NGOs) to manage habitats and species within Myanmar. Conservation programmes are typically targeted at endangered species such as the Hoolock Gibbon (*Hoolock hoolock*), the Burmese Star Tortoise (*Geochelone platynota*) and Tiger (*Panthera tigris*). Marine and bird habitat conservation and management initiatives are also being established. Legislation relevant to biodiversity conservation include the Elephant Preservation Act, the Wild

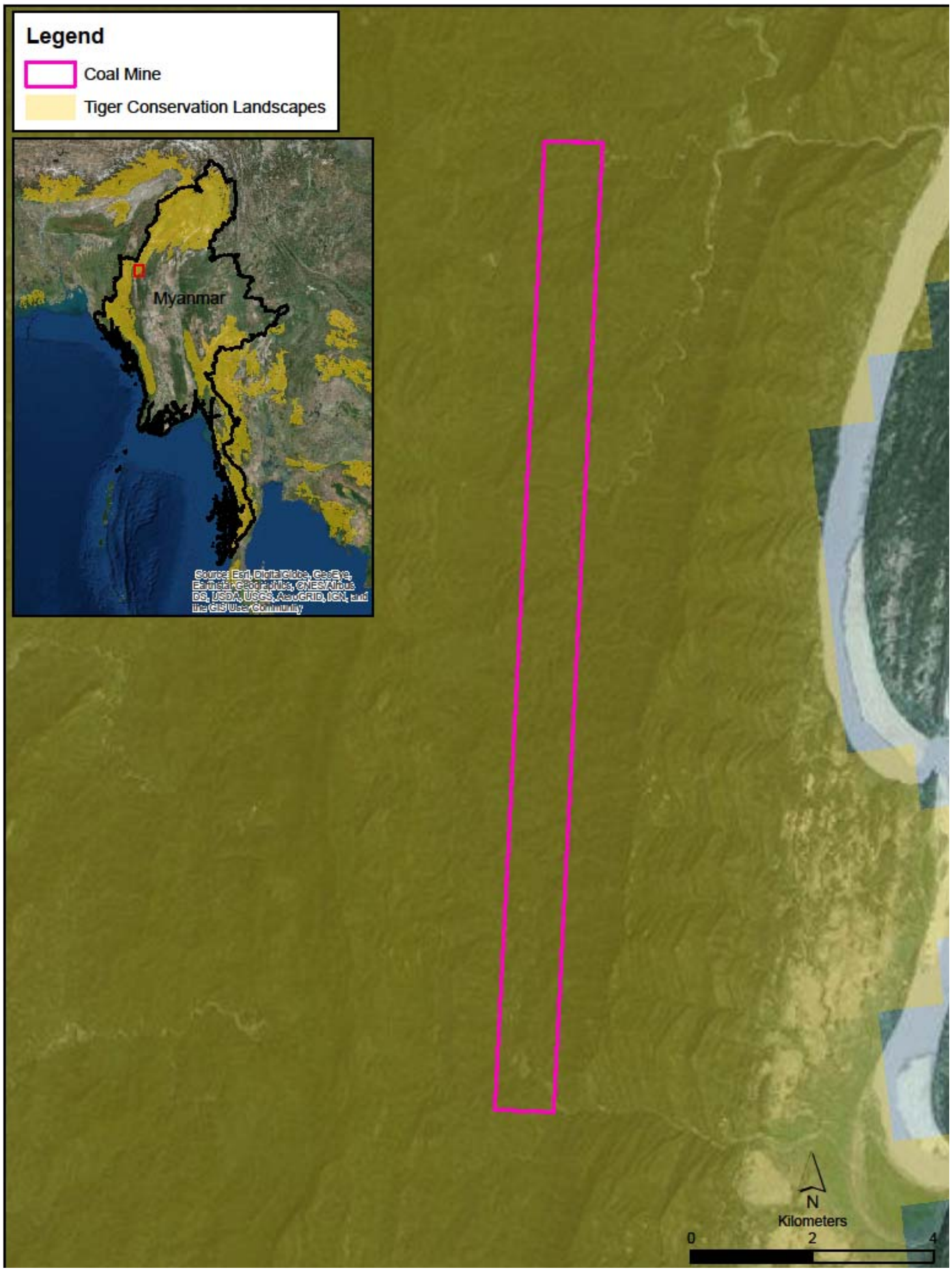
Birds and Animals Protection Act, the Wildlife Protection Act, the Forest Law, Protection of Wildlife and Conservation of Natural Areas law, Forest Policy and Rules relating to the Protection of Wildlife and Conservation of Natural Areas.

MONREC has identified key threats to biodiversity and habitat conservation in Myanmar. These include the hunting and poaching of wildlife, conversion of natural habitats, shifting cultivation, water pollution, introduction of invasive species and weak law enforcement [(1)].

With the exception of shifting cultivation, the remainder of these priority threats are relevant to the Project.

(1) Nature and Wildlife Conservation Division, Forest Department (nd) Status of Biodiversity Conservation in Myanmar. Retrieved from https://www.cbd.int/doc/meetings/nbsap/nbsapcbw-seasi-01/other/nbsapcbw-seasi-01-mm-en.pdf

Figure 3.1 Tiger Conservation Landscape Location in relation to Coal Mine Concession



4 SCOPING OF THE ESIA

The ESIA was undertaken in two phases: an initial Scoping Phase followed by an Impact Assessment (IA) Phase. The purpose of the Scoping Phase was to identify potentially signficant environmental and social impacts that may be caused by the Project (scoped-in impacts). The Scoping Phase was also used to determine the ESIA Terms of Reference (ToR), which detailed the baseline studies, stakeholder consultation, impact assessment and management plans that would need to be undertaken and prepared to address these potentially signficant impacts. The ToR for the ESIA were agreed with the STC and IFC upon conclusion of the Scoping Phase. The IA Phase was then conducted in accordance with the ESIA ToR to evaluate the significance of these impacts and recommend appropriate mitigation measures as well as management plans.

This section presents the approach and findings of the Scoping Phase of the ESIA.

4.1 METHODOLOGY OF ESIA SCOPING

ESIA Scoping followed a systematic process that involved the following activities:

- Gathering of information on Project activities during each phase of the Project through desktop review of information provided by STC and STM;
- A site visit to the Project Site and its vicinity in November 2016 to obtain preliminary information on existing site conditions as well as environmental and socio-economic receptors and/or resources;
- Identifying environmental and socio-economic receptors and/or resources identified in the AOI;
- Identifying potential interactions between Project activities and resources/receptors based on information obtained above;
- Prioritising potential interactions in terms of their likelihood to lead to significant impacts; taking into consideration the extent and nature of Project activities, and the existing condition/ sensitivities of the resources;
- Developing the ESIA ToR which detailed the methodology and requirements of the subsequent IA Phase to address potentially significant impacts that are most likely to affect Project planning, decision-making and which are of stakeholder interest.

Potential impacts which were not likely to be significant, and hence will need little further consideration or associated data gathering during the IA Phase, were "scoped-out" of the ESIA at this stage.

4.2 SCOPING RESULTS: KEY IMPACTS & CONCEPTUAL MITIGATION MEASURES

Findings of the Scoping Phase are presented in the Scoping Report of the Project under a separate cover [1]. The ESIA ToR is extracted from the Scoping Report and appended in *Annex A*.

As presented in the ESIA ToR, potential significant impacts to air quality, noise, surface water quality, waste management, biodiversity and ecosystems, traffic management and socio-economic conditions are expected from the construction and operation of the Project. Baseline data collection, stakeholder consultation, impact assessment and the preparation of management plans been undertaken, with findings presented in *Sections 5-10* of this ESIA Report.

Three priority impacts of the Project identified during the Scoping Phase, for which particular attention were paid during the current IA Phase are discussed in detail below.

4.2.1 Soil Erosion and Runoff Control at the Coal Mine and Access Roads

The existing 15 km access road from the base camp to the coal mine is a seasonal road built by STM from unconsolidated material and without rock armoring and drainage. Numerous stream crossings were observed with serious impacts to the flow of the stream as well as its water quality. Control of run-off and erosion at the coal mine itself is clearly a challenge owing to the high rainfall (approximately 2 m of annual rainfall) at the site. Runoff and erosion from the coal mine is causing significant impacts to the stream flow, its water quality and aquatic biodiversity.

4.2.2 Biodiversity

Biodiversity impacts from the operation of the Project have the potential to disturb resident fauna and have ongoing impacts to their habitats. The habitats on site may be classed as Natural Habitat or Critical Habitat, depending on further assessments. Key species of concern will include any endemic/restricted range species identified within the limestone hills. At the coal mine, species of conservation concern include: Pangolin (*Manis spp*.) (CR) and Hoolock Gibbon (*Hoolock hoolock*) (EN). Threatened flora may also be present including, *Dalbergia oliveras* (EN).

Residual impacts will require offsetting through the improvement of like-for-like biodiversity values. Loss of the area of limestone quarry and coal mine

(1) Scoping Report - Supplementary ESIA for STC Cement Plant & Associated Facilities in Myanmar, ERM, 2016.

will need to be offset to achieve a no-net-loss of biodiversity values (if classed as Natural Habitat) and net-gain (if classed as Critical Habitat).

4.2.3 *Enhanced Access for Illegal Logging at both the Cement Plant and Coal Mine*

Both legal and illegal timber extraction has been occurring in the vicinity of the cement plant and coal mine for many years before Shwe Taung's arrival in these areas. However, the upgrading of access roads by Shwe Taung at both locations has unintentionally improved access to timber resources. The introduction of vehicles and machinery to areas that were previously inaccessible or accessible only by bullock cart has resulted in rapid deforestation at both sites. At both the cement plant and coal mine, local residents spoke of an increase in "outsiders" coming to the area in search of teak since after Shwe Taung had constructed and/or upgraded access roads.

The economic incentives of illegal timber extraction are compelling for local residents as evidenced by the fact that no residents of the closest villages to Shwe Taung's cement plant (Kubyin Village) or coal mine (Chaungzon Village) are employed by Shwe Taung. Higher incomes are readily available through the illegal extraction of timber via roads that have been built or upgraded by Shwe Taung, an unintended consequence of access road improvement.

5 STAKEHOLDER ENGAGEMENT

As a part of the Supplementary ESIA process, consultation was carried out with the indirectly and directly affected population in five villages within the Project's Area of Influence (AOI) as well as conservation NGOs working in areas of interest to the project. This included interviews with Village Leaders in each of the five villages in the AOI for the cement plant and coal mine.

ERM undertook scoping visits and preliminary consultation with Village Tract leaders in November 2016 followed by preparation of a Stakeholder Engagement Plan (SEP) to guide the consultation activities for the remainder of the Supplementary ESIA.

ERM visited the two project sites in January 2017 to consult with stakeholders, explaining the project and administering questionnaires to individuals and groups. The consultation served the dual purpose of informing the public about the potential impacts of the Project and seeking community views on issues.

5.1 OBJECTIVES OF THE STAKEHOLDER ENGAGEMENT

The objectives of stakeholder engagement during the ESIA were to:

- Identify stakeholders and communities potentially affected by Project activities;
- Update stakeholders about the expansion Project; and
- Engage with potentially affected groups and individuals to understand their views, concerns and perceptions in order to inform the ESIA and Livelihood Restoration Plan, if required.

5.2 OVERVIEW OF CONSULTATION UNDERTAKEN

In summary, the following consultation was undertaken for the Supplementary ESIA:

- Consultation with Village Tract Leaders during Scoping in October 2016.
- Community briefings in five villages within the AOI in January 2017.
- 100 Household surveys in five villages within the AOI in January 2017.
- Focus Group Discussions with women and farmers in five villages in January 2017.
- Consultation with Flora and Fauna International and Wildlife Conservation Society concerning the establishment of biodiversity offsets in January 2017.

5.3 *HOUSEHOLD SURVEYS*

Household (HH) survey questionnaires were used to gather data and solicit views about the Project from the communities around the cement plant and coal mine to inform the ESIA. The data is relevant to understanding current socio-economic conditions in the Area of Influence of the Project, historical impacts associated with the construction of the cement plant and coal mine as well as potential issues associated with the on-going operation of the Project.

Prior to conducting HH surveys, an introductory meeting was convened in the host community to introduce the purpose of the consultation. Each community consultation event consisted of an update of the project by Shwe Taung.

The information collected is reflected in the Socio-economic Baseline in ***Section 7*** of this Supplementary ESIA.

5.3.1 *Data Collection*

Data was collected through community meetings, household surveys and face to face discussions with stakeholders. Special attention was given to potentially vulnerable groups such as women who have traditionally faced issues with land tenure (although not for this Project).

Community meetings were arranged by STC in collaboration with the Township General Administration Department Authorities and Village leaders. These meetings provided an opportunity to update stakeholders on the Project as well as gather feedback.

A total of 100 useable household surveys, 5 surveys of Village leaders, and 15 group discussions for socio-economic systems were completed across all 5 villages with particular focus on the livelihoods of women and farmers. The details the surveys conducted are in ***Error! Reference source not found.*** and photos of the community meetings are presented in *Figures 5.1-5*.

Table 5.1 The details of the surveys conducted in project area

Date	Village	Village Tract	Township	Region	No. of HH Consulted by Village Tract
17-1-17	Kubyin & Pyi Nyaung	Pyi Nyaung	Tharzi	Mandalay	Meeting with Village leaders and 2 Socio-economic Surveys
18-1-17	Kubyin	Pyi Nyaung	Tharzi	Mandalay	25 HH Survey
19-1-17	Pyi Nyaung	Pyi Nyaung	Tharzi	Mandalay	25 HH Survey
20-1-17	Kubyin & Pyi Nyaung	Pyi Nyaung	Tharzi	Mandalay	2 Townhall Meetings, 6 Groups Discussion
22-1-17	Paluzawa	Ywatha	Kalaywa	Sagaing	Townhall Meeting, 11HH Surveys, Socio-economic survey and 3 Group Discussion
23-1-17	Nanmawke	Ma Sein	Kalaywa	Sagaing	Townhall Meeting, 19HH Surveys, Socio-economic survey
24-1-17	Chaungzon	Ma Sein	Kalaywa	Sagaing	Townhall Meeting, 20HH Surveys and Socio-economic survey
25-1-17	Nanmawke & Chaungzon	Ma Sein	Kalaywa	Sagaing	6 Groups Discussion
Total Surveys			**100 HH Surveys, 5 Socio-economic survey and 15 Groups discussion**		

Source: ERM, 2017

5.4 *KEY FINDINGS FROM CONSULTATION WITH AFFECTED COMMUNITIES*

Representative photos taken during the consultation are shown in *Figures 5.1-5*. Key findings of consultation are presented below.

Pyi Nyaung

- All the surveyed respondents were aware of the proposed Project.
- All respondents described the Project as important for the community.
- Positive impacts of the STC development include: i) the upgrading of the road from Pyi Nyaung to the Cement Plant that provides improved access for firewood collection; and ii) the renovation and upgrade of a 17 bed clinic in the village increasing staffing and treatment capabilities.
- The majority of respondents (80%) expect the Project to create job opportunities, thus increasing income, and a further 16% mentioned improved transportation. One respondent mentioned a new school.
- The community noted increased water and air pollution as a concern relating to the Cement Plant. The respondents anticipate that the Project will generate air pollution (80% mentioned it) and one raised concerns about increased noise.
- All the respondents are concerned about outside people coming to the village to work on the construction and maintenance of the Project.

Kubyin

- All the respondents described the Project as important for the community.
- While residents all appreciate the improved access from the upgraded road to Pyi Naung, concerns were raised about the road encouraging an influx of outsiders for logging, exerting pressure on their own livelihoods.
- Concerns were raised that the Cement Plant has led to pollution and sedimentation of the Kubyin River. They attributed an increase to skin disease in children to this issue.
- Residents of Kubyin also claimed that dust pollution is created on a twice weekly basis from the Cement Plant.
- All the surveyed respondents were aware of the proposed Project.
- The majority of respondents (52%) expect the Project to create job opportunities and a further 32% mentioned improved transportation. Four respondents did not mention anything.
- The respondents overwhelmingly anticipate that the Project will generate air pollution (80% mentioned it), increase noise (52% mentioned it) and 8% raised concerns over failed crop harvest .

- All the respondents are concerned about outside people coming to the village to work on the construction and maintenance of the Project.

- One respondent raised concerns about the health and agricultural situation of his community and enquired over the drinking water (supply) in relation to the Project.

Chaungzon

- All the respondents described the Project as important for the community.

- Residents also noted increased dust from road construction.

- All the surveyed respondents were aware of the proposed Project.

- The majority of respondents (85%) expect the Project to improve transportation and, within these, 20% of the total respondents hope it will also create job opportunities.

- Most respondents do not anticipate any negative impacts from the Project on their community but 30% (6 respondents) mentioned that they fear landslides. One respondent mentioned that landslides occur every year during the rainy season, the last one in 2016, due to deforestation.

- All the respondents are concerned about outside people coming to the village to work on the construction and maintenance of the Project.

- One respondent expressed his/her wish to have a monastery and a well built.

Paluzawa

- All the respondents described the Project as important for the community.

- Residents complained of the odour from spontaneous combustion of coal from nearby coal staging areas, including at Coal Staging Area 1 operated by STM.

- Residents also noted increased dust from road construction.

- All the surveyed respondents were aware of the proposed Project.

- All the respondents are concerned about outside people coming to the village to work on the construction and maintenance of the Project but no other concern, question or comment on the difficulty faced by their community was mentioned.

Nanmawke

- All the respondents described the Project as important for the community.

- No notable issues regarding the coal mine development.

- All the surveyed respondents were aware of the proposed Project.

- Some respondents (21%) expects the Project to create job opportunities, thus increasing income, and a further 42% mentioned improved transportation.

- Nearly half of the respondents (42%) anticipate that the Project will generate water pollution and one raised concerns over air pollution. The majority of respondents (53%) had no opinion on the potential negative impacts.

- All the respondents are concerned about outside people coming to the village to work on the construction and maintenance.

5.5 *NEXT STEPS*

Consultation outcomes have been incorporated into the design of mitigation measures for Project and are contained in this ESIA Report. These include:

- Routine air and water monitoring in communities closest to the cement plant. Dust deposition gauges have been installed in Kubyin and Pyi Nyaung Villages and STC has committed to communicating the results of this air monitoring to local residents;

- Procedural controls to minimize the likelihood of auto-ignition of stockpiled coal;

- Engineering controls to prevent erosion and runoff from entering surface streams at the cement plant, coal mine and access roads;

- A code of conduct will be developed for imported workers during the construction phase of the project; and

- Development of a formal grievance procedure for use by local residents.

During the ESIA disclosure period, STC has committed to briefing those communities consulted as part of the ESIA process to provide feedback on how the concerns raised are being addressed.

Figure 5.1 Consultation at Pyi Nyaung Village

Figure 5.2 Consultation at Kubyin Village

Figure 5.3 Consultation at Chaungzon Village

Figure 5.4 Consultation at Paluzawa Village

Figure 5.5 Consultation at Nanmawke Village

6 ENVIRONMENTAL BASELINE

This Section is structured to provide information on the environmental baseline characteristics and conditions in the Project Site and its AOI. 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.

Baseline information has been collated from a range of sources including publicly available information, primary data collection and through consultation.

6.1 AREA OF INFLUENCE

The AOI of the Project encompasses:

- the primary Project Site including the cement plant and associated mudstone and limestone quarries;
- the coal mine and associated staging areas and access roads; and
- areas potentially affected by the cumulative impacts from other developments or future expansion of the Project as well as induced activities of the Project.

It should be noted that the AOI for a particular resource/ receptor may vary depending on the nature of the change caused by the Project activities and the type of effect being considered, but in each case it is defined to include all the area within which it is likely that potentially significant impacts could result. For example, a 300 m AOI would be considered as sufficient for noise given the localised nature of noise impacts while the AOI for water quality impacts due to unplanned spills would cover the downstream area where elevated pollutant level is expected, which is often more than 300 m. As such, the AOI for each specific resource / receptor / impact will vary and these are defined in the sections below.

6.2 PHYSICAL ENVIRONMENT

This section describes the physical setting of the Project AOI. This is based on a desk top review, a scoping site visit undertaken in November 2016 as well as the baseline surveys of air quality, airborne noise, surface water quality and traffic undertaken in January 2017 ("January 2017 baseline surveys").

6.2.1 Cement Plant

Air quality

Taking into account the nature of activities during the construction and operation phases of the Project and the relative locations of sensitive receptors, an AOI of 500 m and 5 km around all project sites has been established for the construction and operational phases, respectively, for the Air Quality Impact Assessment. The AOIs have been determined so that all potentially impacted sensitive receptors closest to the Project activities during both construction and operation phase have been identified.

Sensitive receptors are split into three categories as described below.

- Human – these are locations of human settlement, schools, hospitals, clinics and government offices. The relevant pollutants of interest for sensitive human receptors are particulate matter as dust, PM_{10} and $PM_{2.5}$, NO_2 and SO_2.

- Ecological – these are locations where there are local, national or internationally protected habitats. The relevant pollutants of interest for sensitive ecological receptors are particulate matter as dust, SO_2 and NO_x.

- Agricultural - these are locations where there are crop growing activities, as crop growth may be detrimentally affected and crops soiled as a result of project activities. The relevant pollutants of interest for sensitive agricultural receptors are particulate matter as dust, SO_2 and NO_x.

A number of representative human sensitive receptors were identified in the vicinity of the cement plant as presented in *Table 6.1* and *Figure 6.1*.

Table 6.1 Representative Air Sensitive Receptors at Cement Plant and Associated Quarries

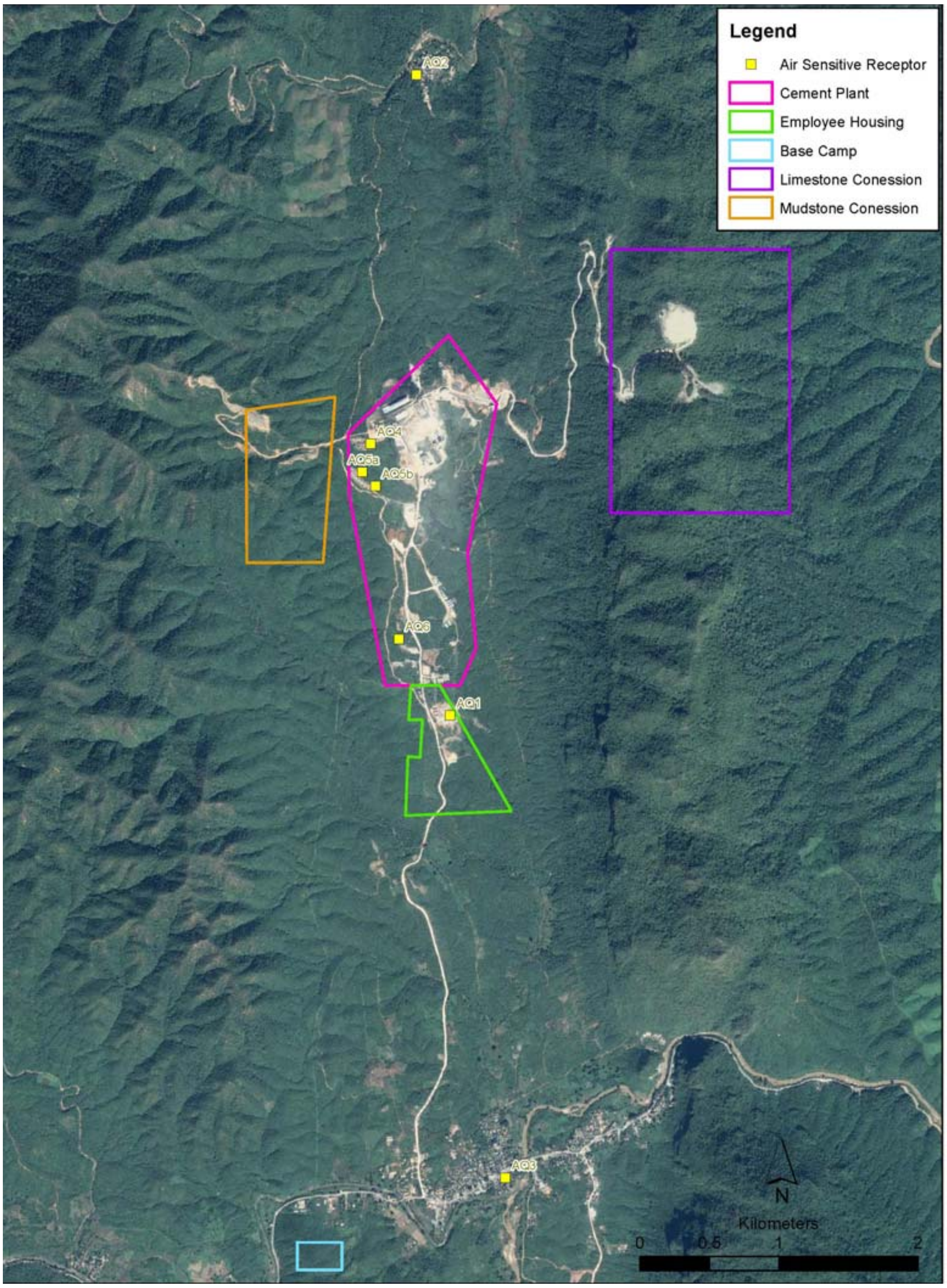
Receptor ID	Receptor Name(1)	Type of Receptor	Approximate Location		Approximate Distance to Project Components(1)			
			Latitude	Longitude	Cement Plant	Limestone Quarry	Mudstone Quarry	Project Road
AQ1	Worker Accommodation	Human	20°50.56.15'N	96°23.35.97'E	<2000m	<2000m	<2500m	<50m
AQ2	Kubyin Village	Human	20°53.25.83'N	96°23.25.07'E	<2500m	<2000m	<1000m	<50m
AQ3	Pyi Nyaung Village	Human	20°49'6.34"N	96°23'35.42"E	<5000m	<5000m	<5000m	<50m
AQ4	Worker Accommodation	Human	20°51'59.29"N	96°23'15.09"E	<500m	<2000m	<1000m	<50m
AQ5	Worker Accommodation	Human	20°51'52.66"N	96°23'13.16"E	<500m	<2000m	<1000m	<50m
AQ6	Worker Accommodation	Human	20°51'13.74"N	96°23'22.86"E	<1000m	<2000m	<2000m	<50m

Notes:

(1) Each receptor identified is not necessarily a single point and may represent a cluster of receptors.

(2) Distances from project components have been estimated using aerial imagery.

Figure 6.1 *Representative Air Sensitive Receptors at Cement Plant and Associated Quarries*



In accordance with WBG guidelines (1), measurement of existing air quality is required for emissions associated with the Project processes over time that have potential to impact the surrounding land use. Primary pollutants associated with the Project are PM_{10} and $PM_{2.5}$, NO_x, NO_2, and SO_2.

Ambient concentrations of NO_2 and SO_2 were measured by means of a diffusion tube survey undertaken by ERM in January 2017. This data have been supplemented by measurements taken by Myanmar Environment

(1) International Finance Corporation (IFC) (2007) Environmental, Health and Safety Guideline: Air Emissions and Ambient Air Quality

Sustainable Conservation (1) in support of the previous EIA completed in March 2016.

The findings from both surveys are presented in the following section.

ERM Baseline Monitoring Survey

Due to imposed time constraints, monitoring for one week was undertaken from 17 to 23 January 2017 to provide an indication of baseline concentrations of air pollutants in ambient air.

Air quality monitoring locations were selected by identifying potentially affected communities, with consideration given to the prevailing wind conditions and Project activities. There is limited local monitoring of meteorology and therefore Weather Research and Forecasting Model data(2) was used to generate meteorological data for the purpose of reviewing climatic conditions, air quality and identifying sensitive receptors.

ERM monitored three locations for NO_2 and SO_2 at locations in the vicinity of the cement plant given the likely future emissions from the cement manufacturing process (*see Table 6.2*). Within the assessment, however, the measured baseline air quality data are conservatively considered representative of the entire Project AOI.

At each monitoring location, measurement of NO_2 and SO_2 was undertaken using Palmes type diffusion tubes in triplicate. Diffusion tubes are passive samplers that consist of small plastic tubes which contain a chemical reagent to absorb the pollutant to be measured directly from the air. The use of triplicate diffusion tubes enhances the robustness of the data set and allows potentially outlying values to be identified and investigated. Preparation and analysis of the diffusion tubes was undertaken in accordance with BS EN 13528. There is best practice guidance, adopted by this assessment, available from the US EPA (3) and from the UK Department for the Environment, Food and Rural Affairs (DEFRA) (4) on the siting and deployment of tubes. The analysis of the exposed tubes was undertaken using Ion Chromatography (United Kingdom Accreditation Service (UKAS) Accredited Method ISO/IEC 17025:2005).

Monitoring locations were initially selected using aerial photography, local knowledge about villages, accessibility and security to determine the location of operations and nearby sensitive receptors in addition to typical wind

(1) Myanmar Environment Sustainable Conservation (2016) Environmental Impact Assessment on Shwe Taung Cement Factory, at Kubyin Village, Pyi Nyaung Area, Tharzi Township, Mandalay Region.

(2) Skamarock, W. C., J. B. Klemp, J. Dudhia, D. O. Gill, D. M. Barker, M. G Duda, X.-Y. Huang, W. Wang, and J. G. Powers, 2008: A Description of the Advanced Research WRF Version 3. NCAR Tech. Note NCAR/TN-475+STR, 113

(3) United States Environmental Protection Agency (USEPA) Ambient Monitoring Technology Information Centre [Online] Available at: https://www3.epa.gov/ttn/amtic/ [Accessed 12th September 2016]

(4) AEA Energy and Environment on behalf of the Department for Environment, Food and Rural Affairs (Defra) and the Devolved Administrations (2008) Diffusion Tubes for Ambient NO_2 Monitoring: Practical Guidance for Laboratories and Users

directions for the time of year of the monitoring. The final decision on locations was then made while in the field to determine the most suitable and representative locations for monitoring equipment to be deployed.

Monitoring locations were chosen to determine general background concentration levels. Primarily, sites were located to measure typical concentrations in areas of high population density i.e. where sensitive receptors are located. Locations were also chosen to reflect local wind conditions with locations downwind of prevailing winds being of important consideration. The monitoring locations identified are presented in *Figure 6.1* with photos shown in *Figures 6.2- 6.4* and further information is provided in *Table 6.2.*

Table 6.2 Air Quality Monitoring Summary

Site	Name	Location		Monitoring	Period
		Latitude	Longitude		
AQ1	Worker Accommodation Housing	20°50'56.15"N	96°23'35.97"E	NO_x, NO_2, SO_2	17 to 23 January 2017
AQ2	Kubyin Village	20°53'25.83"N	96°23'25.07"E		
AQ3	Pyi Nyaung Village	20°49'8.19"N	96°23'51.55"E		

Figure 6.2 Air Quality Monitoring Station at AQ1: Worker Accommodation Quarters

Figure 6.3 Air Quality Monitoring Station at AQ2: Kubyin Village

Figure 6.4 Air Quality Monitoring Station at AQ3: Pyi Nyaung Village

The monitoring data from the air quality survey undertaken by ERM between 17 and 23 January 2017 for NO_2 and SO_2 are presented below in *Table 6.3*.

Table 6.3 ***NO_2 and SO_2 concentrations measured by ERM, 17 - 23 January 2017***

Site	Name	Tube No.	NO_2	SO_2 (1)
			µg/m³	µg/m³
Annual Mean Air Quality Standard (2)(3)			**40**	**n/a**
AQM-1	Worker Accommodation	Tube 1	3.68	<DL
		Tube 2	3.61	
		Tube 3	3.59	
		Average	3.63	
AQM-2	Kubyin Village	Tube 1	10.5	<DL
		Tube 2	10.3	
		Tube 3	10.1	
		Average	10.3	
AQM-3	Pyi Nyaung Village	Tube 1	9.09	<DL
		Tube 2	10.6	
		Tube 3	10.7	
		Average	10.1	

Note:

(1) Results reported as <0.03µgS on tube are below the reporting limit.

(2) WBG General EHS Guidelines, 2007

(3) Myanmar Environmental Quality (Emission) Guidelines, 2015

The data presented in *Table 6.3* have conservatively been used to represent indicative annual background concentrations of NO_2 and SO_2. A review of the baseline data collected concludes that the baseline concentrations are consistently below the relevant annual AQS presented in *Table 3.3*. Baseline concentrations of SO_2 were found to be below the limit of detection at all monitoring sites.

The baseline also needs to be interpreted for short-term periods. The United Kingdom Department for Environment, Food and Rural Affairs (DEFRA) (1) recommends that the short-term baseline is derived by multiplying the long-term by a factor of two. This conversion has been undertaken using the figures presented in *Table 6.3* to provide baseline concentrations for comparison against the one hour NO_2 air quality standards presented in *Table 3.3.* This is considered a conservative approach. The results from applying this methodology are presented below in *Table 6.4.*

Table 6.4 ***Derived Hourly and Daily NO_2 Background Concentrations***

Site	Name	Hourly concentration (µg/m³)
AQM-1	Family Housing	7.26
AQM-2	Kubyin Village	20.6
AQM-3	Pyi Nyaung Village	20.2
Average		16.0
Air Quality Standard (1)(2)		200

(1) Department for Environment, Food and Rural Affairs (DEFRA) (2016) Air emissions risk assessment for your environmental permit [Online] Available from: https://www.gov.uk/guidance/air-emissions-risk-assessment-for-your-environmental-permit [Accessed 2nd March 2017]

Site	Name	Hourly concentration (μg/m³)

Notes:
(1) WBG General EHS Guidelines, 2007
(2) Myanmar Environmental Quality (Emission) Guidelines, 2015

The results from the monitoring conducted in the area indicate that ambient concentrations of NO_2 and SO_2 are below the relevant air quality standards. The receiving airshed in the area can therefore be classified as 'non-degraded' with regard to these pollutants.

Myanmar Environment Sustainable Conservation (MESC) Baseline Monitoring Survey

Air quality baseline information was collected by Myanmar Environment Sustainable Conservation (MESC) in support of the local EIA undertaken for the Shwe Taung Cement Plant in March 2016 (1).

Monitoring of total suspended particulate PM_{10}, $PM_{2.5}$, NO_2 and SO_2 was performed over a 24 hour period using the EPAS Haz-scanner. The exact date the sampling took place is not clear from the local EIA.

Monitoring Locations

The exact monitoring location is not clearly identifiable from the local EIA report however the location is known to be within the study area which was defined as 16 square miles around the cement plant.

The results from the EIA have been extracted and are presented below in *Table 6.5*.

Table 6.5 MESC Baseline Data – Short Term

Pollutant	Concentration (μg/m³)	Averaging Period	Air Quality Standard(1)(2) (μg/m³)
PM_{10}	45 – 50	24-hour	50
$PM_{2.5}$	30.0	24-hour	25
NO_2	3.08	24-hour	n/a
	28.3	1-hour	200
SO_2	0.004	24-hour	20

Notes:
(1) *WBG General EHS Guidelines, 2007*
(2) *Myanmar Environmental Quality (Emission) Guidelines, 2015*

With regard to NO_2 and SO_2, monitoring undertaken by MESC indicates that concentrations are below the relevant air quality standards. The receiving airshed in the area can therefore be classified as 'non-degraded' with regard to pollutants to be emitted by the Project. This conclusion reflects the outcome of the monitoring survey completed by ERM and discussed above.

Analysis of the data collected by MESC indicates that concentrations of PM_{10} and $PM_{2.5}$ over a 24-hour period in the study area are close to or exceed the ambient air quality standards. However the local EIA does not include the monitoring locations and equipment type used. Furthermore, it is noted that the study area is located in a rural setting and, with the exception of the existing cement plant, there are very few combustion or fugitive dust sources from residential, industrial, commercial or institutional sources which would typically be associated with elevated ambient concentrations of $PM_{2.5}$ and PM_{10}.

This evidence, further supported by professional experience and an understanding of the general environment in the study area, suggests that caution should be taken when interpreting the baseline results for PM_{10} and $PM_{2.5}$ for comparison to the air quality standards as the monitoring data may not provide a true indication of the baseline air quality in the study area.

For the purpose of informing this impact assessment, and based on the aforementioned evidence, the airshed in the study area has been classified as 'non-degraded' for both $PM_{2.5}$ and PM_{10}.

The magnitude of the impacts for the impact assessment is defined based on these finding (please refer to *Annex C1* for the air quality impact assessment methodology).

Climate and Meteorology

In order to fully define the baseline meteorology and climate, hourly sequential meteorological data is required for:

- Wind speed;
- Wind direction;
- Precipitation;
- Relative humidity;
- Temperature; and
- Cloud cover.

Following IFC recommendations, data are required for five (5) years in order to capture year on year variability.

There are no meteorological stations in the vicinity of the Project that capture all these parameters or have sufficient data availability. Therefore, five years of meteorological data were modelled using a 12 km x 12 km grid resolution with the Weather Research and Forecasting Model (WRF) (2). The WRF model is a next-generation mesoscale numerical weather prediction system

(1) MESC (2016) EIA on 3,500 tpd Shwe Taung Cement Factory.

(2) Skamarock, W. C., J. B. Klemp, J. Dudhia, D. O. Gill, D. M. Barker, M. G Duda, X.-Y. Huang, W. Wang, and J. G. Powers, 2008: A Description of the Advanced Research WRF Version 3. NCAR Tech. Note NCAR/TN-475+STR, 113.

designed for both atmospheric research and operational forecasting needs. The model is extensively validated using actual observations to ensure the best possible accuracy and precision.

Figures 6.5-6.9 illustrate the monthly meteorological characteristics at the Project site for a five year period from 2012 to 2016. The data show that the climate in this part of Myanmar is characterised by a dry season that occurs December and April and winds that blow from the east.

Figure 6.5 Total Monthly Rainfall

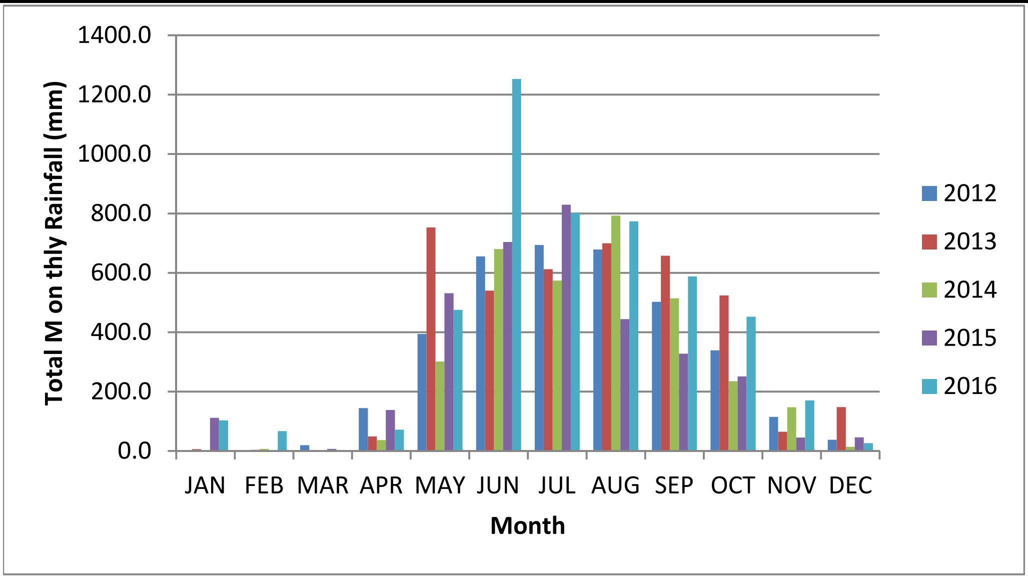


Figure 6.6 Relative Humidity

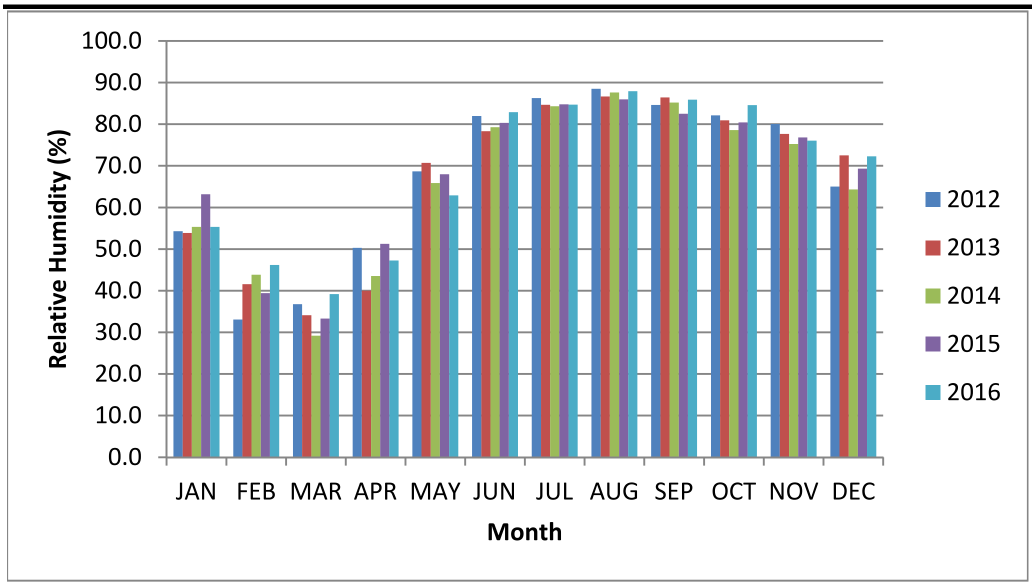


Figure 6.7 Mean Monthly Temperature

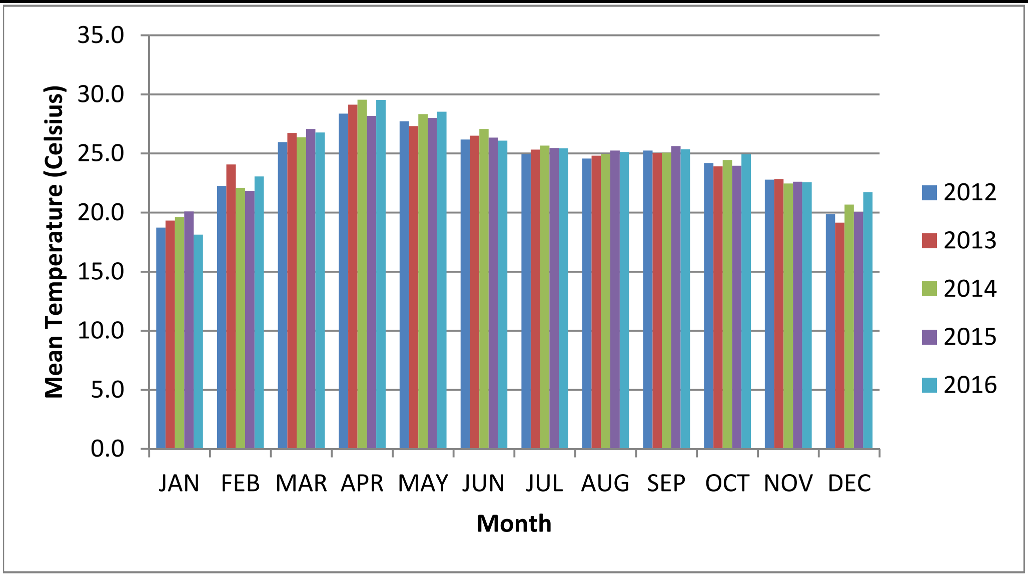


Figure 6.8 Mean Wind Speed

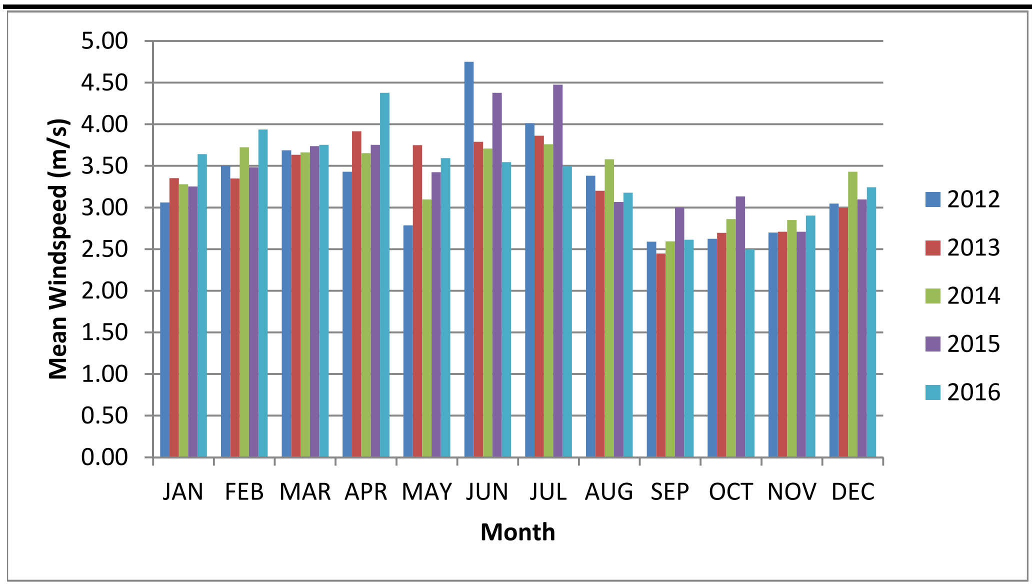


Figure 6.9 Wind Rose 2012 - 2016

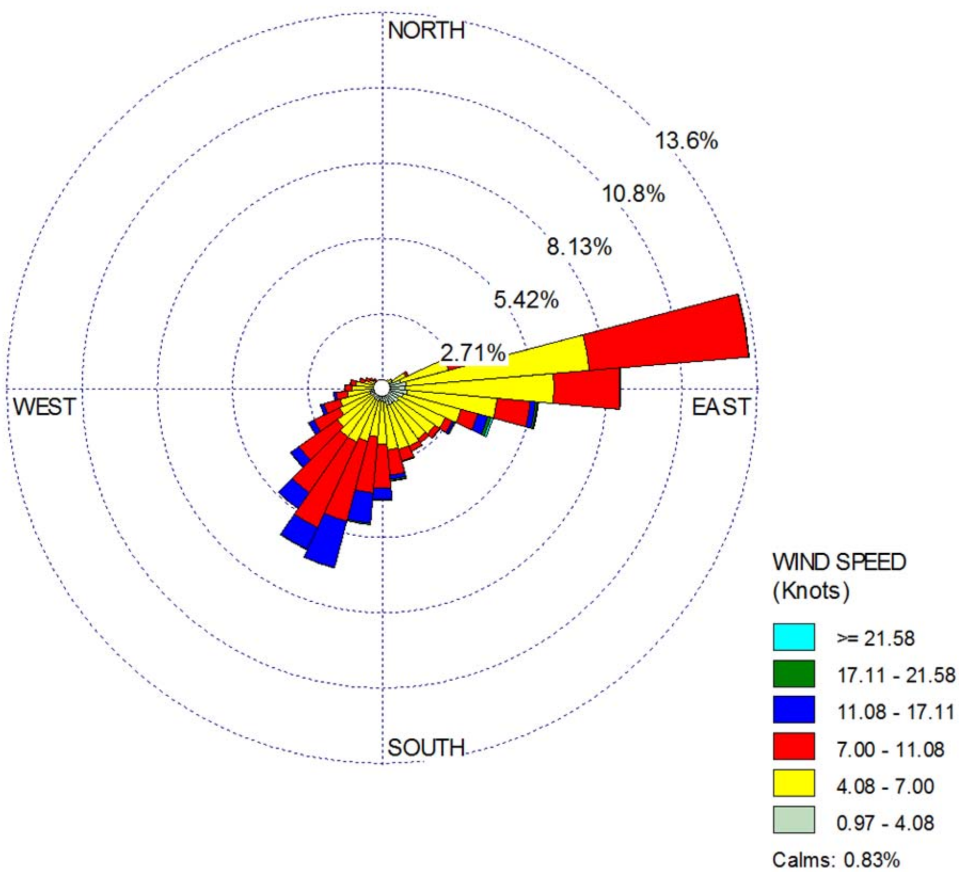


Figure 6.5 indicates that most rainfall is received at the Project Site from May to October, with June, July and August being the most consistently wet months in comparison to the rest of the year.

Relative humidity is presented in *Figure 6.6.* The modelled data show that humidity in the area is highest from July through to September with March recorded as least humid. The average temperatures presented in *Figure 6.7* correlate with average humidity with the highest average temperatures recorded during periods of low relative humidity.

Mean wind speeds are presented in *Figure 6.8* and tend to fluctuate throughout the year. Lower wind speeds are more pronounced during the latter part of the year from September through to December.

A wind rose based on the WRF data is shown in *Figure 6.9.* The figure shows that easterly and south westerly winds dominate. Wind speeds average 3.36 m/s, with a maximum one hour average of 14.4 m/s. Wind direction and wind speed are both important factors when considering air pollution dispersion. Prevailing winds mean receptors downwind are more likely to be exposed to increased concentrations with higher wind speeds leading to increased dispersion.

Emissions of dust are only likely to occur from open exposed surfaces (such as stripped ground and stockpiles) at wind speeds of greater than 5.3 m/s. (1) The data indicate that the wind speed is equal to or greater than 5.3 m/s for 10% of the time. The prevailing wind direction will mean receptors to the west and north east of the Project site will be impacted most as a result of construction and operation activities.

Noise

The nearest representative NSRs that may potentially affected by the noise impacts due to the Project are identified with locations shown in *Figure 6.10* and summarized in *Table 6.6* below:

Table 6.6 Representative Noise Sensitive Receivers

NSR	Description	Type of Uses
N1	Proposed Permanent Housing	Planned permanent residential
N2	Temporary Housing	Worker's camp during construction phase
N3	Temporary Housing	Will be removed when N1 is ready
N4	Existing Permanent Housing	Existing permanent residential

Note:
N2 and N3 are temporary housing during the construction phase and are not included in the operational noise impact assessment.

Baseline noise monitoring was conducted on 18 to 23 January 2017 at three selected noise sensitive receivers (NSRs), which are N1, N2 and N3, located near the Project Site to establish the background levels. The locations of baseline monitoring stations are summarised in *Table 6.7* and are presented in *Figure 6.10* with photos shown in *Figures 6.11-6.13.*

(1) United States Environmental Protection Agency (1995) AP-42 Section 13.2 Fugitive Dust Sources

Figure 6.10 Representative NSRs at Cement Plant and Associated Quarries

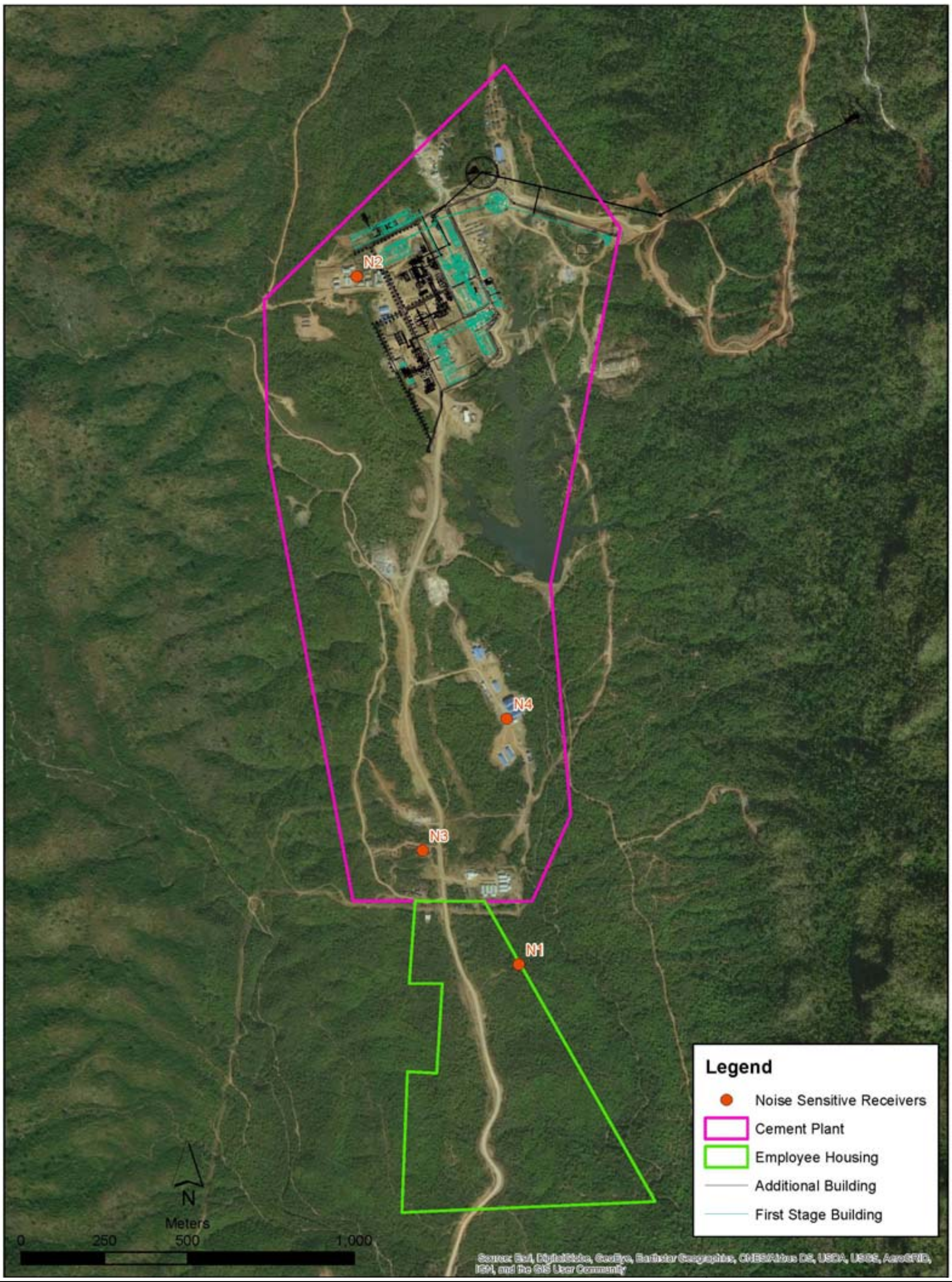


Figure 6.11 Noise Monitoring Station at N1

Figure 6.12 Noise Monitoring Station at N2

Figure 6.13 Noise Monitoring Station at N3

Table 6.7 ***Baseline Noise Monitoring Locations***

NSR	Description	GPS Coordinates	
N1	Permanent Housing - 1	20°50'57"N	96°23'37"E
N2	Temporary Housing - 1	20°52'4"N	96°23'19"E
N3	Temporary Housing - 2	20°51'18"N	96°23'27"E

Hourly A-weighted equivalent continuous sound pressure levels ($L_{Aeq, 1 hour}$) were recorded 24 hours continuously at each location. Daytime and night-time L_{Aeq} were calculated by averaging the hourly sound pressure levels measured between 0700 and 2200 hours and between 2200 to 0700 hours, respectively.

Noise levels (L_{Aeq}) were recorded by a Type I sound level meter, *01dB-Stell Solo,* at about 1.5m above ground with no reflecting surface within 3m in accordance with the IFC Guidelines.

Background noise levels exceeded the noise limits set out in WBG *General EHS Guideline* (2007) during daytime and night-time periods at both temporary worker accommodation areas which are located several hundred metres from the cement plant. The dominant source of noise was from the operation of the existing cement plant and traffic. Results of the baseline noise monitoring are summarised in *Table 6.8*.

Table 6.8 ***Summary of Baseline Noise Monitoring and Noise Criteria***

NSR	Type of Uses	Averaged Background Noise Levels, dB(A)		EQG and IFC Noise Level Guidelines, dB(A)	
		Daytime	Night-time	Daytime	Night-time
N1	Residential	49	44	55	45
N2	Residential	58	57	55	45
N3	Residential	56	54	55	45

Notes:

(a) Daytime refers to the hours from 0700 hrs to 2200 hrs while night-time refers to the hours from 2200 hrs to 0700 hrs.

Surface Water Quality

Water quality impacts could be a potentially significant issue for the construction and operation of the cement plant, for example, in case of contaminated run-off from the coal storage area and refuelling area of the cement plant as well as sediment loaded run-off from the mudstone quarries. Potential contamination of river water from the above sources may affect the Kubyin Village which is located downstream of the cement plant and mudstone quarries. Given the use of Kubyin River water by the Kubyin Village on sensitive uses such as drinking, a baseline water quality survey was conducted in January 2017 at Kubyin Village, the cement plant and at the mudstone quarry to establish baseline conditions and to inform the impact assessment of the plant expansion. The sampling locations and the rationale for inclusion are presented in *Table 6.9*. *Figure 6.14* illustrates the locations of the sampling station with photos shown in *Figures 6.15-6.18*.

Table 6.9 ***Baseline River Water Quality Sampling Locations- Cement Plant/Quarries***

Station	Coordinates		Description
	Latitude	Longitude	
WP1	20° 51' 58.850" N	96° 23' 35.700" E	Located at the cement plant reservoir of the. Reported to release water during the wet season.
WP2	20° 52' 11.900" N	96° 23' 25.000" E	Discharge point from the drainage of the coal staging area.
WP3	20° 52' 11.876" N	96° 23' 25.316" E	Discharge point from the drainage of the coal staging area.
WP4	20° 51' 55.770" N	96° 22' 51.370" E	Stream located downgradient of the mudstone quarry and upstream of Kubyin Village.
WP5	20° 53' 25.640" N	96° 23' 20.560" E	Section of Kubyin River besides Kubyin Village which is near the freshwater intake point of the cement plant.

During the baseline survey in January 2017, two water samples were taken at each sampling location using sampling bottles provided by a laboratory certified under the Hong Kong Laboratory Accreditation Scheme (HOKLAS). These samples were stored at chilled condition and sent to the laboratory for analysis. Water quality parameters measured include *in-situ* measurement of pH and temperature as well as laboratory analysis of chemical oxygen demand (COD), 5-day biochemical oxygen demand (BOD_5), oil and grease, total nitrogen (TN), total phosphorus (TP), total suspended solids (TSS) and total coliform. These parameters are pollutants of concern specified in the WBG *EHS Guidelines for Cement and Lime Manufacturing* (2007) (*Table 3.4*) and WBG *General EHS Guidelines* (2007) for treated sanitary sewage discharge during operation of the Project (*Table 3.6*). For construction of the Project, it is noted that the Myanmar National Environmental Quality (Emissions) Guidelines specified the guidance levels for site runoff and wastewater discharges, which are the same as those specified for treated sanitary sewage discharge by WBG *General EHS Guidelines* (2007).

The baseline water quality data collected in January 2017 are presented in *Table 6.10*. At WP2 and WP3, which are discharge locations of the coal staging area, the level of TSS exceeded both the WBG *EHS Guidelines for Cement and Lime Manufacturing* (2007) and WBG *General EHS Guidelines* (2007) for treated sanitary sewage discharge. The *E. coli* level at WP2 also exceeded the WBG *General EHS Guidelines* (2007) for treated sanitary sewage discharge. These exceedances indicate contamination due to existing operations at the coal staging area through sediment loaded discharge and possibly sewage. In addition, higher COD levels were reported at the coal staging area when compared to other locations which indicated potential issues of contaminated run-off from the coal staging area. The potential issues of run-off and sewage discharges from the cement plant and associated quarries are further assessed with mitigation measures proposed in *Section 9.3.1*. Other measurements were generally within the WBG EHS Guidelines with no specific concern identified.

Figure 6.14 Water Sampling Locations Stations at the Cement Plant and Associated Quarries

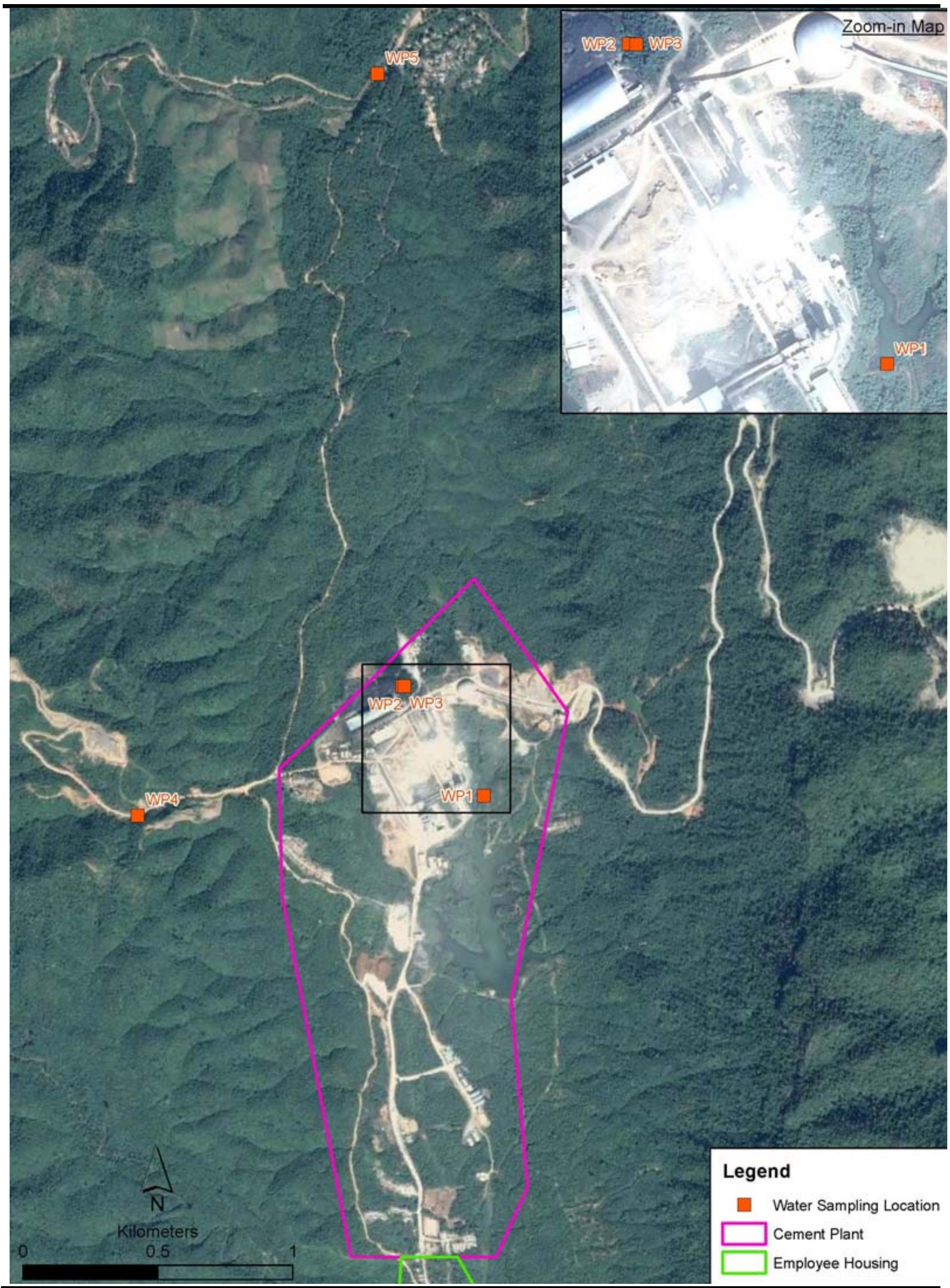


Figure 6.15 Water Quality Sampling Station at WP1

Figure 6.16 Water Quality Sampling Stations at WP2 and WP3

Figure 6.17 Water Quality Sampling Station at WP4

Figure 6.18 Water Quality Sampling Station at WP5

Table 6.10 Baseline Water Quality at the Cement Plant and Associated Quarries, January 2017

Parameter	Unit	Detection Limit	Analytical Method Reference	WP1 - Reservoir	WP2 – Coal Downstream Staging Area	WP3 – Coal Downstream Staging Area	WP4 – Downstream Mudstone Quarry	WP5 – Kubyin Village	WBG EHS Guidelines for Cement and Lime Manufacturing (2007)	WBG General EHS Guidelines (2007) for Treated Sanitary Sewage Discharge
TSS	mg/L	2.00	APHA 2540 D	11.00	118.00	215.50	9.00	23.00	50	50
TP	mg/L	0.01	APHA 4500P:J	0.01	0.03	0.06	0.01	0.06	-	2
TN	mg/L	0.10	APHA 4500P:J APHA 4500-NO3:I	0.40	1.25	1.70	0.30	0.30	-	10
Total Coliforms	CFU/100mL	1.00	DoE Sec 7.8 & 7.9	7.00	2,00.00	45.50	N.D.	14.50	-	400
BOD_5	mg/L	2.00	APHA 5210 B	1.00	5.50	6.50	1.00	1.00	-	30
COD	mg/L	5.00	APHA 5220 C	10.00	21.50	41.50	2.50	4.75	-	125
Oil & Grease	mg/L	5.00	APHA 5520 B	D.L.	D.L.	D.L.	D.L.	D.L.	-	10
pH	Standard Unit	n.a.		7.60	8.00	7.60	5.60	6.30	6-9	6-9
Temperature	^{o}C	n.a.		24.50	24.00	24.00	20.50	24.00	Increase <3 ^{o}C	

Notes:

(1) D.L. = value detected below detection limit for all samples at the station.

(2) n.a. = not applicable

(3) N.D. = not detected

(4) To determine the average level at a station with one of the two samples reported to be below detection limit, value below detection limit is halved for the calculation.

(5) Exceedance of WBG Guidelines is shaded grey.

Traffic & Transport

6.2.2 Coal Mine

Air Quality and Noise

Baseline sampling surveys for air quality and noise were undertaken for the local EIA [(1)] for the coal mine. The location, time and method of sampling are not clearly stated in the local EIAs. According to the local EIAs, the baseline levels of air quality and noise generally complied with the respective guideline values recommended by WHO and WBG.

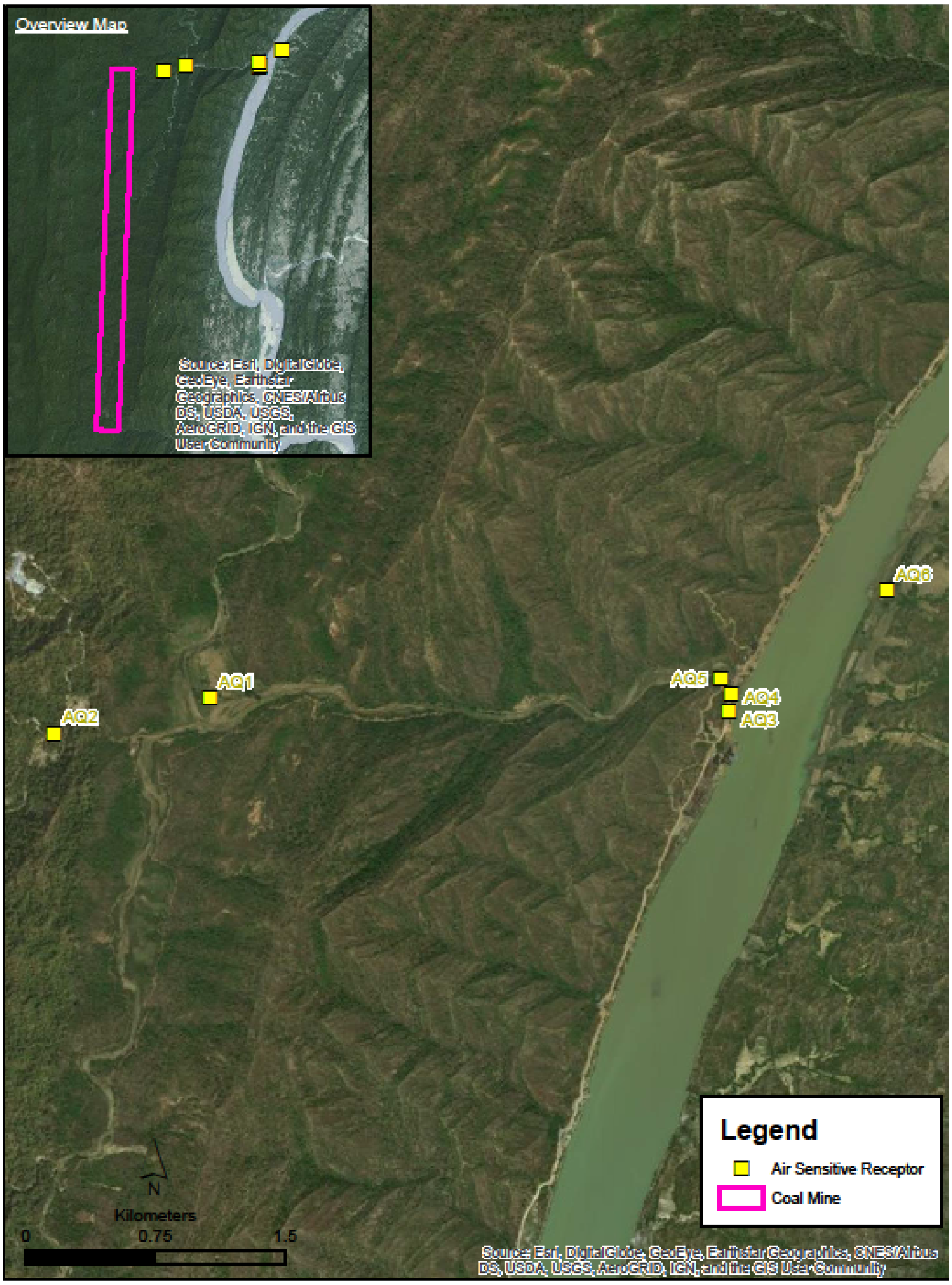
A number of representative air sensitive receptors (human) were identified in the vicinity of the coal mine and are presented in *Table 6.11* and *Figure 6.19*.

Table 6.11 Representative Air Sensitive Receivers at Coal Mine

Receptor id	Receptor Name	Type of Receptor	Location		Approximate Distance to Project Components		
			Latitude	Longitude	Coal Mine	Stockpile Area	Project Road
AQ1	Chaungzon	Human	23°27'18.19"N	94°18'31.36"E	<2000m	<3000m	<50m
AQ2	Base Camp	Human	23°27'11.69"N	94°17'59.48"E	<1500m	<4000m	<50m
AQ3	Paluzawa	Human	23°27'14.91"N	94°20'17.16"E	>5000m	<50m	<50m
AQ4	Paluzawa	Human	23°27'17.93"N	94°20'17.61"E	>5000m	<100m	<50m
AQ5	Paluzawa	Human	23°27'21.01"N	94°20'15.56"E	>5000m	<200m	<50m
AQ6	Village A	Human	23°27'37.26"N	94°20'49.60"E	>5000m	<1500m	<1500m

(1) MESC (2016) EIA on the 100,000 tpa Shwe Taung Coal Mine, at Chaung Sone Village (Paluzawa area), Kalaywa Township, Sagaing Region.

Figure 6.19 Representative ASRs at Coal Mine



Air quality impacts due to dust emission and noise impact due to operation of powered mechanical equipment during the construction and operation of the coal mine are not expected to be concerns to air and noise sensitive receivers due to the distance and elevation change between source and receptor. As such, no additional baseline surveys are undertaken for air quality and noise under the Supplementary ESIA.

Surface Water Quality

During the scoping site visit in November 2017, it was observed that runoff and erosion from the coal mine and its access road were causing significant impacts to the stream flow and water quality of the South Paluzawa Stream. As such, baseline water quality survey was conducted in January 2017 to understand baseline conditions and to inform the impact assessment for the future operation of the coal mine and its access road. The sampling locations and the rationale for inclusion are presented in *Table 6.12*. *Figure 6.20* illustrates the locations of the sampling station with photo shown in *Figures 6.21-6.23*.

Table 6.12 Baseline Water Quality Sampling Locations for the Coal Mine

Station	**Coordinates**		**Description**
	Latitude	**Longitude**	
CW1	23° 27' 14.548" N	94° 18' 28.796" E	Stream section beside Chaungzon Village, not flowing from the coal mine and access road, thus not affected by their operation.
CW2	23° 27' 0.241" N	94° 18' 19.004" E	Stream section beside Chaungzon Village downstream of the coal mine and access road, potentially affected by coal mine operations.
CW3	23° 27' 12.611" N	94° 18' 28.289" E	Stream section besides base camp downstream of the coal mine and access road, potentially affected by coal mine operations.

During the baseline survey in January 2017, two water samples were taken at each sampling location using sampling bottles provided by a laboratory which is certified under HOKLAS. These samples were stored at chilled condition and sent to the laboratory for analysis. Water quality parameters measured include *in-situ* measurement of pH and temperature as well as laboratory analysis of chemical oxygen demand (COD), 5-day biochemical oxygen demand (BOD_5), oil and grease, total nitrogen (TN), total phosphorus (TP), total suspended solids (TSS), total coliform, free cyanide, total cyanide, weak acid dissociable cyanide, hexavalent chromium, iron, arsenic, cadmium, copper, lead, mercury, nickel and zinc. These parameters are pollutants of concern specified in the WBG *EHS Guidelines for Mining* (2007) (*Table 3.5*) and WBG *General EHS Guidelines* (2007) for treated sanitary sewage discharge during operation of the Project (*Table 3.6*). For construction of the Project, it is noted that the Myanmar National Environmental Quality (Emissions) Guidelines specify the guidance levels for site runoff and wastewater discharges, which are the same as those specified for treated sanitary sewage discharge by WBG *General EHS Guidelines* (2007).

The baseline water quality data collected in January 2017 are presented in *Table 6.13*. Except for nickel, all other parameters were at levels lower than those specified by the WBG *EHS Guidelines for Mining* (2007) and WBG *General EHS Guidelines* (2007) for treated sanitary sewage discharge. The level of nickel exceeded the guidance level specified in WBG *EHS Guidelines for Mining* (2007) at CW2 and CW3, which are downstream of the coal mine indicating the mine as a potential source of contamination. In addition, the levels of TSS were higher at CW2 and CW3 when compared to CW1 for which the stream water was not flowing from the coal mine, which indicated the effects of soil erosion and surface run-off from the coal mine and access road.

Figure 6.20 Locations of Water Sampling Stations for the Coal Mine

Figure 6.21 Water Quality Sampling Stations at CW1

Figure 6.22 Water Quality Sampling Station at CW2

Figure 6.23 Water Quality Sampling Station at CW3

Table 6.13 Baseline Water Quality Data collected in January 2017 at the STM Coal Mine

Parameter	Unit	Detection Limit	Analytical Method Reference	CW1	CW2	CW3	WBG EHS Guidelines for Mining (2007)	WBG *General EHS Guidelines* (2007)
TSS	mg/L	2.00	APHA 2540 D	9.50	26.00	30.00	50	50
TP	mg/L	0.01	APHA 4500P:J	0.01	0.02	0.02	-	2
TN	mg/L	0.10	APHA 4500P:J APHA 4500-NO3:I	0.20	0.20	0.25	-	10
Total Coliforms	CFU/100mL	1.00	DoE Sec 7.8 & 7.9	N.D.	31.00	N.D.	-	400
BOD_5	mg/L	2.00	APHA 5210 B	N.D.	N.D.	N.D.	-	30
COD	mg/L	5.00	APHA 5220 C	5.00	7.00	7.50	150	125
Oil & Grease	mg/L	5.00	APHA 5520 B	N.D.	N.D.	N.D.	-	10
pH	Standard Unit	n.a.	-	7.50	8.40	8.20	6-9	6-9
Temperature	^oC	n.a.	-	26.00	26.00	24.00	<3 degree differential	<3 degree differential
Arsenic	mg/l	0.2	USEPA 6020A	N.D.	N.D.	N.D.	0.1	-
Cadmium	mg/l	0.2	USEPA 6020A	N.D.	N.D.	N.D.	0.05	-
Chromium (hexavalent)	mg/l	0.2	APHA 3500Cr: B & USEPA 6020A	N.D.	N.D.	N.D.	0.1	-
Copper	mg/l	20		N.D.	N.D.	N.D.	0.3	-
Cyanide	mg/l	0.01	APHA 4500CN: A, B & O	0.10	0.71	0.59	1	-
Cyanide (free)	mg/l	10	APHA 4500CN: A, B & N	N.D.	N.D.	N.D.	0.1	-
Cyanide (weak acid dissociable)	mg/l	0.2	APHA 4500CN: B,C,E & I	N.D.	N.D.	N.D.	0.5	-
Iron (total)	mg/l	1	USEPA 6010C	1.50	2.00	2.00	2	-
Lead	mg/l	1	USEPA 6020A	N.D.	N.D.	N.D.	0.2	-
Mercury	mg/l	0.5	USEPA 6020A	N.D.	N.D.	N.D.	0.002	-
Nickel	mg/l	1	USEPA 6020A	1.50	3.50	3.50	0.5	-
Zinc	mg/l	10	USEPA 6020A	N.D.	N.D.	N.D.	0.5	-

Notes:

(1) D.L. = value detected below detection limit for all samples at the station.

(2) n.a. = not applicable

(3) N.D. = not detected

(4) To determine the average level at a station with one of the two samples reported to be below detection limit, value below detection limit is halved for the calculation.

(5) Exceedance of WBG Guidelines is shaded grey.

6.3 BIODIVERSITY

6.3.1 *Protected Areas within 50km of the Project*

As of 2015, there are a total of 39 Protected Areas in Myanmar covering an area of 38,906 km^2. Based on Myanmar's NBSAP for 2015 to 2020, there are plans to establish 9 more Protected Areas in three phases from 2020 to 2021. With the addition of these 9 proposed areas, the total area under protection in Myanmar will be 52,932 km^2, representing a coverage of 7.82% of the country's total land area (1).

National Protected Areas within a 50 km buffer of project sites are listed in *Table 6.14* below and their locations in relation to both project sites is shown in *Figure 6.24* and *Figure 6.25*.

Table 6.14 PAs within 50 km of Project Sites

Project Sites	Protected Area	Details and Triggers (2)
Apache Cement Plant	Panlaung-Pyadalin Cave Wildlife Sanctuary (6 km north)	• Lat: 96.3738 • Lon: 21.0218 • IUCN Category IV • Wildlife Sanctuary • Asian Elephant, Banteng, Gaur, Clouded Leopard, Serow
Shwe Taung Coal Mine	Maharmyaing Wildlife Sanctuary (24 km east)	• Lat: 94.7132 • Lon: 23.3929 • IUCN Category IV • Wildlife Sanctuary • 1,180 km^2 • Hoolock Gibbon, Banteng, Sambar Deer

Internationally Recognised Sites for Biodiversity

Internationally recognised areas (3) within 50 km of Project sites are listed in *Table 6.15* below. Some project sites have been evaluated together as they are located in close proximity to each other. The location of these sites in relation to both project sites is shown in *Figure 6.24* and *Figure 6.25*.

(1) Republic of the Union of Myanmar, National Biodiversity Strategy and Action Plan 2015-2020 (Oct, 2015) Retrieved from https://www.cbd.int/doc/world/mm/mm-nbsap-v2-en.pdf

(2) Istituto Oikos and BANCA (2011) Myanmar Protected Areas. Context, Current Status and Challenges. Milano, Italy. Ancora Libri.

(3) According to IFC PS6, internationally recognized areas are exclusively defined as UNESCO Natural World Heritage Sites, UNESCO Man and the Biosphere Reserves, Key Biodiversity Areas, and wetlands designated under the Convention on Wetlands of International Importance (Ramsar Convention)

Table 6.15 Internationally Recognised Areas within 50 km of Project Sites

Project Sites	Internationally Recognised Area	Type	Details and Triggers
Apache Cement Plant	Panlaung-Pyadalin Cave Wildlife Sanctuary (6 km north)	Protected Area KBA	• Lat: 96.3738 • Lon: 21.0218 • IUCN Category IV • Wildlife Sanctuary • Yellow Tortoise (*Indotestudo elongata*) (EN)
	Paunglong Catchment Area (29 km south)	KBA	• Lat: 96.4979 • Lon: 20.2326 • 2,550 km² • Big-headed Turtle (Platysternon megacephalum) (EN) • Yellow Tortoise (*Indotestudo elongata*) (EN)
Shwe Taung Coal Mine	Maharmyaing Wildlife Sanctuary (24 km east)	IBA	• Lat: 94.7132 Lon: 23.3929 • IUCN Category IV • Wildlife Sanctuary • 1,180 km² • Green Peafowl (*Pavo muticus*) (EN)
	Kennedy Peak (50 km west)	IBA	• Lat: 93.7902 • Lon: 23.3819 • 200 km² • Data Deficient

Figure 6.24 Area of Interest, Protected Areas and Internationally Recognised Sites for Biodiversity, Apache Cement Plant

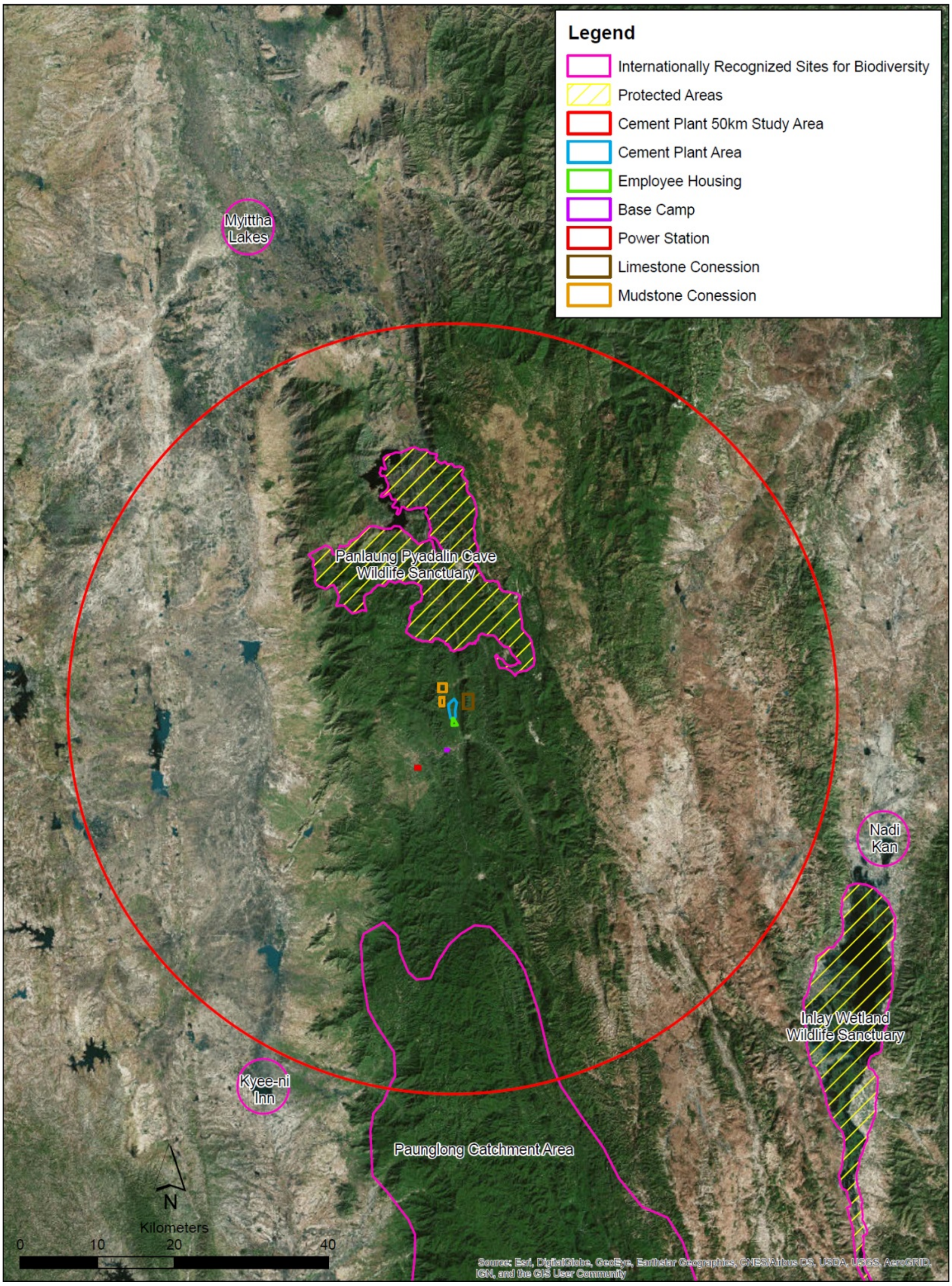
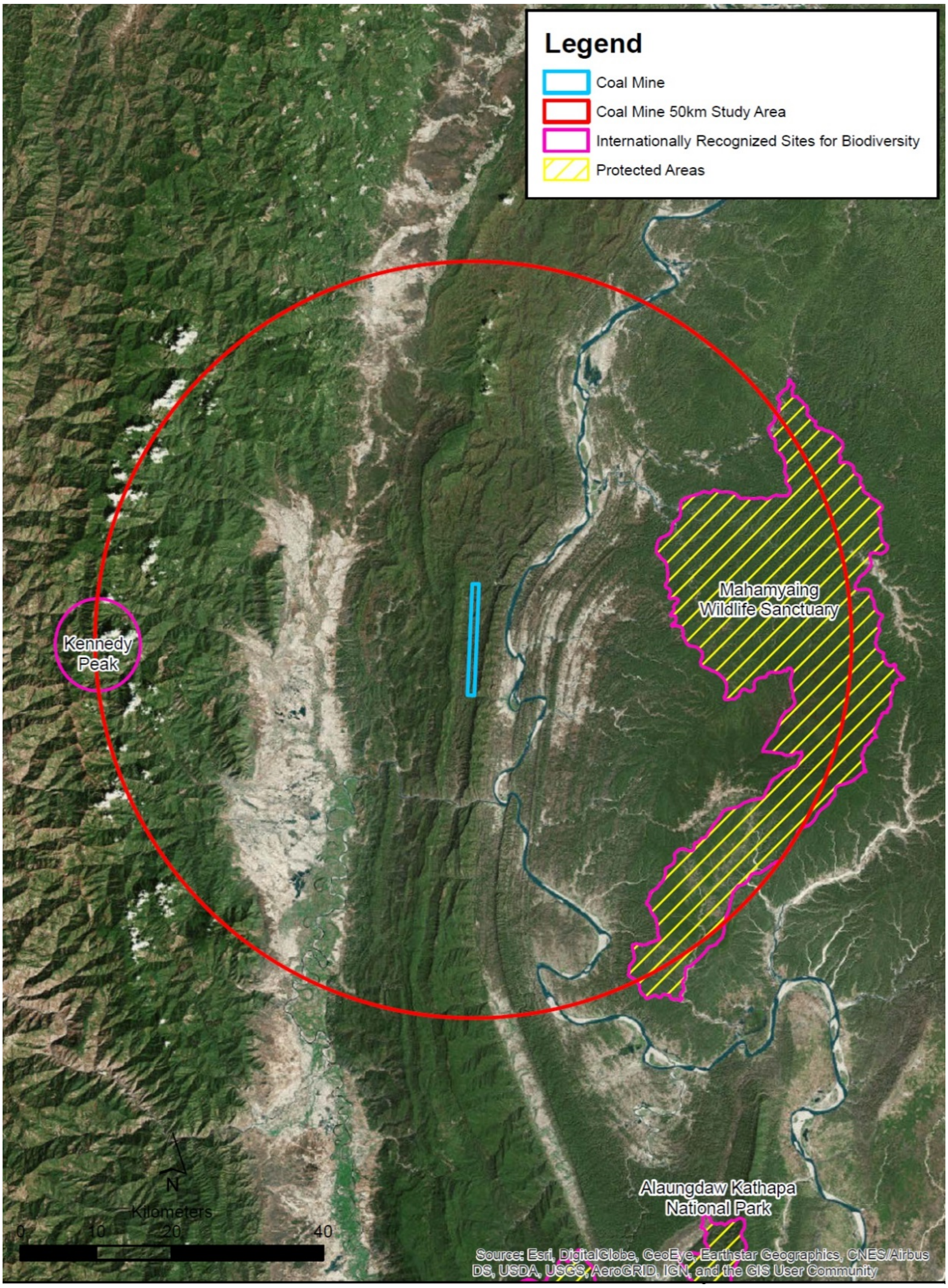


Figure 6.25 Area of Interest, Protected Areas and Internationally Recognised Sites for Biodiversity, Coal Mine



6.3.2 *WWF EcoRegions related to the Project Sites*

The WWF EcoRegions that coincide with the Cement Plant and Coal Mine sites are shown in *Table 6.16*.

Table 6.16 WWF EcoRegions coinciding with Project Sites

Site	EcoRegion	Size (ha)	Status
Cement Plant	Northern Indochina Subtropical Forests	437,000,000	Vulnerable
Coal Mine	Mizoram-Manipur-Kachin Rainforests	13,600,000	Vulnerable

Northern Indochina Subtropical Forests

The ecoregion experiences a summer monsoonal climate with precipitation averaging 1,200 to 2,500 mm a year during April to October. Dry conditions prevail from November to March. Some mountains in the ecoregion are composed of limestone, typically below 2,000 m.

Important tree taxa in the ecoregion belong to the families Theaceae, Magnoliaceae and Fagaceae at high elevations; and families Betalaceae, Fagaceae, Hamamelidaceae, Lauraceae, Magnoliaceae, Sapotaceae, Elaeocarpaceae and Theaceae at lower elevations. The dominant vegetation type is subtropical broadleaf evergreen forest with a three-layered structure and upper crowns reaching about 30 m in height.

In Myanmar, forests within this ecoregion (eastern Shan State, along the border with Laos and China), have been cleared. A few large blocks of habitat still persist in the ecoregion in Myanmar. Biodiversity in this ecoregion faces threats in the form of land clearing for shifting cultivation and logging; and hunting for food and income.

Mizoram-Manipur-Kachin Rainforests

The ecoregion is characterized by semi evergreen forests containing several species of Dipterocarpaceae including *Dipeterocarpus alatus, D. turbinatus, D. griffithii Parashorea stellata, Hopea odorata* and *Shorea burmanica*. The forest consists of a dense understorey with evergreen trees and bamboo groves. *Hopea odorata* and *Lagerstroemia speciose* dominate along stream banks and in low-lying areas.

One-hundred and forty-nine (149) mammal species are known to inhabit this ecoregion including the Tiger (*Panthera tigris*) as the ecoregion still retains large intact forests in some parts. Other threatened mammal species found include the Gaur (*Bos gaurus*) and Hoolock Gibbon (*Hoolock hoolock*). The WWF has recommended the preservation of remaining landscapes that possess interconnectivity and contiguity with one another. The ecoregion possesses approximately 580 bird species.

An estimated half of this ecoregion's natural habitat is still intact, particularly in the eastern areas of Myanmar. Biodiversity in this ecoregion faces threats in the form of habitat loss due to deforestation for cultivation and fuelwood, overgrazing and trampling by livestock, and unsustainable levels of hunting.

Karst/Limestone Ecosystems

As the Cement Plant involves quarrying of limestone from karst formations, particular attention has been paid to karst ecosystems and landscapes in Myanmar.

Limestone karsts occur over an area of approximately 400,000 km^2 in Southeast Asia, an estimated 10% of the total land area?[(1)]. Karst landforms occur most extensively in Indonesia, Thailand, Vietnam, and to some extent Malaysia, Cambodia, Laos, Myanmar and the Philippines. Karst environments possess economic, cultural, spiritual and scientific values [(2)]. Karsts are also viewed as drivers of key evolutionary processes. Due to a variety of habitats (including caves), complex terrains and unique soil properties, karst-dwelling species often display highly specialized adaptations. These features contribute to the high levels of species diversity and endemism found at karsts, giving these landforms high scientific value and ecological importance.

Karst areas in Myanmar face the same threats as with their counterparts throughout Southeast Asia. Pressures on karst areas extend from quarrying for cement, tourism, wildfires and hunting.

Some studies have been conducted on caves in Myanmar but the body of literature remains small. Cave expeditions in 2012 and 2013 in the Shan plateau have collected 251 specimens comprising 62 taxa in 17 different caves. Typically encountered cave fauna include bats (both fruit and insectivorous), caves spiders (Genus: Heteropoda), cave centipede (*Thereupoda longicornis*) and cave crickets (Genus: Diestrammena) [(3)].

6.3.3 Review of Existing EIAs

Local EIAs were undertaken for the cement plant and coal mine sites in 2014. Flora and fauna surveys were conducted at both sites; the latter focused on fish, mammals, herpetofauna, birds and insects. A summary of the environmental baseline in 2014 is presented in the following sections.

(1) Watson J, Hamilton-Smith E, Gillieson D, & Kiernan K (1997) IUCN World Commission on Protected Areas: Guidelines for cave and karst protection. IUCN, Gland, Switzerland and Cambridge, UK. 63 pp

(2) Watson J, Hamilton-Smith E, Gillieson D, & Kiernan K (1997) IUCN World Commission on Protected Areas: Guidelines for cave and karst protection. IUCN, Gland, Switzerland and Cambridge, UK. 63 pp.

(3) Dreybrodt J & Steiner H (2015) Karst and Caves of the Shan Plateau in Myanmar. Asian Transkarst Conference. Lichuan, China. Retrieved from http://www.myanmarcaves.com/reports/Transkarst%202015%20Myanmar.pdf

Apache Cement Plant

The forest cover within this area consists of mixed semi-evergreen forest and lower mixed deciduous forest. These forest types exist on well drained slopes interspersed with limestone formations with distinct floristics.

Previous surveys were undertaken in April 2014 of the Project Area. In total, 28 tree species belonging to 26 genera were identified. The major tree species identified include: *Dipterocarpus tuberculatus* (LC), *Shorea obtusa* (Thit-ya) (LC), *Shorea siamensis* (In-gyin) (LC), *Avogeissus accuminata* (Yon) (NA), *Dalbergia cultrata* (Yin-daik) (NT), *Pterocarpus microcarpus* (Pa-dauk) (NA), *Bombax sp*: (Let-pan) (NA) and *Lannea sp.* (Na-be) (NA), *Tectona grandis* (Kyun) (LC), *Xylia xylocarpa* (Pyin-ka-do) (NA), *Millettia ovalifolia* Kurz (Thin-win) (DD).

Previous surveys for fauna were undertaken from March to April 2014. The survey identified 80 species of fauna, including: 16 species of fishes; 13 species of herpetofauna; 26 species of birds; 9 species of mammals; and 18 species of insects. Species identified during the 2014 surveys include the following species. Reptiles: King cobra (*Ophiophagus Hannah*) (VU); Burmese python (*Python reticulatus*) (Appendix II of CITES); Birds: Black Kite (*Milvus migrans*) (LC); Crested Serpent Eagle (*Spilornis cheela*) (LC); Peregrine Falcon (*Falcon peregrines*) (LC); Mammals: Guar (*Bos gaurus*) (VU); Banded langur (Presbytis femoralis) (NT); East Asian Porcupine (*Hystrix brachyura*) (LC); Jungle cat (*Felis chaus*) (LC); Red Goral (*Naemorhedus baileyi*) (VU).

Shwe Taung Coal Mine

The flora assessment in 2014 identified 239 plant species, including 89 species of tree. One tree was identified as being listed as EN, *Dalbergia olivera*. The Local EIA noted that the area had been targeted for illegal logging with little evidence of primary forest remaining.

Fauna surveys in 2014 targeted birds, herpetofauna and mammals. No birds or herpetofauna were identified as threatened species. The mammal survey did identify threatened species, including Chinese pangolin (*Manis pentadactyla*) (CR) as well as other species of interest including: Slow loris (*Nycticebus coucang*) (VU), Southern Serow (*Capriconis sumatraensis*) (VU), Red Goral (*Naemorhedus baileyi*) (VU), Hog Badger, (*Arctonyx collaris*) (NT), Giant Squirrel (*Ratufa bicolor*) (NT), Large Indian Civet (*Viverra zibetha*) (NT).

Discussions with local residents and workers from the mine during the site visit (November 2016) identified potential sighting of the Pangolin (*Manis spp*.) (CR), Leopard Cat (*Prionailurus bengalensis*) (LC), Hoolock Gibbon (*Hoolock hoolock*) (EN), Muntjac (*Muntiacus spp*.) (VU/LC), Porcupine (*Hystrix spp*.) (VU/LC) and Macaques (*Macaca spp.)* (VU/LC).

6.3.4 *Field Survey Findings*

Field surveys of the Apache Cement and Shwe Taung Coal Mine sites were conducted to obtain an understanding of baseline diversities for a selection of taxa groups. *Table 6.17* lists the surveys that were undertaken, their targeted taxa and dates conducted.

Table 6.17 Surveys Conducted at Cement and Coal Mine Sites

Target Organism Group	Method Summary	Survey Dates
Apache Cement Plant		
Bird, herpetofauna, arboreal mammal/primate and ground dwelling mammals	Transect Survey Interviews	27th January – 31st January 2017
Flora	Transect Survey	31st January – 7th February 2017*
Snails	Soil sampling Handpicking of snail shells	February 2017
Reptiles	To be completed	April 2017
Limestone range flora	To be completed	May/June 2017
Shwe Taung Coal Mine Site		
Mammals	Camera Trapping Transect Survey Interviews	25th – 9th February 2017 4th – 7th February 2017
Flora	Transect Survey	8th – 15th February 2017
Reptiles	Transect Survey	Yet to be Undertaken

Note:

* Denotes camera trapping duration

Methodologies

Detailed methodologies can be found in *Annex E1 Survey Reports*.

6.3.5 Field Survey Results

Field survey findings are summarized in the following sections. Detailed survey findings may be found in *Annex E1 Survey Reports*.

Cement Plant

<u>Mammal Survey</u>

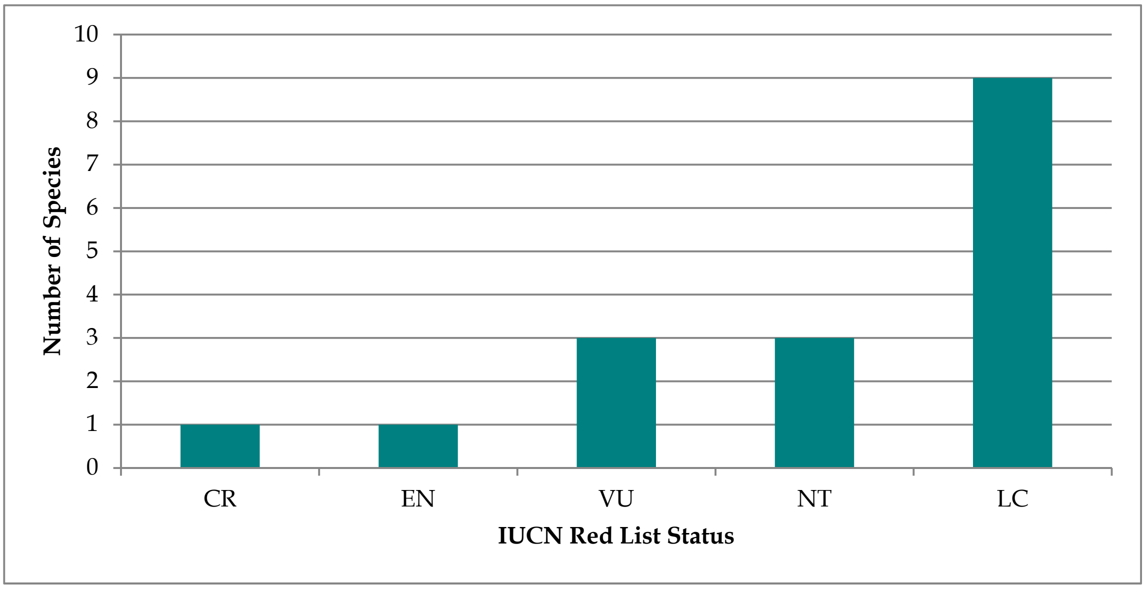
The interviews and transect walks confirmed either directly or indirect the presence of 17 species of mammals within and around the project area. Of these species, the Chinese Pangolin (*Manis pentadactyla*) and the Shan State Langur (*Trachypithecus phayrei shanicus*) are listed on the IUCN Red List as Critically Endangered and Endangered respectively. The list of species found from the project area and its surroundings is presented in *Table 6.18.*

Table 6.18 Mammal Species within and around the Cement Plant project area

S/N	Common Name	Scientific Name	Evidence	Within Project	Adjacent to Project	IUCN Red List Status
1	Chinese Pangolin	Manis pentadactyla	Interview	+	+	CR
2	Bengal Slow Loris	Nycticebus bengalensis	Interview	+	+	VU
3	Shan Langur	Trachypithecus phayrei shanicus	Interview	-	+	EN
4	Rhesus Macaque	Macaca mulatta	Interview	+	+	LC
5	Assamese Macaque	Macaca assamensis	Interview	+	-	NT
6	Eastern Hoolock Gibbon	Hoolock leuconedys	Interview	-	-	VU
7	Leopard Cat	Prionailurus bengalensis	Interview	+	+	LC
8	Jungle Cat	Felis chaus	Interview	-	+	LC
9	Common Palm Civet	Paradoxurus hermaphroditus	Interview	+	+	LC
10	Small-toothed Palm Civet	Arctogalida trivirgata	Interview	+	+	LC
11	Large-toothed Ferret Badger	Melogale personata	Interview	+	+	LC
12	Yellow-throated Marten	Martes flavigula	Interview	+	+	LC
13	Hog Badger	Arctonyx collaris	Interview	-	+	VU
14	Chinese Serow	Capricornis milneedwardsi	Interview	+	-	NT
15	Red Muntjac	Muntiacus muntjac	Interview	+	+	LC
16	Wild Boar	Sus scrofa	Interview Tracks	+	+	LC
17	Black Giant Squirrel	Ratufa bicolor	Sighting	+	-	NT

A graphical summary of the mammal species list according to their IUCN status is presented in *Figure 6.26*.

Figure 6.26 IUCN Status of Mammal Species Surveyed (Cement Plant)



Main threats to mammal species within and around the cement plant project area were identified to be habitat degradation, logging and habitat fragmentation. Hunting appeared to be a minor threat as most interviewees said that hunting has become more inefficient given the drastic decline in wildlife in recent years.

Vegetation Survey

A total of 136 vegetation plots along 5 random transects were established across the limestone and mudstone quarries. *Table 6.19* captures the findings of the flora survey for both areas.

Table 6.19 Flora Survey Findings, Cement Plant site

Site	Total Number of Species	Number of IUCN Red List Species	EN/CR IUCN Red List Species	Number of Invasive Species
Limestone Quarry	226	23	Dalbergia oliveri (EN)	10
Mudstone Quarry	160	14	Nil	9
Total (Both Sites)	250	23	Dalbergia oliveri (EN)	11

Table 6.20 and *Table 6.21* list the invasive species found within the limestone quarry and the mudstone quarry.

Table 6.20 Invasive Flora Species, Limestone Quarry

S/N	Scientific Name	Family
1	Ageratum conyzoides	Asteraceae
2	Bidens pilosa	Asteraceae
3	Caesalpinia decapetala	Caesalpinaceae
4	Chromolaena odorata	Asteraceae
5	Hiptage benghalensis	Malpighiaceae
6	Leucaena leucocephala	Mimosaceae
7	Mimosa pudica	Mimosaceae
8	Oroxylum indicum	Bigoniaceae
9	Paederia foetida	Rubiaceae
10	Ziziphus jujuba	Rhamnaceae

Table 6.21 Invasive Flora Species, Mudstone Quarry

S/N	Scientific Name	Family
1	Ageratum conyzoides	Asteraceae
2	Caesalpinia decapetala	Caesalpinaceae
3	Chromolaena odorata	Asteraceae
4	Leucaena leucocephala	Mimosaceae
5	Mimosa pudica	Mimosaceae
6	Oroxylum indicum	Bigoniaceae
7	Paederia foetida	Rubiaceae
8	Ricinus communis	Euphorbiaceae
9	Ziziphus jujuba	Rhamnaceae

Eight types of plant associations were derived from the field survey. Based on these associations, three types of vegetation classifications were developed for the project and surrounding areas. These are deciduous and mixed evergreen forests, mixed broad-leaved deciduous forest and bamboo forest. Dominant species common throughout the 12 types of plant associations are *Terminalia* spp., *Tectonia grandis* and *Xylia xylocarpa*.

Limestone Range Snail Fauna Survey (Preliminary Findings) (1)

The limestone range was partitioned into sectors A to E from north to south and surveyed, with sectors A and B falling within the limestone concession. The survey has preliminary identified a potential local-endemic, *Anauchen* sp., from within the limestone concession which has been identified in areas adjacent. Three other local-endemic species have been recorded, namely *Diplommatina* sp. 3, *Diplommatina* sp. 4 and *Diplommatina* sp. 5 aff. *crispata*.

One new-to-science species *Anauchen sp.* was only identified within the limestone concession; however the specialist involved in the survey (Dr J Vermeulin) suggests that this species is a local endemic species, although restricted in range. Further sampling will occur during the wet season flora surveys to be conducted by Dr Vermeulin to confirm this assessment.

(1) Additional surveys for limestone flora and reptiles will occur in the 2017 wet season and will be incorporated into this ESIA.

The compiled results of the surveys are shown in *Table 6.22* and *Table 6.22a* below.

Table 6.22 Preliminary results of snail fauna within the limestone range

SPECIES	AUTHOR, YEAR	INFORMATION ON RSC-STATUS	RSC	9	10	11	8	4	5	6	7	16	17	14	12	13
Local-endemic species (RSC=2) of the Pyinyaung limestone range only Localities 4 to 17 arranged from North to South				N of concession				Concession				S of concession				
Dicharax sp.		No known records in collections	2			1	1									
Dioryx pingoungensis	(Godwin Austen, 1914	Recorded in literature from Pyinyaung only	2			1								1		
Diplommatina crispata **new subsp.**	Stoliczka, 1871	A local form of a widespread complex species	2			1	1			1	1		1	1	1	
Khasiella pingoungensis	(Godwin Austen, 1888	Recorded in literature from Pyinyaung only. May prove to be more widespread	2	1	1	1	1	1	1	1	1			1	1	1
Bradybaena schanorum	(Moellendorff 1899)	Recorded in literature from Kalaw only	2	1	1	1	1	1	1		1		1		1	1
Plectotropis **new sp.**		No known records in collections	2	1	1											
Chloritis anserina	(Theobald, 1866)	Recorded in literature from `Shan States` only, without precise locality data	2	1	1	1	1	1	1	1	1					1
Pseudonenia shanica	(Godwin Austen, 1888	Recorded in literature from Pyinyaung only	2	1	1	1			1		1		1			
Sinoennea **new sp.**		No known records in collections	2	1												
Anauchen **new sp.**		No known records in collections	2					1	1							
# local-endemic species per locality				6	5	7	5	4	5	3	5	0	3	3	3	3

Table 6.22a Similarities between sampling sites

# species shared	N of concession	concession	S of concession	Pyinyaung lst range	E of Kalaw	low alt. (see text)	high alt. (see text)
N of concession	**67**	44	44				
concession		**48**	38				
S of concession			**54**				
Pyinyaung lst range				**79**	22		
E of Kalaw					**33**		
low alt. (see text)						**58**	43
high alt. (see text)							**56**

Dice Similarity Coefficient	N of concession	concession	S of concession	Pyinyaung lst range	E of Kalaw	low alt. (see text)	high alt. (see text)
N of concession		0,77	0,73				
concession			0,75				
S of concession							
Pyinyaung lst range					0,39		
E of Kalaw							
low alt. (see text)							0,75
high alt. (see text)							

The study has found that a north-south gradient in fauna composition is present within the limestone range, but these findings could potentially be limited by incomplete sampling of the southernmost part of the range.

Two snail species that were indicators of disturbance were found from the limestone range. These were *Achatina fulica* and *Allopeas gracile*. The former is an agricultural pest species introduced from Africa and listed as an invasive species in Myanmar. However, the survey found no more than the two abovementioned species, and attributed this lack of disturbance indicators and introduced species to low levels of intensively farmed agricultural land in the vicinity of the limestone range.

Limestone Range Flora Survey (Preliminary Findings)

Flora on the limestone range comprised mostly non-woody species, including some species that are restricted to limestone habitats and a small number of local-endemics. Local-endemics from the genus *Orinthoboea* were recorded from one sampling site and *Amorphophallus* spp. were found from various sites. Additional surveys for limestone flora will occur in the 2017 wet season and will be incorporated into this ESIA.

Limestone Range Reptile Survey (Preliminary Findings)

Three lizard species were observed during the limestone hills survey for molluscs. Two were identified as *Calotes emma* and *Calotes versicolor*. The third species is pending identification. A specialist assessment of reptiles within the limestone hills will occur in April 2017.

Coal Mine

Mammal Survey

The surveys confirmed the presence of 21 species of mammals within and around the project area. Species presence were confirmed through a combination of camera trapping, direct sighting or acoustic evidence, skin or teeth, videos and interviews with local residents. Of these species, the Chinese Pangolin (*Manis pentadactyla*) is listed on the IUCN Red List as Critically Endangered; Phayre's Langur (*Trachypithecus phayrei phayrei*), Western Hoolock Gibbon (*Hoolock hoolock*) and the Dhole (*Cuon alpinus*) are listed as Endangered.

Specific to the camera trap surveys, the effort generated a total of 73 independent species events for mammals and confirmed the presence of 12 species in the concession. It is noted that the species saturation curve (Refer to *Annex E1*) for the camera trap survey had not plateaued at the end of the 16 day camera trapping effort. This indicates that the study has not saturated and there are potentially species present that may not have been identified.

Other notable sightings include 4 bird species, either observed directly or captured by camera trap. Birds caught on camera traps are the Kalij Pheasant (*Lophura leucomelanos*) and Scaly Thrush (*Zoothera dauma*); the Great Hornbill (*Buceros bicornis*) and Red-headed Trogon (*Harpactes erythrocephalus*) were observed directly.

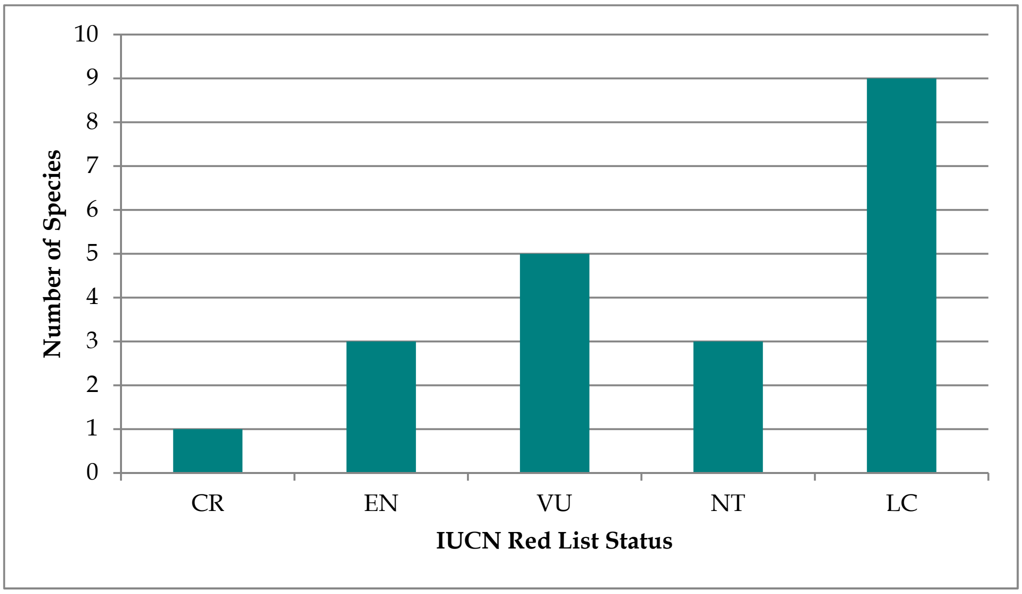
The list of mammal species found from the project area and its surroundings is presented in *Table 6.23*.

Table 6.23 Mammal Species within and around the Coal concession

S/N	Common Name	Scientific Name	Camera Trap	Other Evidence	Within Project	Adjacent to Project	IUCN Red List Status
1	Northern Treeshrew	*Tupaia belangeri*	✓	Carcass	+	+	LC
2	Chinese Pangolin	*Manis pentadactyla*	-	Interview Video	+	+	CR
3	Bengal Slow Loris	*Nycticebus bengalensis*	-	Interview	+	+	VU
4	Phayre's Langur	*Trachypithecus phayrei phayrei*	-	Interview	-	+	EN
5	Rhesus Macaque	*Macaca mulatta*	✓	Interview	+	+	LC
6	Assamese Macaque	*Macaca assamensis*	-	Interview	-	+	NT
7	Western Hoolock Gibbon	*Hoolock hoolock*	-	Acoustic Record Interview	-	+	EN
8	Leopard Cat	*Prionailurus bengalensis*	✓	-	+	-	LC
9	Fishing Cat	*Prionailurus viverrinus*	✓	Tracks	+	+	VU
10	Asiatic Black Bear	*Ursus thibentanus*		Interview	+	-	VU
11	Yellow-throated Marten	*Martes flavigula*	✓	Direct Sighting	+	+	LC
12	Large Indian Civet	*Vivvera zibetha*	✓	-	+	-	LC
13	Common Palm Civet	*Paradoxurus hermaphroditus*	✓	Skin	+	-	LC
14	Dhole	*Cuon alpinus*	-	Canine tooth Interview	+	-	EN
15	Gaur	*Bos gaurus*	-	Interview	+	+	VU
16	Chinese Serow	*Capricornis milneedwardsi*	-	Interview	+	-	NT
17	Sambar	*Rusa unicolor*	-	Interview	-	+	VU
18	Red Muntjac	*Muntiacus muntjac*	✓	Skins Sightings	+	+	LC
19	Wild Boar	*Sus scrofa*	✓	-	+	+	LC
20	Malayan Porcupine	*Hystrix brachyura*	✓	Spines Intestines	+	+	LC
21	Black Giant Squirrel	*Ratufa bicolor*	-	Sighting	-	+	NT

A graphical summary of the mammal species list according to their IUCN status is presented in *Figure 6.27*.

Figure 6.27 IUCN Status of Mammal Species Surveyed, Coal Mine



The main threats to mammal species within and around the coal mine concession project area were identified to be hunting and wildlife trade, logging, bamboo collection, road construction, degradation of aquatic habitats, wastewater pollution and poor waste management. Hunting and wildlife trade seemed to be the major issue in the area, with newly constructed roads providing access into previously inaccessible areas.

<u>Vegetation Survey</u>

A total of 141 vegetation plots on 5 random transects were established. 235 flora species were recorded, of which 28 are listed on the IUCN Red List of Threatened Species and 12 are invasive species. None of species listed on the IUCN Red List were EN or CR. *Table 6.24* lists the invasive species found within the coal mine concession.

Table 6.24 Invasive Flora Species, Coal Mine Site

S/N	Scientific Name	Family
1	Ageratum conyzoides	Asteraceae
2	Amaranthus spinosus	Amaranthaceae
3	Bidens pilosa	Asteraceae
4	Caesalpinia decapetala	Caesalpinaceae
5	Chromolaena odorata	Asteraceae
6	Hiptage benghalensis	Malpighiaceae
7	Imperata cylindrica	Poaceae
8	Mikania micrantha	Asteraceae
9	Mimosa pudica	Mimosaceae
10	Oroxylum indicum	Bigoniaceae
11	Paederia foetida	Rubiaceae
12	Ziziphus jujuba	Rhamnaceae

Twelve types of plant associations were derived from the field survey. Based on these associations, three types of vegetation classifications were developed for the project and surrounding areas. These are deciduous forest, mixed broad-leaved deciduous forest and bamboo forest. Dominant species common throughout the 12 types of plant associations are *Terminalia* spp., *Tectonia grandis*, *Xylia xylocarpa*, *Mitragyna rotundifolia* and to a lesser extent, *Vitex penducularis*.

6.3.6 Discrete Management Unit

Based on IFC PS 6 Guidance Note 6, the project is required to 'determine a sensible ecological or political boundary that defines the area of habitat to be considered for the Critical Habitat assessment'. Termed as a Discrete Management Unit (DMU), this is an area with a 'definable boundary within which the biological communities and/or management issues have more in common with each other than they do with those in adjacent areas'. DMUs may hence be defined using ecological boundaries such as rivers and mountain ridges/valleys where wildlife is determined to be unable to cross, management boundaries such as a Protected Area, or an artificial barriers to movement such as roads and urban areas.

Cement Plant

The DMU identified at the cement plant includes 3 main components:

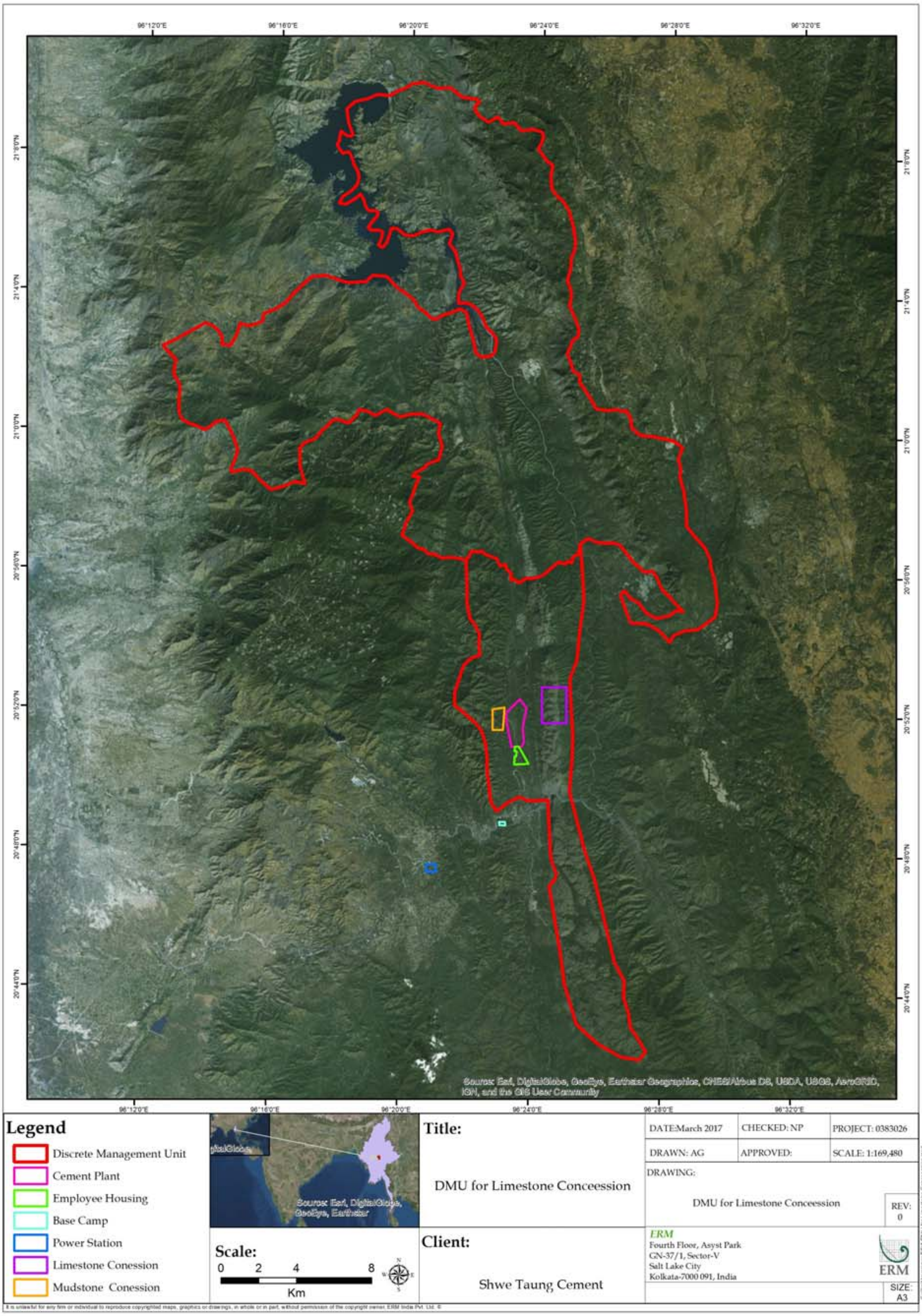
- The limestone outcrop spanning north of the limestone quarry to south of Pyinyaung town;
- Contiguous vegetation within and around the project area, up to the ridge to the west of the project; and
- Panlaung-Pyadalin Cave wildlife sanctuary, 6 km north of the cement factory.

Although the limestone outcrop is bisected by a road at Pyinyaung, the two sections maintain a common geological and geomorphological history. As a result, they are likely to share the same local-endemics and ecosystem types. The sections are essentially part of the same limestone cluster within the Shan plateau. The limestone outcrop in its entirety was thus used to define the DMU.

Based on a review of satellite imagery, it was observed that vegetation within and around the project area was contiguous with Panlaung-Pyadalin Cave wildlife sanctuary. This indicates there is a possibility that there is movement of wildlife between Panlaung-Pyadalin and the Project, hence warranting the inclusion of the protected area into the project DMU.

The DMU for the cement plant occupies a total area of 45,000 hectares. The DMU for the cement plant is presented in ***Figure 6.28***. As the base camp and power stations will be established within built up areas and do not share a contiguous forest with the main project components, they are not included in the DMU delineation.

Figure 6.28 Discrete Management Unit (DMU), Cement Plant



Coal Mine

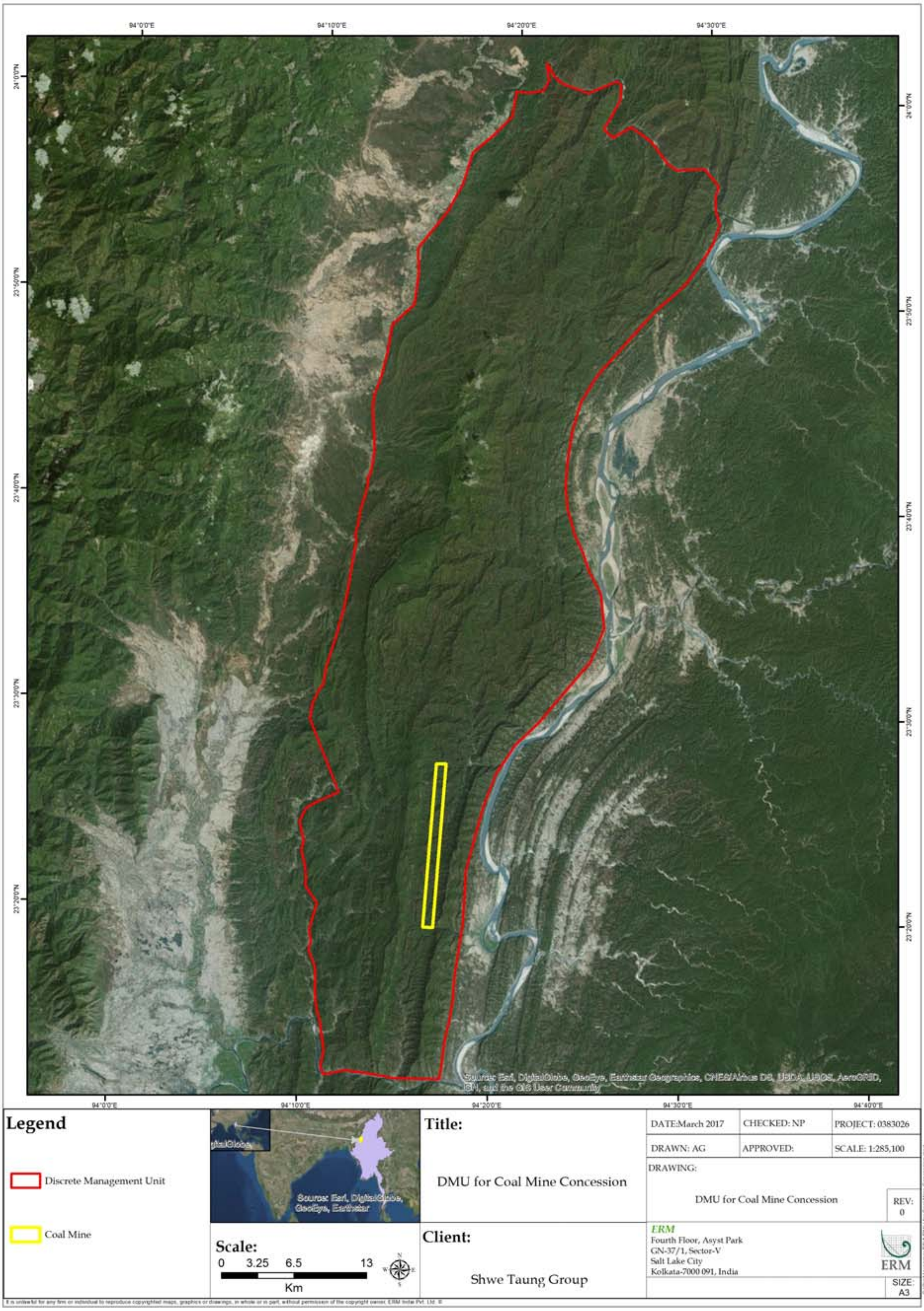
The DMU identified at the coal mine is bounded by:

- A river channel to the north;
- River valley and human-modified landscapes to the west;
- A river channel to the south; and
- The Chindwin river and human-modified landscapes to the east.

There are varying levels of illegal logging and road construction within the DMU leading to forest loss and habitat fragmentation. However, based on a review of satellite imagery and field observations, these are not at a scale to form significant barriers to movement within the DMU. Vegetation within the DMU was thus considered to be fairly contiguous and we looked to more significant barriers to movement such as river valleys, channels and tracts of urban landscapes to inform the boundaries of the DMU.

The DMU for the coal mine occupies a total area of 160,000 hectares. The DMU for the coal mine is presented in *Figure 6.29*.

Figure 6.29 Discrete Management Unit (DMU), Coal Mine



6.3.7 *Vegetation Classes at Project Sites*

Cement Plant

The vegetation classes identified from the cement plant project area are:

- Deciduous forest;
- Mixed evergreen forest;
- Mixed broad-leaved deciduous forest;
- Dry deciduous forest; and
- Bamboo forest.

Deciduous forest, dry deciduous forest and mixed broad-leaved deciduous forests were found largely at the limestone quarry area. Mixed evergreen forest and mixed broad-leaved deciduous forests were found mainly at the mudstone quarry area. Vegetation density identified within the Cement Plant Concession is shown in *Figure 6.30*.

Coal Mine

The flora survey determined that the vegetation types at the coal mine site and surrounding areas comprise deciduous forest, mixed broad-leaved deciduous forest and bamboo forest. The dominant species in the deciduous forest and mixed broad-leaved deciduous forest types comprise *Terminalia spp., Tectonia grandis, Xylia xylocarpa, Mitragyna rotundifolia* and to a lesser extent, *Vitex penducularis*.

Vegetation density within the Coal Mine Concession is shown in *Figure 6.31*.

Figure 6.30 Vegetation Density Distribution: Cement Plant and Quarries

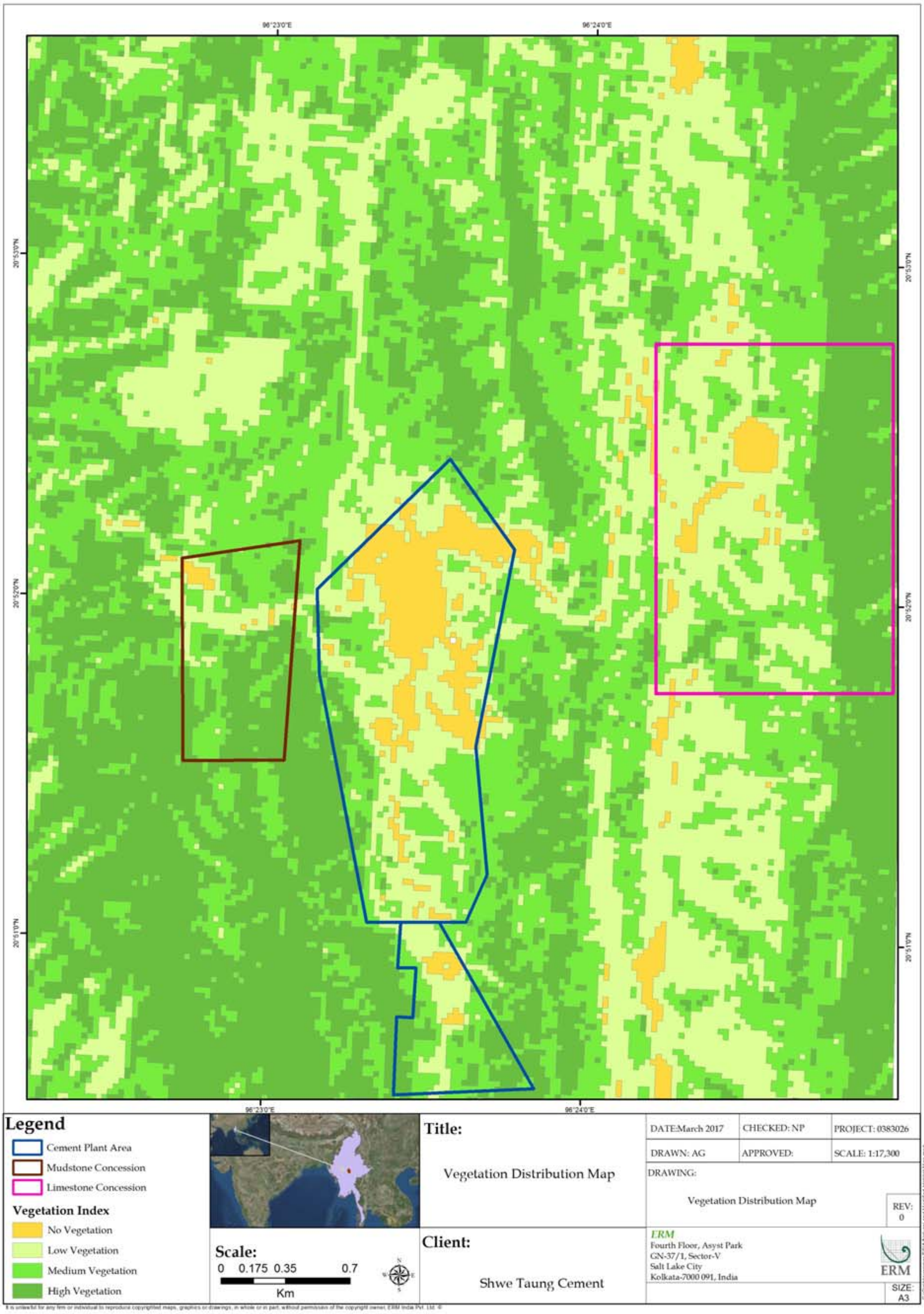
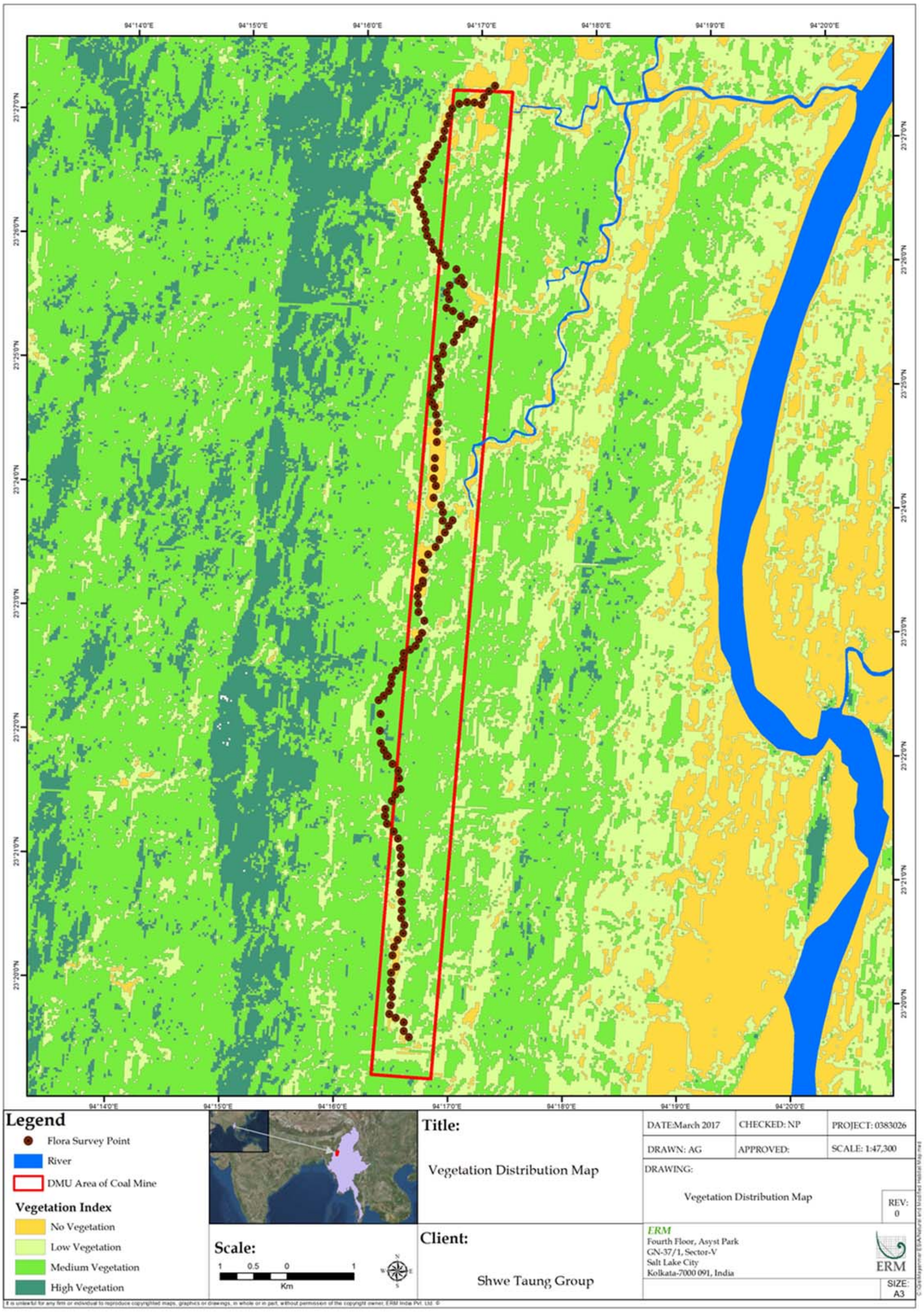


Figure 6.31 Vegetation Density Distribution: Coal Mine Concession



6.3.8 *Land Class Assessment*

Land classes within each site were developed based on a review of existing baseline information, satellite imagery and field observations.

Remote sensing was used to determine the land cover at each concession using LandSat imagery. A number of indices were tested for suitability to map bare ground in the AOI, including the Normalised Differential Vegetation Index (NDVI) and the Bare Ground Index (BGI), however it was found that the following index was most effective: Landsat8 (Band 4 – Band 2) / (Band 4 + Band 2); and Landsat5 andLandsat7 (Band 3 – Band 1) / (Band 3 + Band 1).

Threshold values were set for each time step resulting in a binary image (cleared or not cleared). These images were corrected for cloud cover and converted to polygons for area calculations and mapping in GIS.

Cement Plant

The following land class types within the cement plant have been identified and described in *Table 6.25*.

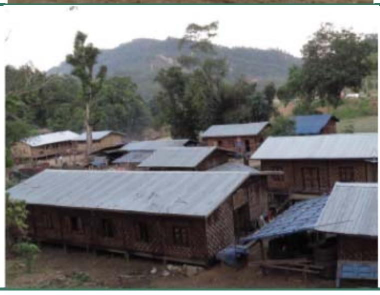
Table 6.25 *Land Classes within the AoI, Project Concession and Project Area*

Land Class	Description	Photo
Karst	This refers to the limestone outcrop ranging from the north to south of the AOI; a section of the outcrop falls within the project limestone concession. The limestone outcrop is part of the Shan plateau series of limestone ranges.	
Agricultural land	This comprises the areas utilized for cultivation of crops such as rice, sesame, ground nut, plantation timber and sunflower etc.	
Scrubland	This refers to the vegetation covering the AOI, project concession and project area.	
Semi-rural/Urban	These are areas where human settlements have been established or land cleared for buildings. This includes the cement plant factory site and areas that have been cleared for the establishment of plant facilities.	
Marsh	This land class can be found surrounding the wetland and reservoirs established within the project area.	
Freshwater habitat	This habitat can be found within the wetland and reservoirs established within the project area. There are also rivers and creeks around the project area in Thazi township.	

Coal Mine

The following land class types within the coal mine have been identified and described in *Table 6.26*.

Table 6.26 Land Classes within the AoI, Project Concession and Project Area

Land Class	Description	Photo
Forest	There are several tracts of forest within the AOI that are noted to be of fairly good quality. These comprise largely of deciduous forest and mixed broad-leaved deciduous forest, interspersed with bamboo forests.	
Agricultural land	This comprises the areas utilized for cultivation of crops such as rice, sesame, ground nut, plantation timber and sunflower etc. Several sunflower fields were observed within the AOI.	
Semi-rural/Urban	These are areas where human settlements have been established or land cleared for buildings. This includes the workers' camps and villages within the AOI.	
Marsh	This land class can be found surrounding the wetland spot and reservoirs established within the project area.	No Photograph is available
Freshwater habitat	This habitat can be found within Paluzawa creek and tributaries within the AOI and project concession. There are also plans to establish wetlands within the project concession.	

6.3.9 *Natural and Modified Habitats*

Given an understanding of the species assemblages within each habitat/land class, and supplemented with field observations of the general quality of these habitats, natural-modified habitat classifications have been assigned as shown in *Table 6.27* and *6.28*. The distribution of Natural Habitat and Modified Habitat for each concession is shown in *Figures 6.32* and *6.33*.

Table 6.27 Natural and Modified Habitats within the Limestone Concession DMU

Land Class	IFC PS6 Habitat Classification	Justification
Karst	Natural	Majority of vegetation and karst fauna are native species. Ecological functions of the karst areas remain intact.
Agricultural land	Modified	These areas are cultivated and retain little of their natural ecological function.
Scrubland	Modified	The vegetation and soils of these areas are heavily degraded through resource extraction. Little natural ecological function remains.
Semi-rural/Urban	Modified	Contains human settlements. Retains little natural ecological function.
Marsh	Natural	While some areas may be products of restoration effort, they are targeted at achieving original ecological function.
Freshwater Habitat	Natural	Majority of freshwater habitats within the AOI remain natural and possess their original ecological function.

Table 6.28 Natural and Modified Habitats within the Coal Mine DMU

Land Class	IFC PS6 Habitat Classification	Justification
Forest	Natural	While some forested areas were degraded and exploited, most were observed to be of fairly good quality. Given the general lack of accessibility, the forests within the AOI are expected to retain natural ecological function.
Agricultural land	Modified	These areas are cultivated and retain little of their natural ecological function.
Semi-rural/Urban	Modified	Contains human settlements. Retains little natural ecological function.
Freshwater Habitat	Natural	While damming has occurred at some streams throughout the concession, majority of freshwater habitats within the AOI remain natural and possess their original ecological function.

The Natural Habitat and Modified Habitat areas found within the Limestone Concession and Coal mine concession are shown in *Table 6.29* below.

It should be noted that STC has advised that not all of the Project areas will be impacted due to project operations. An exact footprint of the project areas was not available at the time of writing. For the limestone quarry, STC advised that 68% of the site would be impacted due to operations. For the mudstone quarry, 52% of the site would be disturbed. For the coal mine site, 68% would be impacted by mining activities. As such, the total area of each concession has been discounted by the estimated percentage of disturbance. Additionally, the construction of the access road for the coal mine will consist of a 15 m right of way for 10 km (15ha) from Nanmawke to Phase 3 of the strip mine

Table 6.29 Natural Habitat and Modified Habitat within Limestone Concession and Coal Mine Concession

Project Area	Natural Habitat Area (Ha)	Modified Habitat Area (Ha)	Total (Ha)
Limestone Quarry	235.58	118.79	354.37
Mudstone Concession	32.59	82.67	115.26
Total	**268.17**	**201.46**	**469.63**
Coal Mine Concession	**884.95**	**2.95**	**887.9**
Coal Mine Access Road	**15**	**-**	**15**
Total	**899.95**	**2.95**	**902.90**

Figure 6.32 Natural and Modified Habitat Limestone Concession

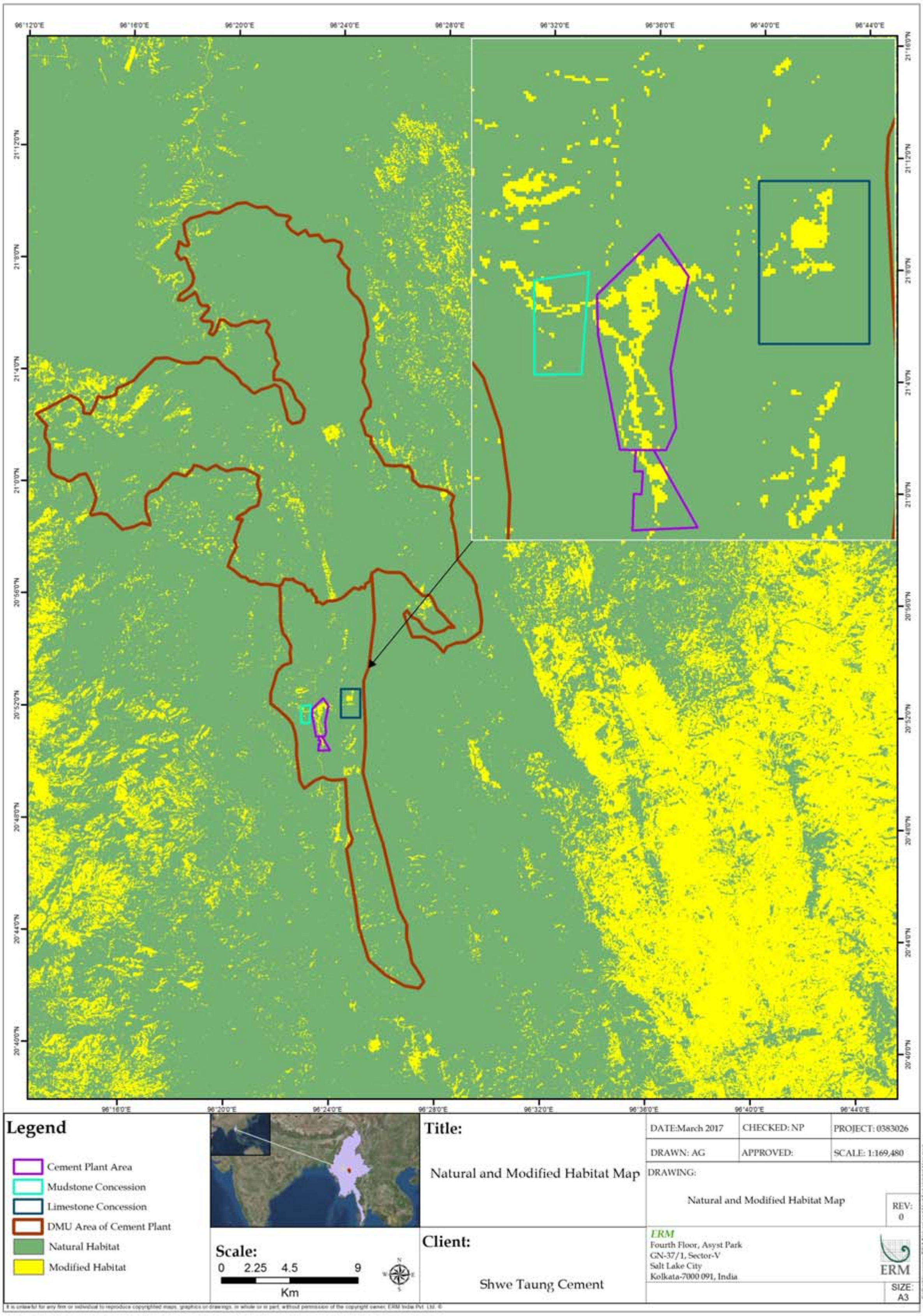
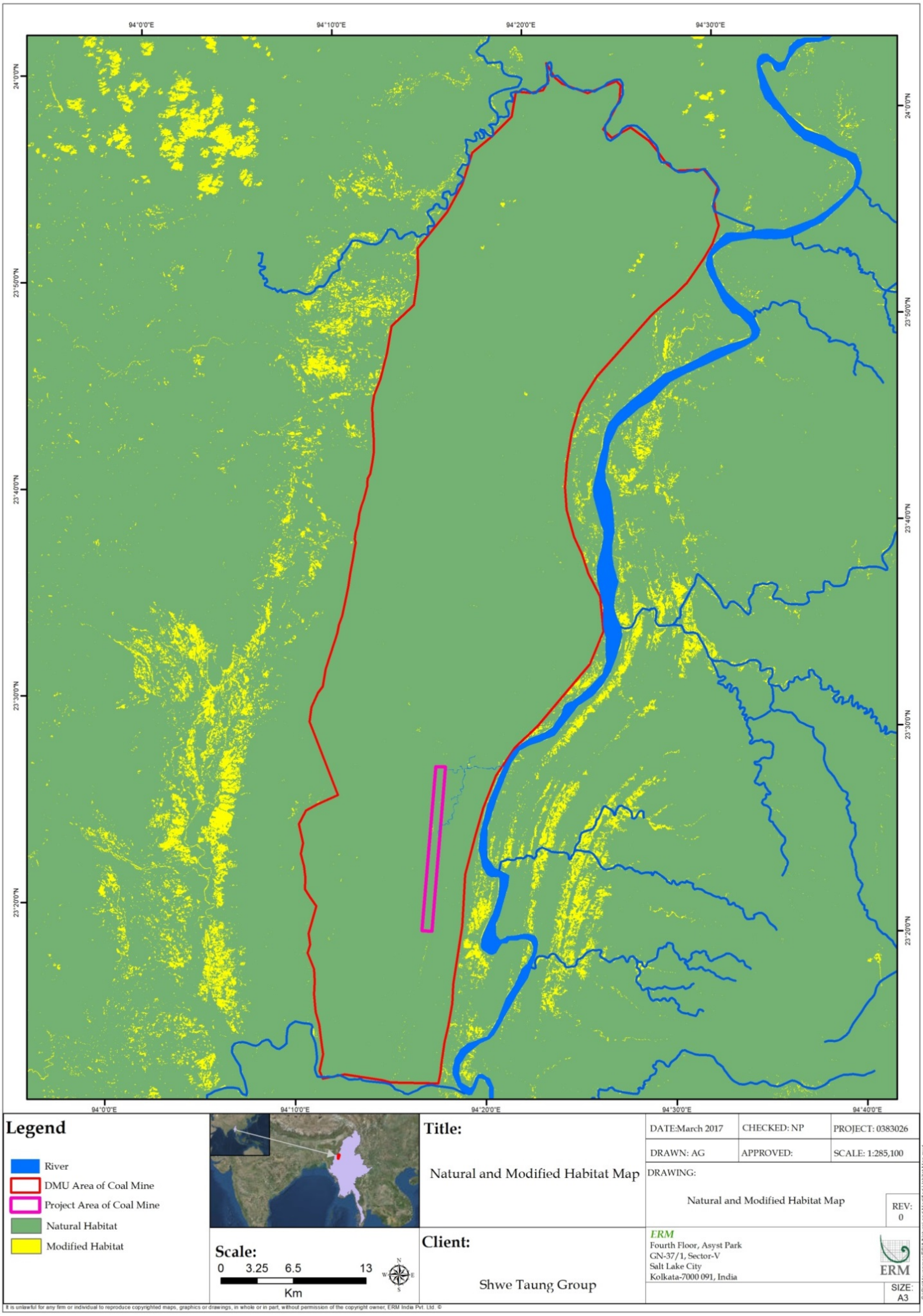


*Figure 6.33	Natural and Modified Habitat Distribution Coal Mine Concession*



6.3.10 *Critical Habitat Screening Assessment*

Critical Habitat Candidate Species

For Critical Habitat Criterion 1-3 this exercise has used species identified as threatened species. Threatened species were evaluated as threatened based on IUCN status (CR or EN), endemicity, restricted range and habitat requirements.

Further desktop assessment and consultation did not identify any additional data sources for threatened species that may be considered CH candidates within both Project sites.

The findings from karst reptile and flora surveys are currently pending. The CH assessments for these groups will be placed on hold until more information is available.

Potential Critical Habitat Species (Criterion 1-3)

The CH Screening Assessment identified three (3) species for the cement plant and six (6) species for the coal mine that are CH species for Criterion 1-3. These Critical Habitat candidates are considered as part of the impact analysis is outlined in *Error! Reference source not found.***6.30.**

The complete Critical Habitat Screening Assessment for Criterion 1-5 is contained in *Annex E2*.

Table 6.30 ***Candidate Critical Habitat Assessment Summary***

SN	Species	Common Name	IUCN Listing
Cement Plant			
1	*Manis pentadactyla*	Chinese Pangolin	CR
2	*Trachypithecus phayrei shanicus*	Shan Langur	
3	*Dalbergia oliveri*	Burma Rosewood	EN
4	*Trachypithecus phayrei* spp. *shanicus*	Shan State Langur	EN
5	Karst Snails	-	NA
6	Karst Flora	-	NA
7	Karst Reptiles	-	NA
Coal Mine			
1	*Manis pentadactyla*	Chinese Pangolin	CR
2	*Hoolock hoolock*	Hoolock Gibbon	EN
3	*Dalbergia oliveri*	Burma Rosewood	EN
4	*Dipterocarpus baudii*	-	CR
5	*Dipterocarpus costatus*	-	EN
6	*Gastrochilus calceolaris*	-	CR

Criterion 4) Highly Threatened and /or Unique Ecosystems

Highly threatened and unique ecosystems as defined by the IFC are those that are a) under significant threat; b) small in size; and/or c) have unique species assemblages. An assessment of the presence of habitats within the concessions at the Cement Plant and Coal Mine which meet these criteria and relevant discussions are provided below.

Ecosystems at Risk of Significantly Decreasing in Area or Quality

The forests associated with the Northern Indochina Subtropical Forest have been largely reduced in Vietnam and in the eastern Shan State of Myanmar, along the border with Laos and China. A few large blocks of habitat remain, but these are either degraded, or found within protected areas scattered throughout the ecoregion. Based on field observations at the cement plant, the forests surrounding the site are highly degraded due to firewood harvesting, limestone extraction and associated bushfires.

Based on the assessment habitats in the ecoregion and DMU are not decreasingly rapidly in area. However, the quality of forest habitats within and surrounding the project area was noted to be highly degraded, with intense pressure from extraction of limestone resources and associated vegetation cover for lime production. Panlaung-Pyadalin Wildlife Sanctuary within the DMU was reported to be poorly staffed and ill-equipped for enforcement, hence at risk of degradation. Given this baseline of existing severe degradation, subsequent activities leading to further degradation are unlikely to be significant in the current context. Hence, forest ecosystems at the cement plant DMU do not qualify as Critical Habitat under Criterion 4.

Cement Plant – Karst Ecosystem

Karsts in Southeast Asia face a number of threats and lack adequate levels of protection. Poorly planned quarrying operations may destroy whole karst landforms, wiping out site-endemics and greatly reducing the populations of regional-endemics. There is also a lack of representation of karst ecosystems in Protected Area networks in Southeast Asia, with the percentage of protected karst areas ranging from 0 – 45% of total karst areas depending on the country. An assessment of protected karst areas in Southeast Asia reported that only 1 % of karst areas in Myanmar is protected (within Shwe u Daung and Shwesettaw Game Reserves, and Pindaya Cave) (1).

While there is no reported data on the decrease of karst ecosystems in Southeast Asia and Myanmar in particular, the under-representation of karsts in Protected Areas and the country's burgeoning economic growth suggests that resource extraction will continue to threaten this ecosystem. In the context of the DMU, an estimated quarter of the limestone range is within the project concession and will be lost from quarrying. However, the same limestone range exists further south and other geologically and geomorphologically related outcrops are distributed across the Shan Plateau.

Whilst karst ecosystems are not well represented in the protected area system, there is insufficient data available to suggest that they are currently highly threatened in Myanmar. Therefore, it is not likely that karst ecosystems in Myanmar qualify as Critical Habitat under Criterion 4.

(1) Day M & Urich P (2000) An Assessment of Protected Karst Landscapes in Southeast Asia. Cave and Karst Science. Volume 27, No.2

Coal Mine

Evidence collected from the field studies suggest that habitats in the DMU are not decreasing rapidly in area; however the quality of habitats is at risk from logging, conversion and fragmentation. Field observations note that there is still remaining good quality forest adjacent to the concession. The forest habitats therefore are not currently threatened in area; however they are currently impacted by threats in relation to habitat quality. Illegal logging in Myanmar is a major threat to forest ecosystems. In relation to the DMU, whilst this threat is present, it is not determined to be a significant threat to the persistence of the forest ecosystem in terms of area. A visual assessment of satellite imagery for the DMU indicates that stands of mature forests exist within the DMU and that logging has occurred only where access has enabled this threat to occur. Therefore, the forest ecosystem within the DMU is unlikely to qualify as Critical Habitat under Criterion 4.

Ecosystems with a Small Spatial Extent

Cement Plant

The limestone ecosystems within the DMU were considered in the context of the Shan plateau – an extensive karst occurring over an area of 500 km by 300 km. The limestone outcrops within the Shan Plateau are assumed to be geologically and geomorphologically related. As limestone outcrops can differ significantly from each other in terms of habitat, a review of the findings of the karst survey was also conducted to understand if the karst ecosystem present on the limestone within the concession was replicated elsewhere across the range.

No site endemics were recorded from the limestone within the project concession and preliminary findings indicate that local-endemic species are likely to occur across the limestone range and its extension further south. This suggests that the limestone ecosystem within the DMU does not occur within a small spatial extent, and hence is unlikely to trigger Critical Habitat under this Criterion.

Coal Mine

The ecosystem found within the DMU is an extension of the deciduous forest ecosystem within the coal mine concession. In the context of the DMU (160,000 hectares), the coal mine concession occupies less than 1% of the total area. The forest ecosystem is representative of a larger forest complex that extends into Northern Myanmar and into India. The DMU in turn occupies less than 1% of the Mizoram-Manipur-Kachin Rainforest ecoregion (3,600,000 ha). The ecosystem does not have a small spatial extent and hence is unlikely that Critical Habitat is triggered under this Criterion.

Ecosystems Containing Unique Assemblages of Species Including Assemblages or Concentrations of Biome-Restricted Species

Cement Plant

The forests around the project were also observed to be highly degraded. These suggest that the forest ecosystem around the project area has a low capacity for an assemblage of species that can be deemed unique. Therefore, forest ecosystems at the project do not qualify as Critical Habitat under Criterion 5.

Surveys of the limestone range indicate an absence of site-endemics in the project concession but a presence of local-endemics across the range. Limestone areas are typically known for containing limestone-restricted species and display high levels of endemism. The limestone range in the DMU thus qualifies as Critical Habitat under Criterion 5.

Coal Mine

Given the general inaccessibility to parts of good forest in the site, it is likely that there may be more sensitive and elusive species within the DMU. The project site is within a Tiger Conservation Landscape, and although this species was not determined to be present during surveys conducted for this project, suitable prey species exists within the landscape. Insufficient evidence currently exists to evaluate the coal mine site as containing a unique assemblage of species or biome restricted species. The species present are representative of the species that are normally associated with this habitat type in SE Asia. Therefore, the ecosystems within the DMU are not evaluated as Critical Habitat under this Criterion.

Criterion 5) Key Evolutionary Processes

Criterion 5 recognises the attributes of a region that that can influence evolutionary processes and give rise to regional configuration of species and ecological properties. Examples can include isolated areas where populations are phylogenetically distinct, areas of high endemism, environment gradients or ecotones and biological corridors.

While no site endemic species were recorded within the limestone concession, several local-endemic species were found throughout the limestone range, including within the project concession. Most of the unidentified species (constituting a third of all recorded species) are also potentially new to science. Two limestone restricted flora species were recorded. It is likely that there are more local-endemic and limestone restricted species within the range as the surveyors could only access sites that were severely degraded. While results are preliminary and no quantitative findings have been reported, the initial findings reflect the richness limestone-restricted species within the range. This is testament to the evolutionary significance of limestone ecosystems; hence the limestone range within the DMU qualifies as Critical Habitat under Criterion 5.

Criterion 5 assessment will be updated upon review of Final Karst Survey Report

6.3.11 *Ecosystem services Assessment*

The International Finance Corporation's (IFC) performance standards require projects to assess and preserve the benefits from ecosystem services. The IFC also requires that the environmental and social risks and impacts identification process considers a project's dependence on ecosystem services. A fundamental component is to apply the mitigation hierarchy to determine measures to limit impacts on ecosystem services.

ERM has utilized the World Resources Institute (WRI) Guidelines: *Weaving Ecosystem Service into Impact Assessment* to guide the approach used to assess ecosystem services in relation to the project.

Ecosystem service Data Collection

ERM visited the two project sites in January 2017 to consult with the Project stakeholders explaining the concept of the project and administering questionnaires to individuals and groups. The stakeholder engagement included specific discussions regarding ecosystem services.

ERM undertook the following consultation as part of ESIA:

- Consultation with 100 households living in close proximity to the cement plant and coal mine from selected communities (5 villages); and
- Consultation meetings with government authorities, NGOs, PAPs and other interested people.

Household survey questionnaires were used to gather data from the communities around the cement plant and coal mine to solicit their opinions on both the positive and negative aspects of the Project development to inform the ESIA. The data is relevant to understanding current socio-economic conditions in the Area of Influence of the Project, historical impacts associated with the construction of the cement plant and coal mine as well as potential issues associated with the on-going operation of the Project.

Prior to conducting household surveys, an introductory meeting was convened in the host community to introduce the purpose of the consultation.

Priority Ecosystem Services

The following priority ecosystem services shown in *Table 6.31* have been identified. Assessment of impacts to ecosystem services is incorporated into Sections 8 and 9 of this Report. The complete dataset for the ecosystem services assessment is contained at *Annex E3*.

Table 6.31 Priority ecosystem services

Priority Ecosystem Service	Description
Timber and wood products	Evidence suggests that wood is harvested from within the Project Area and AoI for use by local people. The project may restrict this activity. The amount of timber available to local people has been decreasing. Unsustainable harvesting of timber will lead to continued reductions in availability of timber.
Freshwater	Evidence suggests that freshwater is used by local people from within the Project Area and AoI. The project may restrict or impact this activity. Freshwater impacts were reported by all villages within both Project AoIs. Impacts from the coal mining site impacted downstream, especially during the wet season. Decreases in water flows were also reported.
Erosion regulation (Coal Mine concession only)	Evidence suggests that the Project area of AoI for the coal mine site has regulating erosion on slopes and riparian areas in the vicinity. The forest at the coal mine site provides stability to the slopes to reduce the chance of land slips and erosion. The coal mine site has had an increased incidence of erosion due to coal mine operations.

7 SOCIO-ECONOMIC BASELINE

7.1 SOCIO-ECONOMIC CONDITIONS

7.1.1 *Demographics and Population*

The socio-economic baseline is derived from engagement with village leaders, groups of farmers and women and a survey of 100 households from five villages in the vicinity of the Project sites.

Basic information concerning the surveyed households and villages is summarised in ***Table 7.1*** and ***Table 7.2***.

Table 7.1 Population Data of Surveyed Households

Village Name	Number of respondents	Ethnic Group - Bamar	Ethnic Group - Karen	Average number of members per HH	Total number of residents in village	Male / Female Respondents (%)	Average Age of Respondent (years)
Kubyin	25	19	6	4.84	271	12%/88%	42
Pyi Nyaung	25	25	0	4.80	2,569	48%/52%	49
Chaungzon	20	20	0	4.15	80	60%/40%	37
Paluzawa	11	11	0	4.27	253	36%/64%	49
Nanmawke	19	19	0	5.21	75	16%/84%	35

Table 7.2 Economic Data of Surveyed Villages

Village Name	Average Monthly Income (Kyat per HH)	Average Monthly Expenditure (Kyat per HH)	Land Holdings (number of HH / surveyed) (1)	Average Land Holding (acres) (1)	Total Land Holding of the Surveyed HH (acres) (1)
Kubyin	284,400	52,020	16 (of 25)	1.81	29
Pyi Nyaung	264,400	180,520	18 (of 25)	3.56	64
Chaungzon	243,350	189,975	18 (of 20)	2.39	43
Paluzawa	201,818	126,682	10 (of 11)	2.27	25
Nanmawke	247,895	116,842	15 (of 19)	2.97	56

Note:

(1) The farmland is state owned forest area which villagers cleared to grow crop, except for Kubyin Village. The farmers of Kubyin Village are farming government owned forest, which is a replantation area under the management of the Forest Department.

7.1.2 *Health*

The residents consulted in the five villages stated that they considered themselves healthy and do not face any serious diseases. Malaria was noted as the main cause of adult mortality, however, villagers have not suffered new cases of malaria for a long time. In the dry season, sometimes they suffer from minor skin irritation due to the water shortage.

7.1.3 *Education*

Of those consulted in January 2017, the majority were illiterate. Only one village (Pyi Nyaung) has people that had attended university education. The illiteracy rate in the households consulted ranged from 21 to 44%. Data collected area presented in *Table 7.3*.

Table 7.3 Number of Households (surveyed) within Education

Village Name	Illiterate	Primary	Middle School	Secondary School	University
Kubyin	11 (44%)	9 (36%)	5 (20%)	0	0
Pyi Nyaung	8 (32%)	8 (32%)	6 (24%)	1 (4%)	2 (8%)
Chaungzon	6 (30%)	12 (60%)	2 (10%)	0	0
Paluzawa	6 (55%)	4 (36%)	0	1 (9%)	0
Nanmawke	4 (21%)	4 (21%)	11 (58%)	0	0

7.2 *CEMENT PLANT*

The Project is located within Pyi Nyaung Village of Tharzi Township in Mandalay Region. The populations of Pyi Nyaung and Kubyin are 2,569 (53% male) and 271 (50% male), respectively. The household surveys indicate that most of the people in both villages are of the Bamar ethnicity and are predominantly Buddhist. There are a six ethnic Karen (Christian) households in Kubyin (of the six households; four were met) and one was met in Pyi Nyaung. Consultation with officials and the community revealed that there are no areas or sites of special cultural importance within the Project area.

Pyi Nyaung Village

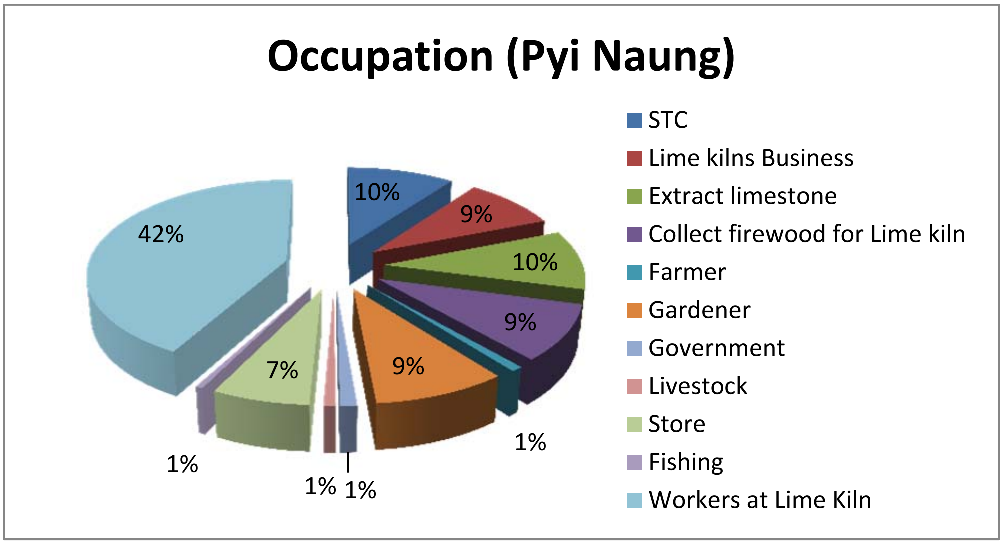
Located six km south of the cement plant and founded in 1946, Pyi Nyaung Village is home to some 594 households for a population of 2,569. About 500 households include a working age member. The survey was run among 25 households, reaching out to 120 people (4.8 members per household on average). According to the Pyi Nyaung Village Tract leader, 60 HH have a member working at STC on a full time or casual basis and approximately 300 households (80% of the working population) are engaged in lime production from kilns scattered throughout the village: approximately 53 households manage lime kilns, 60 extract limestone from a nearby hill (does not overlap with any other concession) and approximately 56 collect firewood for lime production, which is the main economic activity in the village. About 250 households have at least one member engaged as casual labour for the lime kilns. Another 40 households package and trade lime or run small shops, restaurants, market stalls or are engaged in hawking.

A majority of the households surveyed hold land (72% or 18 households) for an average size of 2.56 acres. The farming land for the 25 surveyed households spreads over 64 acres (including 30 acres belonging to the same household). According to the Village Tract Leader, about 55 households are small scale gardeners. Of the 25 surveyed households, only one household is involved in large scale farming and holds 30 acres of land.

Rice cultivation is widespread on the outskirts of the village. The average land holding size in the village is two to four acres and a total of five households are engaged in this activity. The main crops grown in the area are summer paddy rice, banana and mango. Rice is sown in June or July and harvested in September or October. Bananas are grown in April through May. Of the 25 surveyed households, a quarter owns livestock (chicken, buffalo, pig, goat and duck) for consumption (chicken and pigs) or sale (buffalos, cows and goats).

Within Pyi Nyaung Village, three households are engaged in electric fishing (which is illegal) and another seven households work for the government in administration, education and health functions.

Figure 7.1 Employment in Pyi Nyaung Village



Source: ERM, 2017

While limestone production, including the extraction of limestone and firewood, is reportedly the main source of income for residents of Pyi Nyaung, an unknown number of residents are involved in logging of teak and other hardwood timber and its transportation to the nearby towns of Taunggyi, Thazi and Meikhtila.

The average monthly income is Kyat 264,400 with 5 households earning double and one more than triple that amount, from his business. The median monthly income of those surveyed is Kyat 210,000. One respondent declared earning double the average from "other sources".

Over half of the respondents (56% or 14 households) stated having taken a loan for their business (28%), to buy food (16%) or for education or medical expenses (12%) but only two-thirds (36%) of those declaring loans mentioned repaying a loan as part of their expenditures.

The majority of the respondents (64% or 25 households) buy purified drinking water and the remaining respondents (36%) source their water for drinking and other domestic usage from the nearby creek. The village relies on water in the Myithar River as its natural water source and there is a supply of piped water from a hand-dug well near to the river that serves a few areas. All of the respondents described the drinking water quality as "good". According to the Village Tract Leader, there is a shortage of water each year in the summer months and this was confirmed by 40% of those interviewed.

Virtually all surveyed respondents (96%) use dry pit latrines and consider sanitation satisfactory for the community's needs (the remaining respondent found it good). The respondents are satisfied with arrangements for solid waste disposal: 24 found it satisfactory and 1 good. There are mixed views concerning the changes in water quality and quantity over the last three years, with an equal number of respondents reporting a decline in quality/availability as those saying that it has not changed.

The electricity supply for Pyi Nyaung Village is from the national grid via a transmission line provided by STC and three other companies. This arrangement has been in place since 2014. Only 60 % of HH have access to electricity from the national grid, which is reflected in the household survey, with the remainder reliant on diesel generators (20% of surveyed households) and solar energy (one surveyed household). Four surveyed households (16%) have no regular access to electricity. A majority of respondents (88%) believes the electricity supply is adequate for the community, including the respondents with no regular access to electricity, with 12 % (or 3 households) describing it as satisfactory (two are connected to the national grid, one to a power generator).

Pyi Naung has a relatively good road network connected to a main highway and all the surveyed respondents described the roads and transport options as good (100%). However, most of the smaller access roads are impassable during the rainy season. The terrain and nature of the soils requires regular maintenance of roads, hence making road maintenance important. An induced impact of the improvement to access routes brought about by the development of the STC cement plant is the increased pressure on forest resources from activity by residents of Pyi Nyaung Village and from settlements further afield. The improved access allows larger trees to be harvested using equipment and transportation that would previously not been able to access these areas. Those travelling from Thazi, Taunggyi and Meikhtila are generally seeking the larger teak and other hardwood north of Kubyin Village rather than competing with local residents for firewood.

The majority of the surveyed respondents (56% or 14 households) use fire as a cooking fuel. The consumption of firewood per day is about 3 kg for one household (90-100kg a month) and one household of three members consuming three times that average. All surveyed respondents but three buy firewood. The firewood can be collected in forest areas 30 minutes by foot from the village. Up to 1 kg of charcoal per day is also used for cooking by about a quarter of villagers. Half of the surveyed households use electricity for cooking.

Three households (12%) described themselves as entirely dependent on forest products for their livelihood for lime production or to sell as firewood: these same households indeed stated that all of their income comes from their business activities. Nearly half (48%) stated they are half dependent on such resources and ten households (40%) assessing themselves as a quarter dependent. A total of 16% (4 households) stated they rely on forest products for lime production and 80% (20 households) for firewood.

No household raised any concern associated with firewood and none described the deforestation that may be happening in their area as a source of concern. Residents reported having multiple options for places to collect firewood for domestic use and for sale.

The respondents spend on average 28% of their income on education: this represents 27% of the total income of the 25 households that is spent by 17 of them. All the respondents described the education services as good (100%) – there is a secondary school. A slight majority (52%) described the medical services as also good or satisfactory (32%) but 16% (4 households) as unsatisfactory.

About 36% of respondents described the law and order as satisfactory and the remaining respondents as good.

Figure 7.2 Socio-economic Survey at Pyi Nyaung Village

Kubyin Village

Located approximately 4 km north of the cement plant, Kubyin Village is home to some 65 households. Situated within the Kubyin Forest Reserve that is under the local administration of the Meikhtila Forest Department, Kubyin is a relatively isolated village established in 1970 by the Forest Department to manage and log the teak plantation. The household survey interviewed 25 households and with an average of 4.8 members per household, the surveyed respondents represented 121 of the 271 residents in the Village.

Prior to the construction of the STC plant, the village was only accessible by bullock-cart or on foot from Pyi Nyaung, approximately 10km to the south. No Kubyin residents owned motor vehicles prior to the construction of the concrete access road to the cement plant and the bypass road to Kubyin Village that were constructed by STC.

There is no grid-supplied electricity in Kubyin. In 2015, the Forest Department donated 46 solar panels to the village. Water supply is from the Kubyin River and a single well installed on the bank of the river that is used mainly in the dry season when the water level is low. Drainage from STC's operations flows into the Kubyin River.

There is very little cultivation in Kubyin Village but the majority (96%) of the surveyed respondents described themselves as farmers, with 16 households earning income from their land and an additional 7 involved in labour work. The Village Tract Leader stated that 58 out of 65 households are engaged in agriculture (summer paddy, maize, sesame). The farmers of Kubyin Village are farming in government owned forest, which is a replantation area under the management of the Forest Department. Agriculture provides 66% of the total income of the sample and on average 56% of the income of those involved in farming on their own land (average plot size of 1.16 acres), and 30% of the income of those involved in labour work. The farming land for the 25 surveyed households spreads over 29 acres. While it was not reported by residents in the surveys, it is clear that a large number of residents in Kubyin village extract forest products as their main source of income.

Of the 25 surveyed households, 80% reported owning livestock (210 chickens, 56 buffalos, 23 cows, 12 pigs) mainly for consumption and a smaller amount for sale.

According to the Village tract Leader, some households collect firewood for delivery to the lime kilns in Pyi Nyaung (there are no kilns in Kubyin). All the respondents (25) of the household survey stated that they rely on firewood as a source of cooking fuel and 92% (23 households) get it from the forest. Only one household (of 4 members) buys it, dedicating 64% of its monthly expenditure to that item (with the outstanding entirely spent on telephone costs), while the other household, the monastery, receives it from donation. It takes households nearly 40 minutes to reach a place in the forest where they can get firewood and the respondents declared consuming on average 465kg of firewood per household a month. Eight households consume on average 886kg a month (225kg per household member) while the remaining 18 households consume on average 267kg a month (63kg per household member). Academic research carried out in the Taungyi District, Shan State[1], reports that the monthly average rural household consumption of fuelwood is 222kg.

About 9 households (36%) described themselves as entirely dependent on forest products for their livelihood while 11 households (44%) stated they are half dependent on such resources and 5 (20%) assessing themselves as a quarter dependent. A large proportion of this income is understood to be related to timber extraction, transportation and trade.

No household raised any concern associated with firewood, however several households and the village leader described the deforestation in their area as a source of concern.

(1) Chaw Sein C., Min Aye Z., Razafindrabe Bam H.N. (2015), Study on consumption of fuel wood and its impacts to forest resources in Taungyi District, Global Journal of Wood Science, Forestry and Wildlife, 2449-1780 Vol. 3 (2), pp.43-51

None of the residents of Kubyin work at STC's cement plant. The market prices for forest products advised by residents of Kubyin Village indicate that the economic incentives favour collection of forest products over working at STC.

Table 7.3 Market Price of Forest Products vs Wages at STC

Item	Market Price (MMK)
Length of regular bamboo	100
Length of elephant bamboo	1,500
Small tree (kiln fuel)	5,000
Large teak tree	120,000-150,000
Minimum Daily Wage at STC	3,600-5,000

Reportedly, residents of Kubyin are not attracted to working at STC's plant given the significant difference between salaries offered at the cement plant compared with what can be earned through timber extraction and harvesting of other forest products. Reportedly, the main source of income for most households in Kubyin is the extraction and sale of teak and other timber. This has intensified since the start of STC's operations due to improved accessibility afforded by the upgraded road to the cement plant. Prior to the construction of STC's cement plant, Kubyin residents transported timber via bullock cart 10 km to Pyi Nyaung and onwards to market. Today, the use of six-wheeled trucks and tractors by Kubyin residents is common. One resident that ERM spoke with sold his house in Pyi Nyaung in 2015, moved to Kubyin and purchased three six- wheel trucks that he rents out to extract timber.

Due to a rapid decline in hardwood timber in and around Kubyin over the last few years, in 2015 residents of Kubyin constructed a 6 km road north along the valley floor to Shan Gate (at the border of Shan State) to allow for timber extraction.

The average monthly income of those interviewed is Kyat 284,400 with 7 households earning more than that amount (the median monthly income was Kyat 180,000 and the Village tract Leader mentioned that all the households earn Kyat 100,000 to 200,000 per month with three earning up to Kyat 300,000 per month). One respondent declared earning an agricultural income which represents 8 times the average agricultural income declared by all the surveyed households. The source of this "agricultural" income is very likely timber extraction.

The average monthly expenditure is Kyat 52,020 per household mostly spent in small amounts on education, diesel/petrol, loan repayments and telephone. The nearest market is in Pyi Nyaung Village, 30 minutes away by motorbike.

Some of the respondents declared having a loan (9 households or 36%) to buy seeds but only two-third of those with a loan mentioned repaying a loan as part of their expenditure.

The feedback from respondents regarding employment is negative, with 88% describing local employment as unsatisfactory and 8% stating it is unavailable. As context, respondents stated that they can generate higher incomes from timber extraction compared with working at the STC cement plant.

The majority of the respondents (96% or 24 households) source their water for drinking and other domestic usage from the Kubyin creek. About 76% of households described the drinking water quality as "good" and 24% as "poor". Regarding the adequacy of the drinking water supply to the community, 76% found it satisfactory and 24% good.

About 84% of respondents use dry pit latrines and overall, 76% of respondents found the sanitation satisfactory and 24% "good" for the community's needs. About 28% of respondents found that the water quality, and 32% that its quantity, have declined over the last three years (the remaining respondents found no change, with the monastery not responding). Whether this has been occurring in the rainy or summer season, or every day or sometimes only, is not conclusive. The respondents raised concerns about the adequacy of the waste disposal system with 68% describing it as unsatisfactory and 16% as non-existent.

As recorded in January 2017, most households (56%) are connected to solar panels donated from the Forest Department for their power supply and about 40% rely on a generator. One household does not have access to electricity supply. It is reported by STC that the company has donated a 60 kVA generator to Kubyin Village in February 2017 and now the whole village has access to electricity suppl.

Respondents described the roads and transport options as either satisfactory (32%) or good (68%).

The respondents spend on average 25% of their income on education. All the respondents described the education services as satisfactory (60%) and even good (40%) – there is a middle school - but medical services is not available (except the household representing the monastery). Residents reported that there have been no malaria cases for a long time.

Half (48%) of respondents described the law and order as satisfactory or good (16%) but 36% found it unsatisfactory, with concerns raised about "outsiders" coming to the area to (illegally) extract timber and other forest products.

Figure 7.3 Socio-economic Survey at Kubyin Village

7.3 *COAL MINE*

Chaungzon Village

Located approximately 1 km from the base camp, Chaungzon Village comprises 22 households with a population of approximately 100 people. With an average of about 4 members per household, the surveyed respondents represented 83 villagers. All the 20 surveyed respondents in Chaungzon were Bama and Buddhist.

According to the Chaungzon Village leader, all the villagers farm rice (but also peas, banana, tomato, sunflower) and most hunt and gather firewood. All but three surveyed households stated they are involved in farming (85%) with 9 households deriving 100% of their income from farming. Agriculture provides for 67% of the 20 surveyed households total income. All the households that were surveyed hold some land for an average size of 2.39 acres except two of the three not involved in farming activities. The farming land for the 20 surveyed households spreads over 43 acres.

Of the 20 households, 18 stated they own livestock (chicken, buffalo, pig, goat and duck) for consumption or for sale.

It is also clearly visible that residents are engaged in the extraction of hardwood timber, which appears to be a significant source of income for the village. None of the residents of Chaungzon Village work at Shwe Taung's mining operations. Reportedly the salaries are too low and monthly payments do not suit the local residents.

Three of the households involved in farming are also involved in business activities, and another one full time. Business-related income provides for 9% of the surveyed households total income and casual labour work for the remainder (35%).

The average monthly income of the surveyed households is Kyat 243,350 with seven households earning up to just over twice that amount, mainly derived from agricultural income, likely logging. The Village Tract Leader estimated that most villagers earn Kyat 50,000-100,000 per month, with three earning up to Kyat 200,000.

The average monthly expenditure is Kyat 189,975 per household with three households spending two to three times that average mainly on food, agricultural inputs and diesel/patrol.

Over half of the respondents (55% or 11 households) stated having a loan for their business (10%), to buy food (10%) or seeds (5%) or for education, medical or household expenses (30%). Loan repayment diverts about 9% of the surveyed households' total income.

Regarding the adequacy of employment opportunities to the community, 60% of households describe them as unsatisfactory (but 40% as satisfactory).

A majority (95% or 19 households) of the respondents rely on firewood as a source of cooking fuel that they source in the forest at about 10 to 15 minutes from their home, except for one household who buys charcoal for cooking fuel. Amongst these 19 households, 18 have electricity access via a generator. One household has access to electricity via solar panels.

The 19 households that consume firewood do so at an average of 147kg per month. All the surveyed households described firewood as very important for their income and 55% described themselves as half dependent on forest products with the remaining a quarter dependent.

No household raised any concern associated with firewood and none described the deforestation that may be happening in their area as a source of concern.

The majority of the respondents (90% or 18 households) source drinking water from the nearby creek, one from hand-dug well and one buys purified drinking water (however this household uses the creek for other purposes). All of the respondents described the drinking water quality as "good". Regarding the adequacy of the drinking water supply to the community, 25% found it good and 75% satisfactory.

About 90% of respondents use dry pit latrines and the remaining use flush toilets. All the respondents found the sanitation satisfactory for the community's needs. On the other hand, about 60% of respondents found that the water quality and its quantity have declined and decreased over the last three years, while 40% of respondents found no change to either quality or quantity. Changes were observed in both the summer and the rainy seasons. All the respondents found the current quality and quantity of water acceptable.

All the respondents are satisfied with the solid waste disposal system.

Most households (95%) have electricity access via generator and one household via solar panels. A majority of respondents believes the electricity supply is adequate for the community, describing it as satisfactory (75%) or good (25%).

The respondents described the roads and transport options as satisfactory (75%) or good (25%).

The respondents spend on average 20% of their income on education: this represents 7% of the total income of the 20 households. All the respondents described the education services as satisfactory (75%) or good (25%) – there is a primary school - as well as the medical services (25% satisfied and 75% found them good).

According to the Village tract Leader, flooding occurs every year.

Figure 7.4 FGD with Farmers at Chaungzon Village

Paluzawa (Coal Staging Area 1)

Located approximately adjacent to Coal Staging Area 1, the village comprises 52 households with a population of approximately 250 people. Eleven households were surveyed, and with about 4.3 members per household, this represented about 47 villagers. The village was set up in 1945 and is situated at the confluence of the Paluzawa creek and the Chindwin River. Ten out of 11 respondents were Bama and Buddhist except one household of 5 members who was Kachin and Christian.

The majority of the surveyed respondents (82%) are involved in farming, While a number of residents also work as day labour for the Shwe Taung mine, transporting coal from the staging area onto barges. A majority of the households stated they hold land (91% or 10 households) for an average size of 2.27 acres and ranging from 1 to 4 acres. The farming land for the 11 surveyed households spreads over 25 acres and caters for monsoon rice paddy, banana and sunflower.

Of the 11 surveyed households, most (9) own livestock (chicken, buffalo, pig and cow) for consumption or for sale.

The feedback from respondents regarding employment is fairly positive (64% finds the situation satisfactory) while the remaining (36% or 4 respondents) described local employment opportunities as unattractive.

The two business-related income in the surveyed community provide for 21% of the surveyed households total income, with farming contributing to 32%, casual work to 28% and services to 16% (two households involved). The average monthly income is Kyat 201,818 with 2 households earning nearly double that amount. The median monthly income is Kyat 200,000. One respondent declared earning from "other sources".

The average monthly expenditure is Kyat 126,682 per household with seven households spending the equivalent of 55% of the surveyed households total income on "ration". There are no market facilities in the village: the nearest market for daily needs is 2 to 3 hours away.

A third of the respondents (36% or 4 households) stated having a loan for buying food (27%) or seeds (9%) but only two households mentioned repaying a loan as part of their expenditures including one who stated having contracted a loan.

A majority (82% or 9 households) of the respondents rely on charcoal as a source of cooking fuel that they buy, except for two households who rely on firewood that they source in the forest, one at about 30 minutes from their household and the other one at about 50 minutes. They consume on average 125kg of firewood a month.

Nearly three-quarters (73% or 8 households) described themselves as 25% dependent on forest product for their household's livelihood (including one of the two households that sources firewood) and the remaining as half dependent (including the other household that sources firewood).

No household raised any concern associated with the availability of firewood and none described the deforestation that may be happening in their area as a source of concern.

All the respondents source their water for drinking and other domestic usage from the nearby stream and they all described the drinking water quality as "good". Regarding the adequacy of the drinking water supply to the community however, 45% found it good but the remaining (55%) found it unsatisfactory.

About 45% of respondents found that the water quality and quantity have decreased and declined over the last three years (especially in summer, said the Village Tract Leader), while 36% of respondents found that they had not changed. The remaining 2 households have observed both improvement in quality and increase in quantity of water supply. Changes were observed in the rainy season by 4 respondents. A third of respondents found the changes not acceptable.

All but one household use dry pit latrines (as opposed to flush tilets) and 45% of respondents found the sanitation satisfactory for the community's needs while 18% found it unsatisfactory.

The respondents are generally not satisfied with the solid waste disposal system (73% described as unsatisfactory while the remaining found it satisfactory).

All the respondents stated they have access to electricity via a generator, which they feel satisfied by except one respondent who said having no access to electricity. The Village Tract Leader said that all the villagers had access to electricity via solar panels.

All the respondents described the roads and transport options as good (82%) or satisfactory (18%).

The respondents spend on average 13% of their income on education: this represents 14% of the total income of the 11 households. All the respondents described the education services as good (45%) or satisfactory (55%) – there is a primary school in the village. A majority (64%) described the medical services as satisfactory but 36% (4 households) as unsatisfactory. Residents of Paluzawa are often treated for minor illnesses at Shwe Taung's clinic.

Two respondents mentioned that landslides occur every year during the rainy season, the last one in 2016, due to deforestation. The Village Leader mentioned annual flooding.

Figure 7.5 FGD with Farmers at Paluzawa Village

Nanmawke (Coal Staging Area 2)

Nanmawke is a village of about 13 households and 100 people, according to the Village Leader. The surveyed was carried out amongst 19 households, and with an average of about 5.2 members per households, it reached nearly 100 people. All the 19 surveyed respondents were Bama and Buddhist.

A quarter (26%) of the surveyed respondents are involved in business activities and for three out of these five households, their business provides for their sole source of income. Business-related income provides for 26% of the surveyed households total income. The Village Leader described these activities as coal-related.

Eleven household are involved into farming and additional 5 in casual labour work. A majority of the households stated they hold land (79% or 15 households) for an average size of 2.97 acres and for monsoon rice paddy, pea, pulse, banana, salad and sunflower. The farming land for the 19 surveyed households spreads over 56.5 acres (with one household holding 10 acres and another one 8 acres).

Of the 19 households, 16 own livestock (chicken, buffalo, pig, goat and cow) for consumption or sale.

The feedback from respondents regarding employment is largely negative with 47% describing employment opportunities as unavailable and 53% as unsatisfactory. It is noted that once Shwe Taung begins barging from Coal Staging Area 2, there will be some employment opportunities available in Nanmawke.

Only one respondent declared earning a third of its income from services. The average monthly income is Kyat 247,895 with 4 households earning about double that amount, from business. One respondent declared earning double the average from "other sources".

The average monthly expenditure is Kyat 116,842 per household with four households spending more than double mainly on food and one household on loan repayments. There are no market facilities in the village.

Over half of the respondents (63% or 12 households) stated having a loan for their business (16%) or to buy food or other household consumables (42%) but only 5 respondents of those declaring having a loan mentioned repaying a loan as part of their expenditure.

Three-quarters (74% or 14 households) of the respondents rely on firewood as a source of cooking fuel that they source in the forest (10 to 20 minutes away from their home) except for two households who buy it. The average firewood consumption is 125kg per month.

Half of the respondents (47%) described themselves as 50% dependent on forest products for their livelihood and the remaining as 25% dependent. They all stated they rely on forest products for firewood.

No household raised any concern associated with firewood and none described the deforestation that may be happening in their area as a source of concern.

All the respondents source their water for drinking and other domestic usage from the nearby creek, except one which uses a hand dug well. All of the respondents described the drinking water quality as "good". Regarding the availability of drinking water supply to the community, most found it unsatisfactory (68%) and the remaining found it good.

About 42% of respondents found that the water quality and quantity have declined and decreased over the last three years, while 58% of respondents see no change. Changes were observed in the summer season. The Village Leader mentioned that there is a rain water storage tank in the village.

A majority of respondents (84%) use dry pit latrines and the remaining use flush toilets. A third found the sanitation unsatisfactory while the remaining found the system satisfactory.

All the respondents are satisfied with the solid waste disposal system.

Most households (63%) have access to electricity via solar panels, 26% via a generator and two households stated they have no access to electricity. All the respondents described the roads and transport options as good (100%).

The respondents spend on average 20% of their income on education: this represents 14% of the total income of the 19 households. All the respondents described the education services as good (79%) or satisfactory (21%) – there is a primary school within 10 minutes walking distance. All the respondents said medical services are not available to the community but the Village Leader stated that they can have access to a clinic operated by Shwe Taung situated 3km away.

One respondent raised concerns about the health situation in the community and one stated they would like a monastery and a pagoda for the village.

The Village Leader mentioned annual flooding.

Figure 7.6 Socio-economic Survey at Nanmawke Village

Other Coal Mines and Industry

There are three other coal mines in the vicinity of Shwe Taung's concession:

1) Kokant Golden Dragon Company initially constructed the road from Paluzawa Village to its lease in order to access a 60-acre concession that was used for a small underground mine. This mine is no longer in operation.

2) Mandalay Golden Friends Company: has a coal mining lease approximately 3 km North of Phase 1 of Shwe Taung's concession. The mine is accessed by an existing logging road that passes by Shwe Taung's base camp.

3) Tun Thwin: operates an underground mine east of Shwe Taung Phase 2.

Until early 2015, (legal) timber extraction in the broader area was undertaken by a Mandalay based company that accessed the area via the existing logging road that runs past the Shwe Taung base camp. Timber was transported down to the dock at Paluzawa Village and then onto barges.

Illegal timber extraction remains common in the area along all roads that provide access to the forest, including the road constructed to the Shwe Taung mine. Extracted timber is transported down to the dock at Paluzawa Village and then onto barges. Alongside the coal mining operations, timber extraction it is the main economic activity in the area and appears to be preferred by those in the area.

8 CONSTRUCTION PHASE IMPACT ASSESSMENT

8.1 AIR QUALITY

8.1.1 Cement Plant

Potential Impacts

Construction of the Project has the potential to generate dust as a result of soil movement, use of construction vehicles on unmade roads and stockpiles of material. Fugitive dust has the potential to cause impacts on sensitive receivers in the vicinity of construction activities if not managed accordingly.

The following section qualitatively addresses the potential impacts from dust emissions associated with construction phase activities including earthworks, material handling, vehicle movements over unpaved surfaces and stockpiling. Where activities are considered likely to result in generation of dust with potential to impact ambient air quality, mitigation has been identified so that those impacts are reduced to an acceptable level.

The main construction phase will occur over a period of 24 months and the activities identified as having a potential impact on air quality during this time include:

- Vehicle movements over unpaved surfaces within construction areas;
- Site clearance, site formation and levelling involving excavation and spoil dumping; and
- Construction of the main infrastructure.

Project activities can result in emissions of dust and particulate matter (Total Suspended Particulate (TSP), PM_{10} and $PM_{2.5}$) to air. The distance at which impacts occur depends on the duration and type of construction activity, the size distribution of particles generated, the sensitivity of the receptors and the meteorological conditions.

The Institute of Air Quality Management (IAQM) [(1)] provide guidance for defining the significance arising from construction sites based on the magnitude of the change and the sensitivity of the receptors identified. The risk of dust emissions is defined using a number of variables including, but not limited to the activities being undertaken, the duration of activities, the size of the site and the meteorological conditions. The guidance further provides screening criteria of 350 m and 50 m from the construction site and access road, respectively, beyond which impacts are not considered likely. The premise of the guidance is that with the implementation of effective site

(1) Institute of Air Quality Management (2014) Guidance on the Assessment of Dust from Demolition and Construction

specific mitigation measures, the environmental effect will not be significant in most cases. While this is likely to be applicable during the wet season, it is considered that airborne dust may travel further in Myanmar during the dry season owing to climatic conditions and generally weaker site environmental practices.

In terms of dust emissions from open surfaces (i.e. exposed construction areas, disturbed land, stockpiles), the USEPA [(1)] present evidence which suggests that at wind speeds of less than 5.3 m/s and where rainfall exceeds 0.25mm over a 24 hour period, dust is unlikely to be lifted and emissions will therefore be negligible. Statistical analysis of the meteorological data generated for this AQIA indicates that based between 2012 and 2016, the wind speed is less than 5.3 m/s for 90% of the time, and rainfall is more than 0.25mm for 57% of the time, therefore the periods where dust emissions are likely are greatly reduced (perhaps to as much as around 5% of the time). Furthermore, wind speed generated using the WRF model are provided at a height of 10 m, therefore the wind speed at ground level or at the mean height of the stockpiles (assumed less than 10 m) would be reduced further reducing the time that dust emissions from open surfaces is likely. It should be noted, however, that fugitive dust emitted from an unpaved surfaces or from material handling processes may be dispersed via substantially lower wind speeds once emitted and travel considerable distances, so additional consideration to this process should be given.

The evidence presented suggests that emissions and subsequent impacts to air quality associated with the construction activities will depend greatly upon the nature of the activities occurring at any one time or location and local meteorological conditions at the time of release. Given that during construction, emission source locations and volumes of materials being moved are constantly changing, impacts have not been separately quantified for separate construction sites or activities, instead, the impact from construction dust is said to have a moderate impact if unmitigated and uncontrolled at receptors within a conservative distance of 500 m of construction activities.

(1) United States Environmental Protection Agency (1995) AP-42 Section 13.2 Fugitive dust sources, www.epa.gov

Table 8.1 Assessment of Impact Related to Construction Dust during Construction

Impact	Adverse impact to air quality from construction related activities at the cement plant and associated quarry sites.				
Impact Nature	**Negative**	Positive	Neutral		
	Elevated ambient concentrations of dust, PM_{10} and $PM_{2.5}$ from construction related activities will have a **negative** impact on air quality.				
Impact Type	**Direct**	Indirect	Induced		
	Elevated ambient concentrations of dust, PM_{10} and $PM_{2.5}$ from construction related activities will have a **direct** impact on air quality.				
Impact Duration	Temporary	**Short-term**	Long-term	Permanent	
	Potential impacts to air quality will occur throughout the construction phase only and can therefore be described as **short term** in nature.				
Impact Extent	**Local**	Regional	International		
	Construction activities at the site have the potential to result in significant emissions of dust up to 500 m from the construction site boundary and can therefore be described as **local.**				
Impact Scale	The scale of the impact is likely to be up to 500 m from the construction site boundary.				
Frequency	Impacts will arise continuously from construction related activities.				
	Positive	Negligible	Small	**Medium**	Large
	The impact magnitude before mitigation is expected to be **Medium.**				
Receptor Sensitivity	Low	**Medium**	High		
	When considering impacts to human health due to inhalation of airborne pollutants, all sensitive human receptors are defined as 'medium' sensitivity. This represents general populations and areas of habitation.				
	Negligible	Minor	**Moderate**	Major	Critical
	The impact magnitude before mitigation is expected to be **Moderate.**				

Mitigation

Dust suppression procedures so minimise impacts to air quality shall include:

- Water suppression should be used on exposed open earthworks when rainfall is less than 0.25 mm in a 24 hour period and wind speeds are forecast to be more than 19 kph;
- Where unpaved roads are utilised by vehicles, water suppression at a rate of 2 litres/m^2/hr should be used where rainfall of less than 2 mm in the last hour has occurred;
- Wheel washing bays shall be installed at the cement plant guardhouse before to avoid construction vehicles tracking dirt onto public sealed roads and generating dust;
- Vehicles transporting dusty materials should be covered;
- Stockpiling of material, for example, rocks, sand and soils should be minimised;
- Design of stockpiles should be optimised to retain a low profile with no sharp changes in shape; and
- Drop heights of material should be minimised.

Residual Impact Significance

When correctly applying and actively managing the mitigating controls outlined above, it is reasonable to conclude that receptors located within 500m downwind of any construction activity are likely to experience minor air quality impacts.

8.2 NOISE

8.2.1 Cement Plant

Potential Impacts

The construction noise impact assessment was conducted with reference to relevant international guidelines and local legislation, regulations, standards where available. Noise level guidelines given in *Myanmar Environmental Quality Guideline* (EQG) and WBG *General EHS Guidelines: Environmental – Noise Management* (2007) are summarized in *Table 8.2* below.

Table 8.2 Noise Level Guidelines

	One Hour L_{Aeq} (dBA)	
Receptor	**Daytime (07:00 – 22:00)**	**Night-time (22:00 – 07:00)**
Residential; institutional; educational	55	45
Industrial; commercial	70	70

The noise guideline values for residential, institutional and educational receptors are adopted for the assessment of impacts at residential areas. The applicable standards are 55 dB(A) $L_{Aeq,1\ hour}$ for daytime and 45 dB(A) $L_{Aeq,\ 1\ hour}$ for night-time, or a maximum increase in background levels of not more than 3 dB(A) at the nearest receptor location off-site. Since baseline monitoring was conducted, noise criterion of a maximum increase in background levels of not more than 3 dB(A) was adopted as the assessment criterion. Details of measured noise levels and proposed noise criteria are given in *Section 6.2*.

The methodology adopted for the construction and operational noise impact assessment is based on standard acoustics principles. The procedures of the assessment are summarised as follows:

- Locate representative Noise Sensitive Receivers (NSRs) that may be affected by the works;
- Assign Sound Power Level (SWL) to each plant item proposed and calculate the overall SWL associated with the proposed plant inventory;
- Determine the distance between the approximate geometric centre of the works area and NSR;

- Apply the correction factors based on the distance and façade correction, in accordance with *BS5228: Part 1: 2009* (1) ; and

- Predict the noise levels at NSRs on the basis of the plant activity and an in built design controls.

The nearest representative NSRs that may potentially experience noise impacts from the construction works of the Project are identified with locations shown in *Figure 6.10* and summarised in *Table 8.3* below:

Table 8.3 Representative Noise Sensitive Receivers

NSR	Description	Type of Uses
N1	Proposed Permanent Housing	Planned permanent worker accommodation
N2	Temporary Housing	Worker camp during construction phase
N3	Temporary Housing	Will be removed when N1 is ready
N4	Existing Permanent Housing	Existing permanent residential

Note:
(a) As N1 will not be occupied during the construction phase, it is not included in the construction noise impact assessment.

The potentially significant noise impacts arising from activities during the construction phase of the Project have been identified as the use of equipment during site preparation, foundation, construction of buildings and equipment installation for the expansion of the cement plant.

Quantitative noise impact assessment was carried out based on an indicative plant inventory. The plant inventory will need to be confirmed by the Engineering, Procurement and Construction (EPC) contractor prior to commencement of the construction phase. Should there be significant differences between the assumed plant inventory and that used on site, additional assessment may be needed and the proposed noise mitigation measures should be updated and implemented accordingly.

The indicative construction plant inventory for the construction activities during daytime period of the Project is summarised in *Table 8.4*. It is assumed that the construction works will be carried out during daytime period only.

(1) Noise and Vibration Control on Construction and Open Sites, Part 1. Code of Practice for Basic Information and Procedures for Noise and Vibration control. British Standard, BS5228: Part 1: 2009

Table 8.4 Indicative Construction Plant Inventory (Daytime)

Plant Item	Reference (a)	Quantity during peak hour	On-time	Unit SWL, dB(A)	Sub-Total SWL, dB(A)	Overall SWL, dB(A) (b) (c)
(A) Site Establishment						
Excavator	BS C2 25	1	100%	97	97	106
Dozer	BS C2 1	1	100%	103	103	
Dump Truck	BS C2 32	1	100%	102	102	
(B) Piling						
Hydraulic Hammer Rig	BS C3 4	1	100%	105	105	105
(C) Superstructure & Substructure						
Batching Plant	BS D6 9	1	100%	104	104	105
Vibrating Compactor	BS C2 42	1	100%	96	96	
Concrete Mixer Truck with Pump	BS C4 24	1	100%	95	95	
Compressor	BS D7 5	1	100%	89	89	
Generator	BS C4 76	1	100%	89	89	
(D) Superstructure & Substructure						
Batching Plant	BS D6 9	1	100%	101	104	105
Vibrating Compactor	BS C2 42	1	100%	103	96	
Concrete Mixer Truck with Pump	BS C4 24	1	100%	114	95	

Notes:

(a) *Noise & Vibration Control on Construction and Open Sites, Part 1. Code of Practice for Basic Information and Procedures for Noise and Vibration control*. British Standard, BS5228: Part 1: 2009.

(b) The figures are rounded up to a whole number.

(c) The overall SWL represents the maximum potential noise impact during construction phase.

The results of the predicted construction noise levels at the representative NSRs are presented in *Table 8.5*.

Table 8.5 Predicted Construction Noise Levels at Representative NSRs

NSR	Construction Activity	Overall SWL from Construction Activities [(a)], dB(A)	Distance between the approximate Geometric Centre of the Works Area and NSR (D), m	Predicted Noise Level[(b) (c)], dB(A)
N2	A	106	229	54
	B	105	229	53
	C	105	229	53
	D	105	229	53
N3	A	106	1615	37
	B	105	1615	36
	C	105	1615	36
	D	105	1615	36
N4	A	106	1250	39
	B	105	1250	38
	C	105	1250	38
	D	105	1250	38

Notes:

(a) The SWL from *Table 8.3* has been adopted in the calculation.

(b) Predicted noise level = overall SWL + distance correction + façade reflection
= 106 – (20 x log D + 8) + 3

(c) The figures are rounded-up to a whole number.

With the indicative plant inventory presented in *Table 8.4*, the predicted construction noise levels at the representative NSRs are in the range of 36 - 54 dB(A). Cumulative noise impact is presented in *Table 8.6*.

Table 8.6 Cumulative Construction Noise Levels at Representative NSRs during Daytime Period

NSR	Plant Item	Predicted Noise Level (A), dB(A)	Daytime Averaged Background Noise Level (B), dB(A)	Cumulative Noise Level , dB(A) [(a)]	Increase in Background Noise, dB(A) [(b)]	Compliance (Yes/No)
N2	A	54	58	60	2	Yes
	B	53	58	59	0	Yes
	C	53	58	59	0	Yes
	D	53	58	59	0	Yes
N3	A	37	56	56	0	Yes
	B	36	56	56	0	Yes
	C	36	56	56	0	Yes
	D	36	56	56	0	Yes
N4[(c)]	A	39	49	49	0	Yes
	B	38	49	49	0	Yes
	C	38	49	49	0	Yes
	D	38	49	49	0	Yes

Notes:

(a) Cumulative Noise Level (C) = 10 x log ($10^{(A/10)}$+ $10^{(B/10)}$)

(b) With reference to assessment noise criterion of a maximum increase in background levels of not more than 3 dB(A).

(c) It is assumed that the background noise environment at N1 and N4 are similar. Measured background noise levels at N1 are considered applicable at N4.

The predicted noise levels at all NSRs during daytime period due to construction activities comply with the IFC General EHS Guidelines. The construction noise impact is considered to be of **negligible** significance at the nearest receptor. A construction noise impact assessment summary is given in *Table 8.7*.

Table 8.7 Assessment of Impact related to General Construction Noise (Cement Plant)

Impact	Noise impact from the construction works during construction phase.				
Impact Nature	**Negative**	Positive	Neutral		
	Noise impact from the construction activities is **negative**.				
Impact Type	**Direct**	Indirect	Induced		
	Noise impact from the construction activities is **direct**.				
Impact Duration	**Temporary**	Short-term	Long-term	Permanent	
	Noise impact from the construction equipment and activities is **local**.				
Impact Extent	**Local**	Regional	International		
	Noise impact from the construction equipment and activities is **local**.				
Impact Scale	Project area.				
Frequency	Throughout the construction period.				
Impact Magnitude	Positive	**Negligible**	Small	Medium	Large
	Considering the predicted noise levels comply with both the noise criteria. The magnitude of the noise impact is **negligible**.				
Receptor Sensitivity	Low	**Medium**	High		
	The identified NSR are residential, the sensitivity of the receptor is considered as **medium.**				
Impact Significance	**Negligible**	Minor	Moderate	Major	Critical
	As the impact magnitude is negligible and the receptor sensitivity is medium, the impact significance is considered as **negligible**.				

8.2.2 Coal Mine

Potential Impacts

The access road from the base camp to the coal mine is a seasonal road built by STM from unconsolidated material which is currently re-built every wet season. An additional access road and a new coal staging area at Nanmawke is currently under construction and will be completed during the wet season of 2018. The construction/maintenance of access roads and coal staging area will involve the use of earth-moving equipment and the construction period is relatively short, lasting for about one to several months only. As the construction activities are considered minor and temporary, construction noise impact is considered to be of **negligible** significance at the nearest receptor. A construction noise impact assessment summary is given in *Table 8.8*.

Table 8.8 Assessment of Impact related to General Construction Noise (Coal Mine)

Impact	Noise impact from the construction works during construction phase.				
Impact Nature	**Negative**	Positive	Neutral		
	Noise impact from the construction activities is **negative**.				
Impact Type	**Direct**	Indirect	Induced		
	Noise impact from the construction activities is **direct**.				
Impact Duration	**Temporary**	Short-term	Long-term	Permanent	
	Noise impact from the construction equipment and activities is **local**.				
Impact Extent	**Local**	Regional	International		
	Noise impact from the construction equipment and activities is **local**.				
Impact Scale	Project area.				
Frequency	Throughout the construction period.				
Impact Magnitude	Positive	**Negligible**	Small	Medium	Large
	Considering the small scale and short duration of the construction activities, the magnitude of the noise impact is **negligible**.				
Receptor Sensitivity	Low	**Medium**	High		
	The identified NSR are residential, the sensitivity of the receptor is considered as **medium.**				
Impact Significance	**Negligible**	Minor	Moderate	Major	Critical
	As the impact magnitude is negligible and the receptor sensitivity is medium, the impact significance is considered as **negligible**.				

8.3 BIODIVERSITY

8.3.1 *Limestone Quarry*

Loss of Habitat

The impacts from the loss of habitat within the limestone concession during the construction phase are predominately related to the construction of infrastructure necessary for the Project (1). In particular, the construction of the conveyer belt and crusher and will result in loss of existing habitats.

Based on spatial assessment of the location of these components within the Project AoI, the impacts will predominately be to Modified Habitat; however construction of the conveyer belt will impact a small area of Natural Habitat. Land class types impacted during construction will be restricted to approximately 0.5ha of limestone hill habitat. Impacts during the construction phase will lead to permanent loss of habitat utilised by species within the area to be occupied by the conveyor belt.

The impact assessment summary for loss of habitat during the construction phase is outlined in *Table 8.9*

(1) Assessment of impacts resulting from quarrying operations is assessed in Chapter 9.

Table 8.9 *Impact Assessment Summary – Permanent and Temporary Loss of Habitat*

Impact	**Permanent and Temporary Loss of Habitat at Limestone Concession**				
Impact Nature	Negative	Positive	Neutral		
	The impact on the terrestrial and aquatic biodiversity is negative				
Impact Type	Direct	Indirect	**Induced**		
	Direct loss of terrestrial habitat in the Project Footprint in areas to be developed. Potential induced effects on remnant/ isolated habitats.				
Impact Duration	Temporary	Short-term	Long-term	Permanent	
	Much of the land clearance needed to accommodate the second line has already occurred. The incremental loss/conversion of habitats will be permanent.				
Impact Extent	**Local**	Regional	International		
	The impact is expected to be local for habitats.				
Impact Scale	Impact will be restricted to mainly Modified Habitats during Construction however 0.5ha of limestone habitat will be impacted during construction of the conveyor belt.				
Frequency	Construction occurs only once.				
Impact Magnitude	Positive	Negligible	**Small**	Medium	Large
	Considering the magnitude of impacts to each habitat discussed above, the overall magnitude of this impact is **Small** during the construction phase.				
Receptor Sensitivity	Low	Medium	**High**		
	Given the large proportion of the area affected is covered by habitats with Low sensitivity, the overall sensitivity is considered **Low**.				
Impact Significance	Negligible	Minor	**Moderate**	Major	Critical
	The significance of this impact is **Moderate**.				

<u>Mitigation</u>

The following mitigation measures will be applied in relation to the permanent and temporary loss of habitat during construction:

- Education of staff and workers of all rules, regulations and information concerning the restriction clearing outside of the Project footprint is to occur;
- Application of the Clearance Protocol (*Annex E4*) is to be applied to all clearance activities;
- The planned clearance area for the construction works shall be clearly identified and marked to avoid accidental clearing;
- Construction Contractor will schedule and implement routine inspection program throughout construction period to monitor clearing extent;
- Use of the access road should be restricted to construction vehicles only. Checkpoints should be used to manage access and inspect vehicles for timber and wood products.

Residual Impacts

Mitigation measures during operation will reduce the severity of impacts of the loss of terrestrial and aquatic habitats so as to reduce the impact to *Minor*.

Degradation of Habitats

A range of Project construction activities have the potential to lead to degradation of native flora and fauna habitats including excavation, land clearing, movement of vehicles, drilling, refuelling, hazardous materials storage and maintenance. In general the impacts will cause: dust; runoff; and release of potential contaminants. Construction activities have been assessed for these impact types, including: construction use of the access roads, construction of the conveyor belt and construction of the cement kiln and facilities. These impacts have assessed as part of other relevant chapters of the ESIA.

Invasive species (flora and fauna) have the potential to be introduced or spread throughout the Project area through increased movement of people, vehicles, machinery, vegetation and soil. An increase in the prevalence of weeds or other pests has the potential to reduce the quality of habitat for some native flora and fauna, including conservation significant species. Invasive flora species can rapidly germinate in disturbed areas whereby affecting the ability of native vegetation communities to re-establish.

Invasive species were detected within the Area of Influence of the Limestone Concession. These species are outlined in ***Table 8.10***.

Table** 8.10* ***Invasive Species detected within the Limestone Concession Area

S/N	Scientific Name	Family
1	*Ageratum conyzoides*	Asteraceae
2	*Bidens pilosa*	Asteraceae
3	*Caesalpinia decapetala*	Caesalpinaceae
4	*Chromolaena odorata*	Asteraceae
5	*Hiptage benghalensis*	Malpighiaceae
6	*Leucaena leucocephala*	Mimosaceae
7	*Mimosa pudica*	Mimosaceae
8	*Oroxylum indicum*	Bigoniaceae
9	*Paederia foetida*	Rubiaceae
10	*Ziziphus jujuba*	Rhamnaceae

Vehicle movement and activities which introduce a risk of invasion will be focused along access road and construction areas. The increase in human activity and movement across the landscape is also a consideration as well as the potential movement of weed seed and aquatic invasive species as a result of runoff. It is therefore likely that the primary transmission will be along existing roads and construction of the limestone conveyor belt.

The impact assessment summary for degradation of habitats during the construction phase is outlined in ***Table 8.11***.

Table 8.11 Impact Assessment Summary – Degradation of Habitats

Impact	**Impact to habitats from degradation including dust, runoff, release of contaminants and invasive species**				
Impact Nature	Negative	Positive	Neutral		
	The impact on the terrestrial and aquatic biodiversity is negative.				
Impact Type	Direct	Indirect	Induced		
	Direct impact to terrestrial flora, mostly from dust impacts adjacent to roads.				
Impact Duration	Temporary	Short-term	Long-term	Permanent	
	Although construction is estimated to take 24 months, the impacts will be mainly temporary during construction.				
Impact Extent	Local	Regional	International		
	The impact is expected to be localised for habitats downstream or alongside linear infrastructure components and activities.				
Impact Scale	It is anticipated that the scale of impact will be limited to downstream areas and areas along linear infrastructure components. Impact will be restricted to Modified Habitats during Construction. Some impacts to Natural Habitat beside the conveyor belt construction may occur.				
Impact Magnitude	Positive	Negligible	Small	Medium	Large
	Considering the magnitude of impacts and that the majority of impact will be modified habitats, the overall magnitude of this impact is **Small**.				
Receptor Sensitivity	Low	Medium	High		
	Terrestrial habitats likely impacted will be predominately modified habitats, however some impacts to Natural Habitat will occur during construction of the conveyor belt.				
Impact Significance	Negligible	Minor	Moderate	Major	Critical
	The significance of this impact is **Moderate**.				

<u>Mitigation Measures</u>

The following additional mitigation measures will be applied during construction to reduce impacts from the degradation of habitats:

- Wheel wash bays will be installed at the guardhouse at the cement plant to remove dirt and plant material from vehicle wheels prior to entering and leaving the Project Area.

- Invasive species within Natural Habitats should be eradicated where possible. Appropriate use of herbicides may be used to control invasive species within the Project Area in accordance with the safe use and label directions of the herbicides.

- Monitoring of invasive species is to occur within the Project Area on an annual basis. New infestations identified are to be controlled.

<u>Residual Impacts</u>

Mitigation measures during operation will reduce the severity of impacts of the loss of terrestrial and aquatic habitats so as to reduce the impact to within the normal range of variation (Magnitude Negligible).

Impacts to Species during construction

<u>Site Endemic Limestone Snails (NA)</u>

The species of snails detected within the concession are locally endemic and are currently only observed within the Limestone range within the DMU. The concession plays host to these species. The construction of the conveyor belt will have a small impact on limestone habitat within the concession.

<u>Site Endemic Limestone Flora (NA)</u>

To be advised at the completion of surveys.

<u>Site Endemic Limestone Reptiles (NA)</u>

To be advised at the completion of surveys.

It should be noted that impacts to forested habitats at the limestone quarry and limestone dependent species during quarrying activities have been considered in the operational impact assessment.

Table 8.12 Impact Assessment Summary – Species Impacts

Impact	Impact to species within the DMU and Project Area				
Impact Nature	Negative	Positive	Neutral		
	The impact on the terrestrial and aquatic biodiversity is negative				
Impact Type	Direct	Indirect	Induced		
	Direct impact to terrestrial an aquatic fauna and flora.				
Impact Duration	Temporary	Short-term	Long-term	Permanent	
	Although construction is estimated to take 24 months, the impacts will be short term and restricted to the construction period.				
Impact Extent	Local	Regional	International		
	The impact is expected to be localised for species.				
Impact Scale	It is anticipated that the scale of impact will be limited to areas within the Project Area and potentially in forested areas to the North of the Project Area, including the Panlaung-Pyadalin Wildlife Sanctuary				
Frequency	Construction occurs only once.				
Impact Magnitude	Positive	Negligible	Small	Medium	Large
	Considering the magnitude of impacts and that the majority of impact will be modified habitats, the overall magnitude of this impact is **Negligible** to **Small**.				
Receptor Sensitivity	Low	Medium	High		
	Terrestrial and aquatic species likely impacted are considered to be a **High** sensitivity given the presence of Critical Habitat candidate species				
Impact Significance	Negligible	Minor	Moderate	Major	Critical
	The significance of this impact is **Moderate**.				

<u>Mitigation Measures</u>

The following additional mitigation measures will be applied during construction to reduce impacts from the degradation of habitats:

- A Biodiversity Action Plan will be required for Critical Habitat triggers. This plan is to be prepared to outline measures to be applied to manage these species within the Project Area and Area of Influence. The management plan will address key threats to the species, including hunting, poaching, illegal logging, pollution and habitat destruction. Speed is to be limited to 40 km/hr for construction vehicles on company operated roads to minimise potential for fauna strike;

- Commitment will be made to raise awareness of values of important species and habitat areas to construction work force and arrangements will be made for restriction of poaching and forest product collection by staff. Hunting wild animals will be strictly prohibited for all staff.

- Non-project related vehicles will not be permitted to enter company-operated roads during construction.

Residual Impacts

Mitigation measures during operation will reduce the severity of impacts of to species so as to reduce the impact to within the normal range of variation (Magnitude Negligible). Permanent loss of limestone habitat will occur during construction of the conveyor belt that will result in minor impacts to limestone dependent flora and fauna.

8.4 WASTE MANAGEMENT

8.4.1 Cement Plant

Potential Impacts

Wastes generated during the construction phase have the potential could cause adverse impacts to the environment if handled or disposed incorrectly. Handling, transport and disposal of non-hazardous and hazardous waste at the construction site should be carried out to industry standards internationally to prevent impacts from incidents such as wind-blown litter, loss of containment, spillage during transportation, fly tipping.

If the handling, storage and transportation of wastes is not executed properly impacts there is potential for releases to the surrounding environment as well as impacting the health and safety of workers and the surrounding community. Loss of containment can lead to the contamination of surface and ground water. Poor chain of custody of wastes can result in the reuse of containers in application to which they are unsuited (e.g. waste chemical containers being used to store drinking water).

The wastes anticipated from the construction phase include:

- Construction waste (off specification construction materials, packaging, spoiled items);

- General waste from the construction camps (capacity 500);

- Wastewater from the construction camps;
- Food / organic waste from the construction camps; and
- Hazardous waste from construction plant maintenance (waste oils etc.).

There are no known in place controls to manage construction waste at the cement plant at this stage as the Project is in the planning stage.

The impact magnitude is considered to be *small* and the receptor sensitivity is considered to be *high*. As such the impact significance associated with wastes generated during construction are considered to be *moderate*.

Table 8.13 Assessment of Impacts related to Waste Management during the Construction

Impact	Waste generated during the construction phase at the cement plant				
Impact Nature	**Negative**	Positive	Neutral		
	There generation of waste is a **negative** impact from the Project.				
Impact Type	**Direct**	Indirect	Induced		
	The impact is direct on the environment. It is also directly impacts the waste infrastructure available to the Project.				
Impact Duration	**Temporary**	Short-term	Long-term	**Permanent**	
	Depending on the choice of waste management solution the impact duration could vary. Landfill would incur permanent impact as capacity at landfill is a finite resource. Recycling / waste to energy solutions are temporary as the capacity, although capped, is in theory infinite.				
Impact Extent	**Local**	**Regional**	International		
	Depending on the availability of waste treatment facilities and / or recyclers the impact extent will be either local or regional.				
Impact Scale	Minor				
Frequency	Waste will be generated daily throughout the construction phase. Disposal of this waste will be at regular intervals as required by the construction phase at the cement plant.				
Impact Magnitude	Positive	Negligible	**Small**	Medium	Large
	The impact magnitude is expected to be **small.**				
Receptor Sensitivity	Low	Medium	**High**		
	The only known facility is the primitive landfill site at the cement plant location that appears only to be suitable for inert waste. Other waste disposal and treatment options are unknown therefore the receptor sensitivity is considered to be **high**.				
Impact Significance	Negligible	Minor	**Moderate**	Major	Critical
	The impact significance is considered to be **moderate** without further mitigation.				

Mitigation

A waste management plan (WMP) for the Project should be developed that sets out plans and actions for construction waste as follows:

- Good housekeeping practices for waste storage and handling referencing GIIP;
- The WMP should include a waste inventory developed in the planning stage, in discussion with the engineers, to establish the types of wastes expected from the construction and to identify appropriate disposal routes;

- Construction materials will be managed in a way to avoid over-ordering, poor storage and maintenance, mishandling as well as improper operation procedures;

- Construction wastes will be separated into reusable items and materials to be disposed of or recycled whenever possible;

- Waste suitable for reuse will be stored on site and reintroduced to the construction process as and when required;

- The WMP will identify disposal routes (including transport options and disposal sites) for all wastes generated during the construction phase;

- A hazardous waste management system covering waste classification, separation, collection, storage, transfer and disposal should be set up and operated. The waste management system will comply with applicable regulation of the government, if any, or in its absence, GIIP;

- Hazardous waste will be stored in such a way as to prevent and control accidental release to the environment (e.g. secondary containment, sealed containers);

- Wastewater should be stored in such a way as to avoid contaminating surface and groundwater sources. It should be collected regularly and taken offsite for treatment at a suitable facility;

- Waste will be collected regularly by reputable waste collectors;

- Recyclables such as scrap steel, metals, plastics, and paper items will be collected for recycling wherever possible;

- Disposal of construction waste in or off the construction site should be prohibited;

- Chain of custody documents should be used for construction waste to monitor disposal; and

- Waste segregation should be practiced at the workers camps with an emphasis placed on reducing, reusing and recycling of waste streams as appropriate.

Residual Impact Significance

By preparing a suitable WMP and ensuring its implementation throughout the construction phase the impact significance from waste generated during construction can be reduced from *moderate* to *minor*.

8.4.2 *Coal Mine*

Potential Impacts

There is a limited amount of activity during the construction phase at the coal mine. As the site has already been operating for a number of years much of the infrastructure for the workforce is in place at Paluzama including construction camps and the machinery laydown and storage area.

An additional access road is under construction and is due to be completed in 2018. The construction of the access road is unlikely to give rise to significant wastes other than general wastes associated with the construction workforce and packaging from construction materials. There may be small amounts of hazardous waste from plant maintenance during the road construction.

There is no detailed information on the handling of waste at the coal mine during construction.

The impact magnitude is considered to be *small.* The sensitivity of the receptor is considered to be *high* as there is limited information available about how wastes are handled and disposed and therefore the impact significance is considered to be *moderate*.

Table 8.14 Assessment of Impacts related to Waste Management during the Construction

Impact	Wastes generated during the construction phase at the coal mine.				
Impact Nature	**Negative**	Positive	Neutral		
	There generation of waste is a negative impact from the Project.				
Impact Type	**Direct**	Indirect	Induced		
	The impact is direct on the environment. It is also directly impacts the waste infrastructure available to the project.				
Impact Duration	**Temporary**	Short-term	Long-term	**Permanent**	
	Depending on the choice of waste management solution the impact duration could vary. Landfill would incur permanent impact as capacity at landfill is a finite resource. Recycling / waste to energy solutions are temporary as the capacity although capped, is in theory infinite.				
Impact Extent	**Local**	**Regional**	International		
	Depending on the availability of waste treatment facilities and / or recyclers the impact extent will be either local or regional.				
Impact Scale	Minor				
Frequency	Waste will be generated daily throughout the construction phase. Disposal of this waste will be at regular intervals as required by the construction phase at the coal mine.				
Impact Magnitude	Positive	Negligible	**Small**	Medium	Large
	The impact magnitude is expected to be **small.**				
Receptor Sensitivity	Low	Medium	**High**		
	The waste disposal and treatment options are unknown therefore the receptor sensitivity is considered to be **high**.				
Impact Significance	Negligible	Minor	**Moderate**	Major	Critical
	The impact significance is considered to be **moderate** without further mitigation.				

Mitigation

If suitable waste disposal sites are not available in the locale of the coal mine then this waste should be transported back to Mandalay where more suitable recycling, treatment and disposal facilities can be found.

This approach should be documented in the WMP.

Residual Impact Significance

By preparing a suitable WMP and ensuring its implementation throughout the construction phase the impact significance from waste generated during construction can be reduced from *moderate* to *minor.*

9 OPERATIONAL PHASE IMPACT ASSESSMENT

9.1 AIR QUALITY

9.1.1 Cement Plant

Potential Impacts

Potential impacts to air quality in the vicinity of the cement plant may arise from the activities outline in *Table 9.1.* The emission concentrations and the subsequent emission rates used to model the impacts to air quality are presented in *Table 9.2* and *Table 9.3* respectively.

The process of deriving emissions from the proposed activities and subsequently informing the dispersion model is set out in *Annex C2* and *Annex C3* and the main inputs, outputs and conclusions are summarised in the following section.

Table 9.1 Project Activities

Project Component	Activity	Pollutants of Interest
Cement Plant	• the kiln systems and clinker coolers; • material transfers and handling including loading and loading crushers and stockpiles; • the crushing, milling and grinding of auxiliary materials and cement; and • the onsite storage of auxiliary material and clinker.	NO_x, NO_2, SO_2, Dust, PM_{10} and $PM_{2.5}$
Limestone Quarry	• clearing and excavating of surface materials; • bulldozing surface materials; • drilling; • blasting; • loading and unloading haul trucks with limestone and waste rock; • vehicle movements over unpaved surfaces; • wind erosion from limestone and waste rock stockpiles.	Dust, PM_{10} and $PM_{2.5}$
Mudstone Quarry	• clearing and excavating of surface materials; • bulldozing surface materials; • drilling; • blasting; • loading and unloading haul trucks with mudstone and waste rock; • vehicle movements over unpaved surfaces; • wind erosion from mudstone and waste rock stockpiles.	Dust, PM_{10} and $PM_{2.5}$

Table 9.2 Point Source Emission Concentrations used in Assessment and Comparison to Emission Limits for Cement Manufacturing

Project Component	Source Type	Source Description	Pollutant Type	Emission Concentrations used in Assessment (mg/Nm^3)	Emission Limit for Cement Manufacturing(1)(2) (mg/Nm^3)
Cement Plant	Point	Preheater stack (1,500tpd)	NO_x	600	600
			SO_2	13	400
			PM	100	100
	Point	Grate cooler stack (1,500tpd)	NO_x	*n/a*	*n/a*
			SO_2	*n/a*	*n/a*
			PM	50	50
	Point	Preheater stack (4,000tpd)	NO_x	600	600
			SO_2	400	400
			PM	30	30
	Point	Grate cooler stack (4,000tpd)	NO_x	*n/a*	*n/a*
			SO_2	*n/a*	*n/a*
			PM	50	50

(1) *WBG EHS Guidelines for Cement Manufacturing, 2007*

(2) *Myanmar national Environmental Quality (Emission) Guidelines, 2015*

(3) Equipment suppliers for the new kiln will comply with limits specified in WBG EHS Guidelines for Cement Manufacturing, 2007. These have been used to represent a worst case scenario.

Table 9.3 Cement Plant Emission Inventory

Project Component	Source Type	Source Description	Pollutant Type	Emission Rate (g/s)
Cement Plant	Volume	Fugitive emission from 5,500tpd process	PM	3.28
	Point	Preheater stack (1,500tpd)	NO_x	40.7
			SO_2	0.881
			PM	6.78
	Point	Grate cooler stack (1,500tpd)	PM	1.56
	Point	Preheater stack (4,000tpd)	NO_x	70.0
			SO_2	46.6
			PM	3.50
	Point	Grate cooler stack (4,000tpd)	PM	3.62
Limestone Quarry	Volume	Fugitive emission from 5,500tpd process	PM	2.06
Mudstone Quarry	Volume	Fugitive emission from 5,500tpd process	PM	1.05

The process contribution from the project and the predicted environmental concentration (project contribution + baseline) for NO_2, SO_2, PM_{10} and $PM_{2.5}$ have been determined based on the methodology outlined in *Annex C2*. The impacts associated with the operation of the Project are set out in the context of the existing airshed (*Section* ***Error! Reference source not found.***) and the significance defined based on the approach presented in *Annex C1.*

The significance of the impacts relating to each pollutant of interest at the sensitive receptor locations in the vicinity of the cement plant are summarised in *Table 9.5* to *Table 9.12.* The sensitive receptor locations are presented in *Table 6.1* and are summarized in *Table 9.4* below. Where minor, moderate or major impacts are predicted, contour figures showing dispersion across the entire study area are presented (see *Figure 9.1* to *Figure 9.6).*

The results of the assessment comprise the 95th percentile highest ground level concentration predicted over a period of five years from 2012 to 2016 on the receptor grid.

Table 9.4 Representative Air Sensitive Receptors

Receptor ID	**Receptor Name**	**Type of Receptor**
AQ1	Worker Accommodation	Human
AQ2	Kubyin Village	Human
AQ3	Pyi Nyaung Village	Human
AQ4	Worker Accommodation	Human
AQ5	Worker Accommodation	Human
AQ6	Worker Accommodation	Human

Table 9.5 *NO_2 1-Hour Average at Representative ASRs (95th Percentile)*

ASR	Baseline Concentration (µg/m³)	Baseline Classification	Air Quality Standard (AQS) (1)(2) (µg/m³)	Process Contribution(3) (PC) (µg/m³)	PC/ AQS (%)	Predicted Environmental Concentration (PEC) (µg/m³)	PEC/AQS (%)	Impact Significance
ASR1	21.0	Non-degraded	200	0.741	<1%	21.8	11%	Negligible
ASR2	7.36	Non-degraded	200	13.4	6.7%	20.8	10%	Negligible
ASR3	21.4	Non-degraded	200	0.322	<1%	21.8	11%	Negligible
ASR4	21.0	Non-degraded	200	4.04	2.0%	25.1	13%	Negligible
ASR5	21.0	Non-degraded	200	3.67	1.8%	24.7	12%	Negligible
ASR6	21.0	Non-degraded	200	3.78	1.9%	24.8	12%	Negligible
ASR7	21.0	Non-degraded	200	1.07	<1%	22.1	11%	Negligible

(1) *WBG General EHS Guideline*, 2007
(2) *Myanmar National Environmental Quality (Emission) Guidelines*, 2015
(3) NO_x results multiplied by a factor of 0.8 to derive short term NO_2 concentration to compare to the air quality standard.

Table 9.6 *NO_2 Annual Average at Representative ASRs*

ASR	Baseline Concentration (µg/m³)	Baseline Classification	Air Quality Standard (AQS) (1)(2) (µg/m³)	Process Contribution(3) (PC) (µg/m³)	PC/ AQS (%)	Predicted Environmental Concentration (PEC) (µg/m³)	PEC/AQS (%)	Impact Significance
ASR1	10.5	Non-degraded	40	0.269	<1%	10.8	27%	Negligible
ASR2	3.68	Non-degraded	40	1.927	4.8%	5.61	14%	Negligible
ASR3	10.7	Non-degraded	40	0.106	<1%	10.8	27%	Negligible
ASR4	10.5	Non-degraded	40	0.859	2.1%	11.4	28%	Negligible
ASR5	10.5	Non-degraded	40	0.887	2.2%	11.4	28%	Negligible
ASR6	10.5	Non-degraded	40	0.920	2.3%	11.4	29%	Negligible
ASR7	10.5	Non-degraded	40	0.363	<1%	10.9	27%	Negligible

(1) *WBG General EHS Guidelines*, 2007
(2) *Myanmar national Environmental Quality (Emission) Guidelines*, 2015
(3) NO_x results multiplied by a factor of 0.75 to derive long term NO_2 concentration to compare to the air quality standard.

Table 9.7 SO_2 10-Minute Average at Representative ASRs (95th Percentile)

ASR	Baseline Concentration(1) (µg/m³)	Baseline Classification	Air Quality Standard (AQS) (2)(3) (µg/m³)	Process Contribution(4) (PC) (µg/m³)	PC/ AQS (%)	Predicted Environmental Concentration (PEC) (µg/m³)	PEC/AQS (%)	Impact Significance
ASR1	<DL	Non-degraded	500	0.549	<1%	0.549	<1%	Negligible
ASR2	<DL	Non-degraded	500	10.0	2.0%	10.0	2.0%	Negligible
ASR3	<DL	Non-degraded	500	0.240	<1%	0.240	<1%	Negligible
ASR4	<DL	Non-degraded	500	2.71	<1%	2.71	<1%	Negligible
ASR5	<DL	Non-degraded	500	2.69	<1%	2.69	<1%	Negligible
ASR6	<DL	Non-degraded	500	2.75	<1%	2.75	<1%	Negligible
ASR7	<DL	Non-degraded	500	0.794	<1%	0.794	<1%	Negligible

(1) <DL (less than detection limit) means less <0.03µgS on sampling tube

(2) *WBG General EHS Guidelines, 2007*

(3) *Myanmar national Environmental Quality (Emission) Guidelines, 2015*

(4) The 10-minutre SO_2 concentrations were derived by applying the power law to the modelled 1-hour concentrations (Ct2 = Ct1 x (t1/t2)^0.2) (http://www.dot.ca.gov/newtech/researchreports/1969-1970/70-07.pdf)

Table 9.8 SO_2 24-Hour Average at Representative ASRs (95th Percentile)

ASR	Baseline Concentration(1) (µg/m³)	Baseline Classification	Air Quality Standard (AQS) (2)(3) (µg/m³)	Process Contribution (PC) (µg/m³)	PC/ AQS (%)	Predicted Environmental Concentration (PEC) (µg/m³)	PEC/AQS (%)	Impact Significance
ASR1	<DL	Non-degraded	20	0.591	3.0%	0.591	3.0%	Negligible
ASR2	<DL	Non-degraded	20	4.86	24%	4.86	24%	Negligible
ASR3	<DL	Non-degraded	20	0.258	1.3%	0.258	1.3%	Negligible
ASR4	<DL	Non-degraded	20	1.40	7.0%	1.40	7.0%	Negligible
ASR5	<DL	Non-degraded	20	1.28	6.4%	1.28	6.4%	Negligible
ASR6	<DL	Non-degraded	20	1.33	6.7%	1.33	6.7%	Negligible
ASR7	<DL	Non-degraded	20	0.688	3.4%	0.688	3.4%	Negligible

(1) <DL (less than detection limit) means less <0.03µgS on sampling tube

(2) *WBG General EHS Guidelines, 2007*

(3) *Myanmar national Environmental Quality (Emission) Guidelines, 2015.*

Table 9.9 $PM_{2.5}$ 24-Hour Average at Representative ASRs (95th Percentile)

ASR	Baseline Concentration (µg/m³)	Baseline Classification	Air Quality Standard (AQS) (1)(2) (µg/m³)	Process Contribution(3)(4) (PC) (µg/m³)	PC/ AQS (%)	Predicted Environmental Concentration (PEC) (µg/m³)	PEC/AQS (%)	Impact Significance
ASR1	n/a	Non-degraded	25	0.144	<1%	0.144	<1%	Negligible
ASR2	n/a	Non-degraded	25	0.432	1.7%	0.432	1.7%	Negligible
ASR3	n/a	Non-degraded	25	0.0396	<1%	0.0396	<1%	Negligible
ASR4	n/a	Non-degraded	25	2.04	8.2%	2.04	8.2%	Negligible
ASR5	n/a	Non-degraded	25	1.67	6.7%	1.67	6.7%	Negligible
ASR6	n/a	Non-degraded	25	1.23	4.9%	1.23	4.9%	Negligible
ASR7	n/a	Non-degraded	25	0.210	<1%	0.210	<1%	Negligible

(1) *WBG General EHS Guidelines*, 2007

(2) *Myanmar national Environmental Quality (Emission) Guidelines*, 2015.

(3) PM results from fugitive sources were multiplied by a factor of 0.053 to derive the $PM_{2.5}$ fraction for comparison to the air quality standard *(USEPA AP-42 Emission Factor Database Chapter 13.2.4 Aggregate Handling and Storage Piles)*

(4) PM results from point sources were multiplied by a factor of 0.18 to derive the $PM_{2.5}$ fraction for comparison to the air quality standard *(USEPA AP-42 Emission Factor Database Chapter 11.6 Portland Cement Manufacturing)*

Table 9.10 $PM_{2.5}$ Annual Average at Representative ASRs

ASR	Baseline Concentration (μg/m³)	Baseline Classification	Air Quality Standard (AQS) (1)(2) (μg/m³)	Process Contribution(3) (PC) (μg/m³)	PC/ AQS (%)	Predicted Environmental Concentration (PEC) (μg/m³)	PEC/AQS (%)	Impact Significance
ASR1	n/a	Non-degraded	10	0.0533	<1%	0.0533	<1%	Negligible
ASR2	n/a	Non-degraded	10	0.130	1.3%	0.130	1.3%	Negligible
ASR3	n/a	Non-degraded	10	0.0143	<1%	0.0143	<1%	Negligible
ASR4	n/a	Non-degraded	10	0.860	8.6%	0.860	8.6%	Negligible
ASR5	n/a	Non-degraded	10	0.597	6.0%	0.597	6.0%	Negligible
ASR6	n/a	Non-degraded	10	0.442	4.4%	0.442	4.4%	Negligible
ASR7	n/a	Non-degraded	10	0.0830	<1%	0.0830	<1%	Negligible

(1) *WBG General EHS Guidelines*, 2007

(2) *Myanmar National Environmental Quality (Emission) Guidelines*, 2015.

(3) PM results from fugitive sources were multiplied by a factor of 0.053 to derive the $PM_{2.5}$ fraction for comparison to the air quality standard *(USEPA AP-42 Emission Factor Database Chapter 13.2.4 Aggregate Handling and Storage Piles)*

(4) PM results from point sources were multiplied by a factor of 0.18 to derive the $PM_{2.5}$ fraction for comparison to the air quality standard *(USEPA AP-42 Emission Factor Database Chapter 11.6 Portland Cement Manufacturing)*

Table 9.11 PM_{10} 24-Hour Average at Representative ASRs (95th Percentile)

ASR	Baseline Concentration (µg/m³)	Baseline Classification	Air Quality Standard (AQS) (1)(2) (µg/m³)	Process Contribution(3) (PC) (µg/m³)	PC/ AQS (%)	Predicted Environmental Concentration (PEC) (µg/m³)	PEC/AQS (%)	Impact Significance
ASR1	n/a	Non-degraded	50	0.788	1.6%	0.788	1.6%	Negligible
ASR2	n/a	Non-degraded	50	1.39	2.8%	1.39	2.8%	Negligible
ASR3	n/a	Non-degraded	50	0.196	0.4%	0.196	0.4%	Negligible
ASR4	n/a	Non-degraded	50	12.6	25%	12.6	25%	Minor
ASR5	n/a	Non-degraded	50	10.6	21%	10.6	21%	Negligible
ASR6	n/a	Non-degraded	50	7.73	15%	7.73	15%	Negligible
ASR7	n/a	Non-degraded	50	1.20	2.4%	1.20	2.4%	Negligible

(1) *WBG General EHS Guidelines*, 2007

(2) *Myanmar National Environmental Quality (Emission) Guidelines*, 2015.

(3) PM results from fugitive sources were multiplied by a factor of 0.35 to derive the PM_{10} fraction for comparison to the air quality standard *(USEPA AP-42 Emission Factor Database Chapter 13.2.4 Aggregate Handling and Storage Piles)*

(4) PM results from point sources were multiplied by a factor of 0.42 to derive the PM_{10} fraction for comparison to the air quality standard *(USEPA AP-42 Emission Factor Database Chapter 11.6 Portland Cement Manufacturing)*

Table 9.12 PM_{10} Annual Average at Representative ASRs

ASR	Baseline Concentration (µg/m³)	Baseline Classification	Air Quality Standard (AQS) (1)(2) (µg/m³)	Process Contribution(3) (PC) (µg/m³)	PC/ AQS (%)	Predicted Environmental Concentration (PEC) (µg/m³)	PEC/AQS (%)	Impact Significance
ASR1	n/a	Non-degraded	20	0.310	1.6%	0.310	1.6%	Negligible
ASR2	n/a	Non-degraded	20	0.551	2.8%	0.551	2.8%	Negligible
ASR3	n/a	Non-degraded	20	0.0786	<1%	0.0786	<1%	Negligible
ASR4	n/a	Non-degraded	20	5.38	27%	5.38	27%	Minor
ASR5	n/a	Non-degraded	20	3.76	19%	3.76	19%	Negligible
ASR6	n/a	Non-degraded	20	2.74	14%	2.74	14%	Negligible
ASR7	n/a	Non-degraded	20	0.491	2.5%	0.491	2.5%	Negligible

(1) *WBG General EHS Guidelines*, 2007

(2) *Myanmar National Environmental Quality (Emission) Guidelines*, 2015.

(3) PM results from fugitive sources were multiplied by a factor of 0.053 to derive the $PM_{2.5}$ fraction for comparison to the air quality standard *(USEPA AP-42 Emission Factor Database Chapter 13.2.4 Aggregate Handling and Storage Piles)*

(4) PM results from point sources were multiplied by a factor of 0.18 to derive the $PM_{2.5}$ fraction for comparison to the air quality standard *(USEPA AP-42 Emission Factor Database Chapter 11.6 Portland Cement Manufacturing)*

Figure 9.1 NO_2 1-Hour Average (95th percentile) Contour Plot

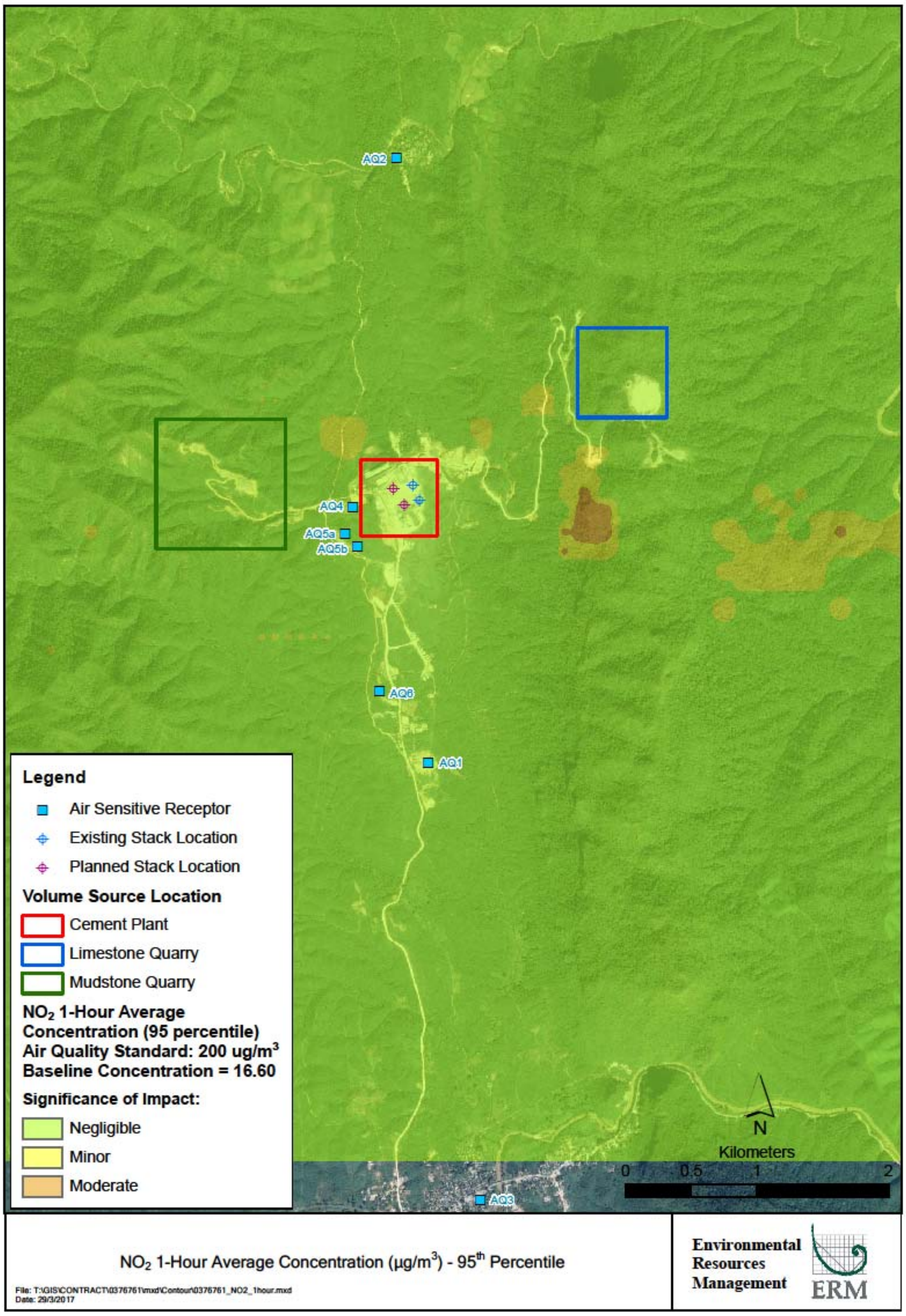


Figure 9.2 NO_2 Annual Average Contour Plot

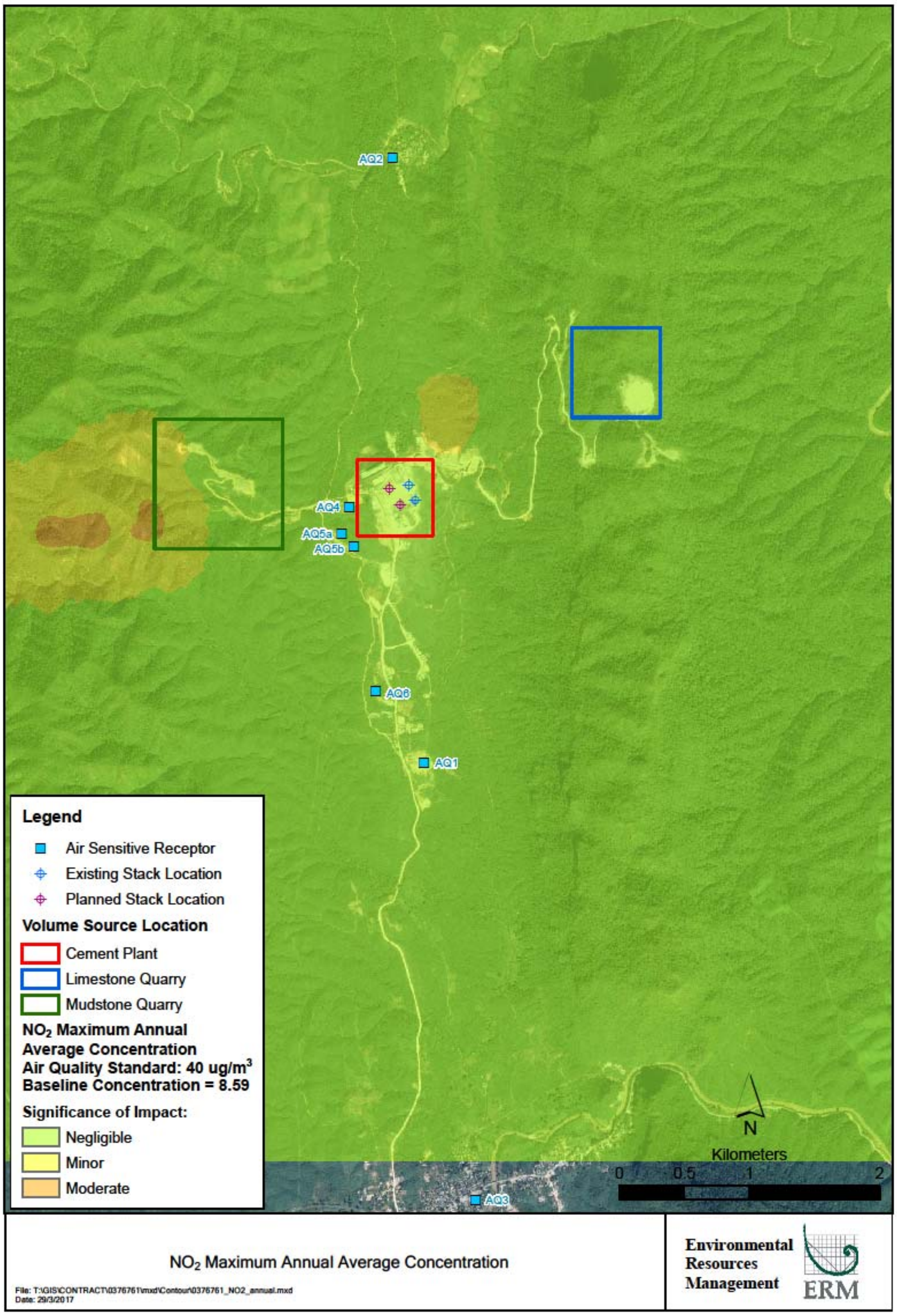


Figure 9.3 SO_2 10-Minute Average (95th percentile) Contour Plot

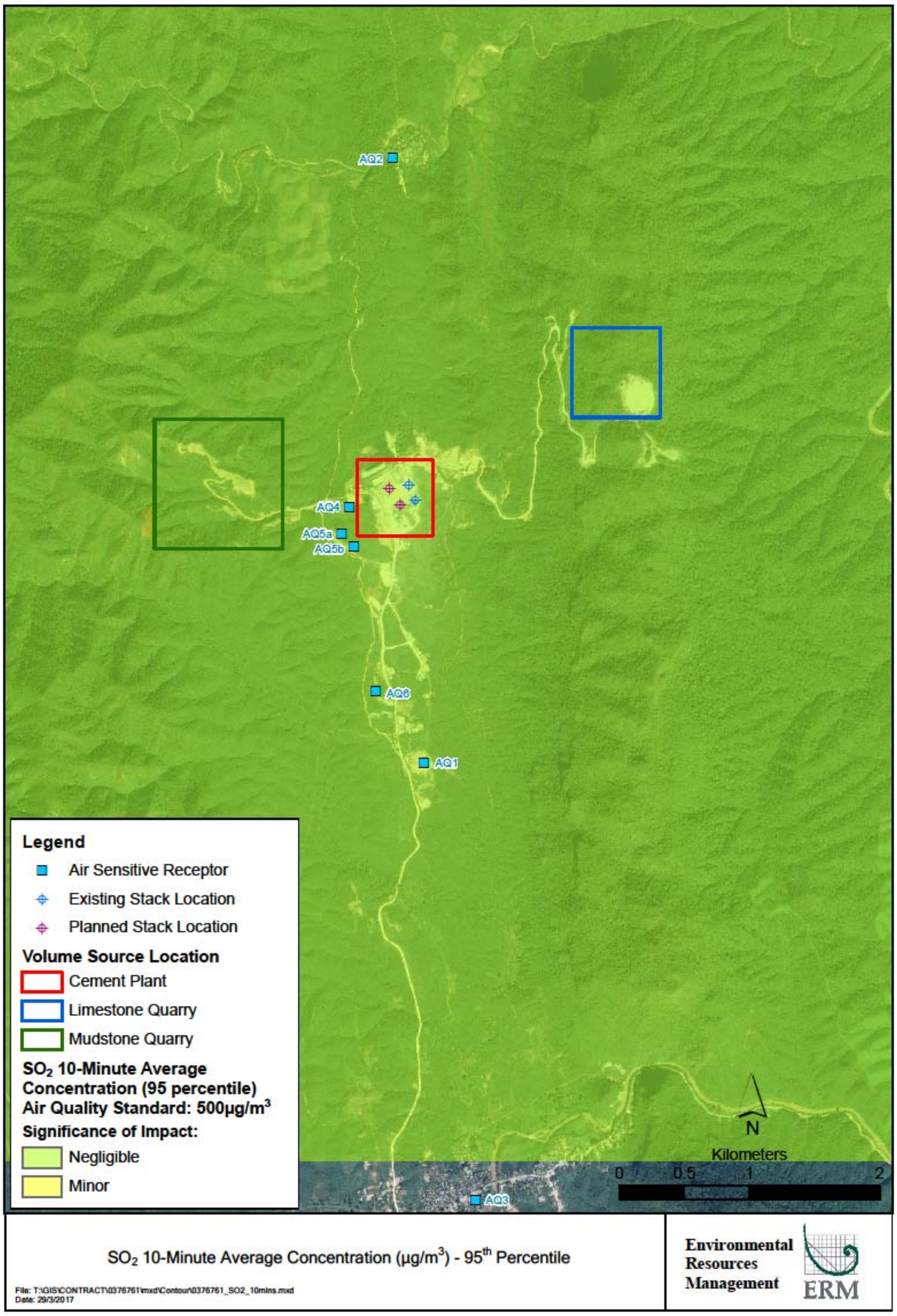


Figure 9.4 SO_2 24-Hour Average (95th percentile) Contour Plot

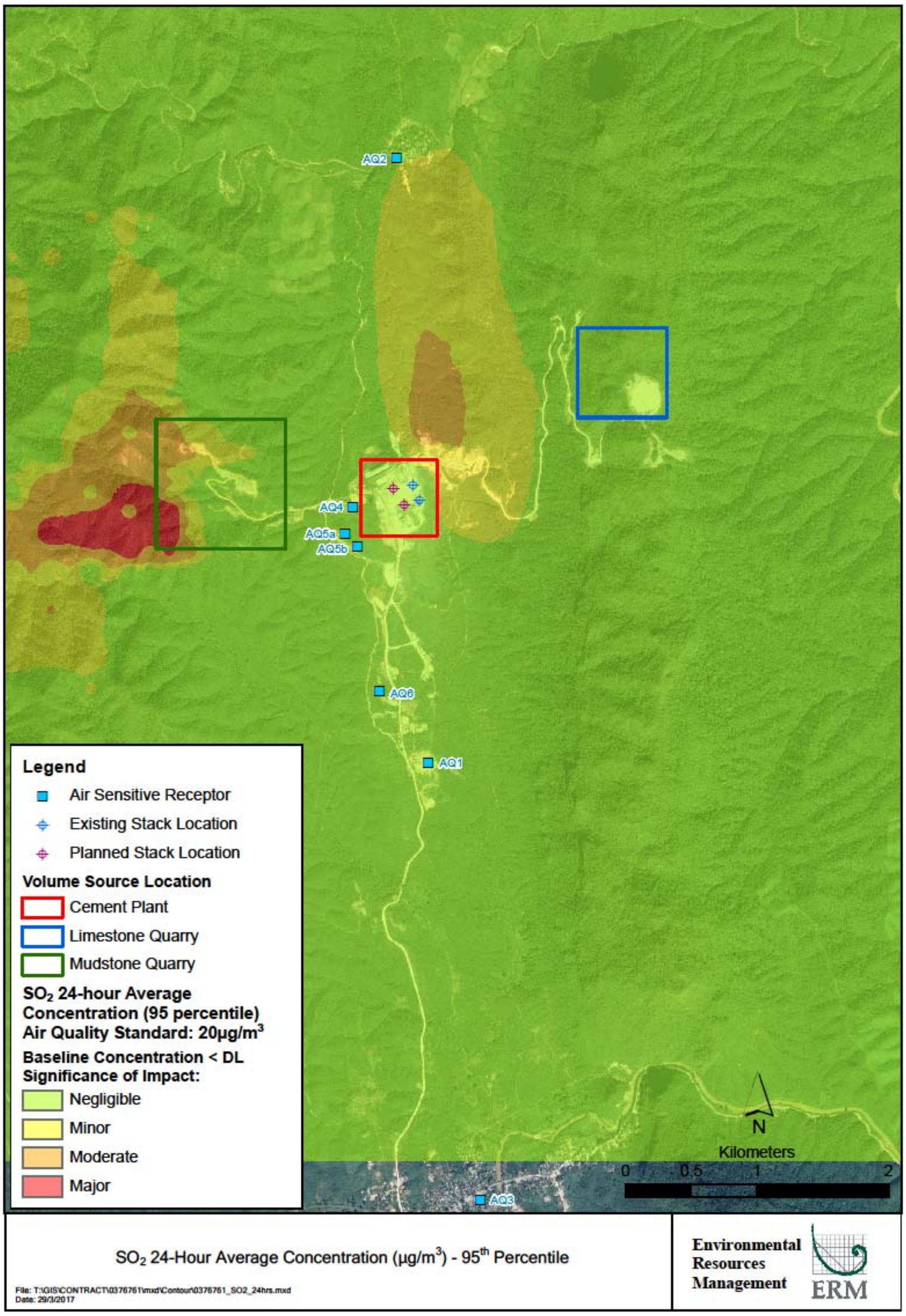


Figure 9.5 PM_{10} 24-Hour Average (95th Percentile) Contour Plot

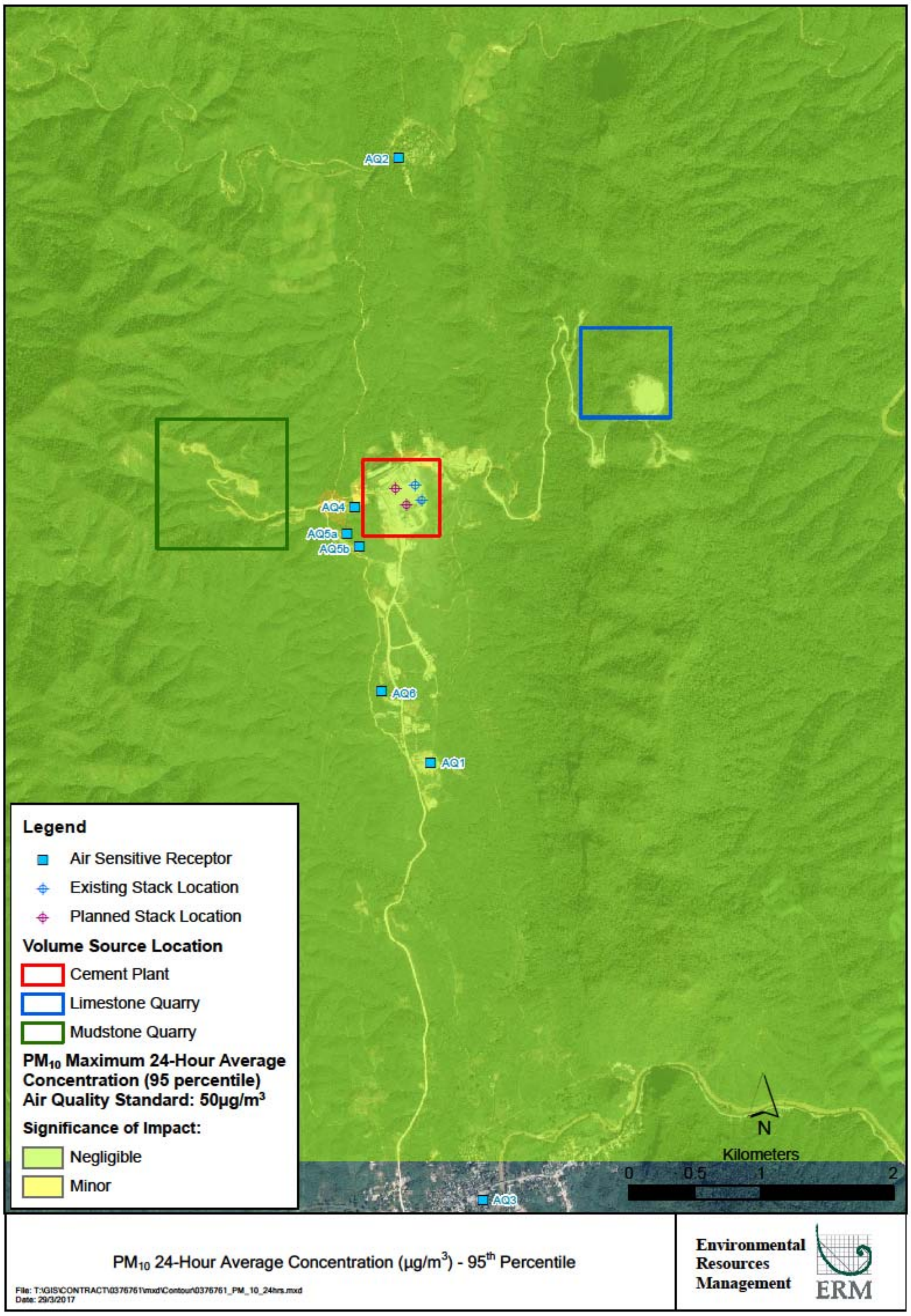
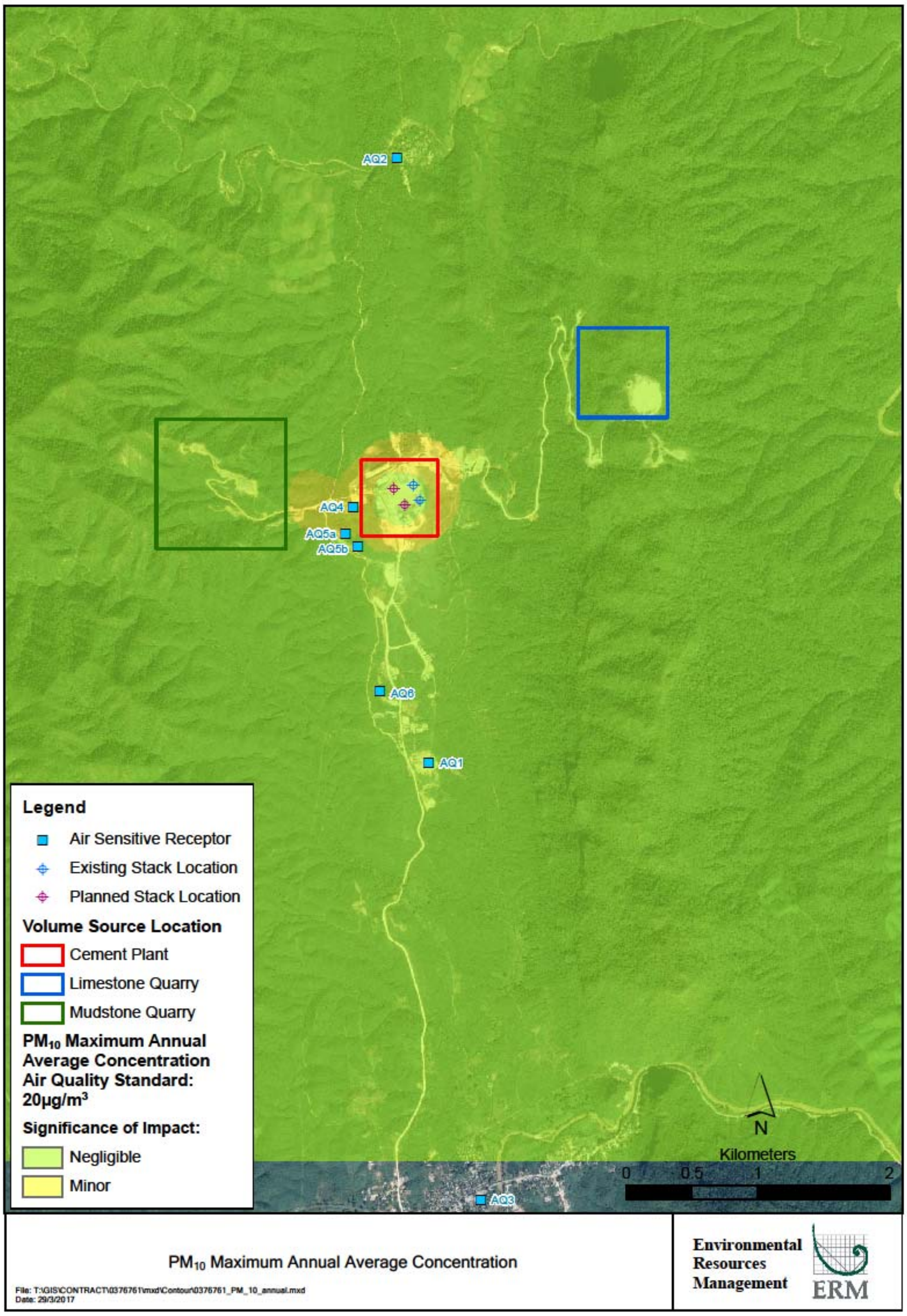


Figure 9.6 PM$_{10}$ Annual Average Contour Plot



Significance of the Impact

Based on the emissions inventory presented in *Table 9.3* and the modeling approach outlined in *Annex C2*, the results from the modelling exercise indicate that the emissions of NO_2, SO_2, $PM_{2.5}$ and PM_{10} during the normal operation of the Project will have a negligible impact on air quality at the air sensitive receptors identified in the study area. However, when considering the SO_2 24-hour process contribution from the Project, exceedances of the air quality standard are predicted at some offsite locations within the study area as presented in *Figure 9.4.* With regard to these exceedances, the following three (3) observations are made:

- the locations where exceedances are predicted are where the terrain is complex (i.e. terrain above the height of the stack) and where the steady-state Gaussian-plume model AERMOD has some inherent limitations in its ability to account for turning or rising wind caused by the terrain itself;

- the locations where the exceedances are seen are in areas where no sensitive receptors exist; and

- the assessment methodology uses a conservative approach to modeling impacts to air quality in the study area. For example, the SO_2 emission rate from the proposed preheater stack was modelled at the emission limit concentration from a kiln stack. It is likely, however, that the plant in practice would operate below the SO_2 emission limit, thus the ground level concentrations of SO_2 at offsite locations would be reduced.

A summary of the impacts at the sensitive receptor locations is presented in *Table 9.13*

Table 9.13 Assessment of Impact at Sensitive Receptors Related to NO_2, SO_2, PM_{10} and $PM_{2.5}$ during Operation

Impact	Adverse impact to air quality from operational related activities at the cement plant and associated quarry sites.
Impact Nature	**Negative** / Positive / Neutral
	Elevated ambient concentrations of NO_2, SO_2, PM_{10} and $PM_{2.5}$ from operational related activities will have a **negative** impact on air quality.
Impact Type	**Direct** / Indirect / Induced
	Elevated ambient concentrations of NO_2, SO_2, PM_{10} and $PM_{2.5}$ from operational related activities will have a **direct** impact on air quality.
Impact Duration	Temporary / Short-term / **Long-term** / Permanent
	Potential impacts to air quality will occur throughout the operation phase and can therefore be described as **long term** in nature.
Impact Extent	**Local** / Regional / International
	Operational activities at the site have the potential to result in significant emissions of NO_2, SO_2, PM_{10} and $PM_{2.5}$ up to 5km from the project site boundary and can therefore be described as **local.**
Impact Scale	The scale of the impact is likely to be up to 5km from the Project site boundary.
Frequency	Impacts will arise continuously from operational related activities.
Impact Magnitude	Positive / Negligible / **Small** / Medium / Large
	Emissions of NO_2 will have a **negligible** impact on air quality at ASRs Emissions of SO_2 will have a **negligible** impact on air quality at ASRs Emissions of $PM_{2.5}$ will have a **negligible** impact on air quality at ASRs Emissions of PM_{10} will have a **small** impact on air quality at ASRs
Receptor Sensitivity	Low / **Medium** / High
	When considering impacts to human health due to inhalation of airborne pollutants, all sensitive human receptors are defined as **'medium'** sensitivity. This represents general populations and areas of habitation.
	Negligible / **Minor** / Moderate / Major / Critical
	Emissions of NO_2 will have a **negligible** impact on air quality at ASRs Emissions of SO_2 will have a **negligible** impact on air quality at ASRs Emissions of $PM_{2.5}$ will have a **negligible** impact on air quality at ASRs Emissions of PM_{10} will have a **minor** impact on air quality at ASRs

Mitigation

The following mitigation measures will be used to minimize impacts to air quality during the operation of the cement plant:

- The discharge to the kiln stack at both the new and existing plant will be fitted with continuous emission monitoring capable of real-time measurement of NO_2, SO_2, Particulate Matter and O_2 and transmitted to the operator control room.
- The new kiln stack shall be fitted with sampling platform and two sampling ports at 90 degrees. Sampling ports should be four-inch (minimum) inner diameter threaded pipe connections with a cap.
- Emission concentrations of NO_x, SO_2 and PM from the existing and proposed kiln system and clinker cooler will not exceed those outlined in the *Myanmar national Environmental Quality (Emission) Guidelines* (2015) for

cement and lime manufacturing and should be further reduced as far as practicable.

- NO_x emissions from the kiln system should be controlled by maintaining secondary air flow as low as possible and using low NO_x burners to avoid localized emission hot spots.

- Particulate matter associated with material handling and storage of raw and finished materials at the cement plant should be controlled by the following good practice techniques:

  - Reduce the number of martial transfer points by simple, linear layout for material handing operations;

  - Use of enclosed belt conveyors for material transportation and emission controls at transfer points;

  - Regular cleaning of conveyor belt systems;

  - Crushed and blended raw materials should be stored in covered or closed bays;

  - Pulverized coal should be stored in silos;

  - Clinker should be stored in covered or closed bays or silos with dust extraction;

- Routine plant maintenance to keep air leaks and spills to a minimum;

- Material handling processes including crushing operations, raw milling and clinker grinding should be undertaken in enclosed systems maintained under negative pressure by exhaust fans. Dust should be removed using cyclones and bag filters; and

- Implementation of automatic bag filling and handling systems.

Particulate matter associated with the operation of the kiln systems, clinker coolers and mills should be controlled by the following good practice techniques:

  - The use electrostatic precipitators (ESPs) or fabric filter systems to collect and control fine suspended particulate emissions in the kiln gases;

  - The use of cyclones to separate larger particulates of cooler gases followed by fabric filters; and finally

  - Mill dust should be captured and recycled using fabric filters within the mill.

- Particulate matter associated with mining operations at the limestone and mudstone quarry should be controlled by the following good practice techniques:

  - Water suppression should be used on unpaved roads and work areas in dry and windy conditions;

  - Storage of dusty materials (i.e. stockpiles) should be enclosed or operated with efficient dust suppression measures;

  - Stockpile heights should be kept to a minimum; and

  - Drop heights during loading and transfer of materials should be minimized and shielded against the wind.

Residual Impact Significance

Based on the proposed emission inventory for the operation of the cement plant and the associated quarry sites, the significance of the impacts to air quality at the ASRs in the vicinity of the plant will be **Minor** or below. The correct application of the above mentioned good practice measures will further support this outcome and reduce the likelihood of adverse impacts to air quality.

9.1.2 Coal Mine

Potential Impacts

Potential impacts to air quality in the vicinity of the cement plant may arise from the activities outline in *Table 9.14.* The emission inventory developed and used to model the impacts to air quality is presented in *Table 9.15*

The process of deriving emissions from the proposed activities and subsequently informing the dispersion model is set out in *Annex C2* and *Annex C3* and the main inputs, outputs and conclusions are summarised in the following section.

Table 9.14 Project Activities

Project Component	Activity	Pollutants of Interest
Coal Mine	• clearing and excavating of surface materials; • bulldozing surface materials; • loading and unloading haul trucks with coal and waste rock; • wind erosion from waste rock stockpiles; • vehicle movements over unpaved surfaces.	Dust, PM_{10} and $PM_{2.5}$
Coal Stockpiling Area	• unloading haul trucks with coal; • loading ships with coal; • vehicle movements over unpaved surfaces; • wind erosion from coal stockpiles.	Dust, PM_{10} and $PM_{2.5}$

Table 9.15 Coal mine Emission Inventory

Project Component	Source Type	Source Description	Pollutant Type	Emission Rate (g/s)
Coal Mine	Volume	Fugitive emission from 100,000tpa coal production	PM	5.03
Coal Stockpiling Area	Volume	Fugitive emission from stockpiling 100,000tpa of coal	PM	1.60

The maximum process contribution from the project and the predicted environmental concentration (project contribution + baseline) for PM_{10} and $PM_{2.5}$ have been determined based on the methodology outlined in *Annex C2.* The impacts associated with the operation of the Project are set out in the context of the existing airshed (*Section* ***Error! Reference source not found.***) and the significance defined based on the approach presented in *Annex C1.*

The significance of the impacts relating to each pollutant of interest at the sensitive receptor locations in the vicinity of the cement plant are summarised in *Table 9.16* to *Table 9.19.* No contour maps are presented as impacts to air quality are negligible across the entire modelling domain.

The results of the assessment comprise the maximum process contribution predicted over a period of five years from 2012 to 2016 on the receptor grid. This approach presents a worst case impact for the pollutants of interest.

Table 9.16 $PM_{2.5}$ 24-Hour Average

ASR	Baseline Concentration (μg/m³)	Baseline Classification	Air Quality Standard (AQS) (1)(2) (μg/m³)	Process Contribution(3)(4) (PC) (μg/m³)	PC/ AQS (%)	Predicted Environmental Concentration (PEC) (μg/m³)	PEC/AQS (%)	Impact Significance
ASR1	n/a	Non-degraded	25	0.236	<1%	0.236	<1%	Negligible
ASR2	n/a	Non-degraded	25	0.401	1.6%	0.401	1.6%	Negligible
ASR3	n/a	Non-degraded	25	1.58	6.3%	1.58	6.3%	Negligible
ASR4	n/a	Non-degraded	25	1.16	4.6%	1.16	4.6%	Negligible
ASR5	n/a	Non-degraded	25	0.978	3.9%	0.978	3.9%	Negligible
ASR6	n/a	Non-degraded	25	0.235	<1%	0.235	<1%	Negligible

(1) *WBG General EHS Guidelines*, 2007

(2) *Myanmar national Environmental Quality (Emission) Guidelines*, 2015.

(3) PM results from fugitive sources were multiplied by a factor of 0.053 to derive the $PM_{2.5}$ fraction for comparison to the air quality standard *(USEPA AP-42 Emission Factor Database Chapter 13.2.4 Aggregate Handling and Storage Piles)*

Table 9.17 $PM_{2.5}$ Annual Average

ASR	Baseline Concentration (μg/m³)	Baseline Classification	Air Quality Standard (AQS) (1)(2) (μg/m³)	Process Contribution (PC) (μg/m³)	PC/ AQS (%)	Predicted Environmental Concentration (PEC) (μg/m³)	PEC/AQS (%)	Impact Significance
ASR1	n/a	Non-degraded	10	0.0360	<1%	0.0360	<1%	Negligible
ASR2	n/a	Non-degraded	10	0.0686	<1%	0.0686	<1%	Negligible
ASR3	n/a	Non-degraded	10	0.278	2.8%	0.278	2.8%	Negligible
ASR4	n/a	Non-degraded	10	0.201	2.0%	0.201	2.0%	Negligible
ASR5	n/a	Non-degraded	10	0.158	1.6%	0.158	1.6%	Negligible
ASR6	n/a	Non-degraded	10	0.035	<1%	0.035	<1%	Negligible

(1) *WBG General EHS Guidelines*, 2007

(2) *Myanmar national Environmental Quality (Emission) Guidelines*, 2015.

(3) PM results from fugitive sources were multiplied by a factor of 0.053 to derive the $PM_{2.5}$ fraction for comparison to the air quality standard *(USEPA AP-42 Emission Factor Database Chapter 13.2.4 Aggregate Handling and Storage Piles)*

Table 9.18 PM_{10} 24-Hour Average

ASR	Baseline Concentration (µg/m³)	Baseline Classification	Air Quality Standard (AQS) (1)(2) (µg/m³)	Process Contribution (PC) (µg/m³)	PC/ AQS (%)	Predicted Environmental Concentration (PEC) (µg/m³)	PEC/AQS (%)	Impact Significance
ASR1	n/a	Non-degraded	50	1.56	3.1%	1.56	3.1%	Negligible
ASR2	n/a	Non-degraded	50	2.64	5.3%	2.64	5.3%	Negligible
ASR3	n/a	Non-degraded	50	10.4	21%	10.4	21%	Negligible
ASR4	n/a	Non-degraded	50	7.66	15%	7.66	15%	Negligible
ASR5	n/a	Non-degraded	50	6.46	13%	6.46	13%	Negligible
ASR6	n/a	Non-degraded	50	1.55	3.1%	1.6	3.1%	Negligible

(1) *WBG General EHS Guidelines*, 2007

(2) *Myanmar national Environmental Quality (Emission) Guidelines*, 2015.

(3) PM results from fugitive sources were multiplied by a factor of 0.35 to derive the PM_{10} fraction for comparison to the air quality standard *(USEPA AP-42 Emission Factor Database Chapter 13.2.4 Aggregate Handling and Storage Piles)*

Table 9.19 PM_{10} Annual Average

ASR	Baseline Concentration (µg/m³)	Baseline Classification	Air Quality Standard (AQS) (1)(2) (µg/m³)	Process Contribution(3) (PC) (µg/m³)	PC/ AQS (%)	Predicted Environmental Concentration (PEC) (µg/m³)	PEC/AQS (%)	Impact Significance
ASR1	n/a	Non-degraded	20	0.238	1.2%	0.238	1.2%	Negligible
ASR2	n/a	Non-degraded	20	0.453	2.3%	0.453	2.3%	Negligible
ASR3	n/a	Non-degraded	20	1.84	9.2%	1.84	9.2%	Negligible
ASR4	n/a	Non-degraded	20	1.32	6.6%	1.32	6.6%	Negligible
ASR5	n/a	Non-degraded	20	1.04	5.2%	1.04	5.2%	Negligible
ASR6	n/a	Non-degraded	20	0.229	1.1 %	0.229	1.1%	Negligible

(1) *WBG General EHS Guidelines*, 2007

(2) *Myanmar national Environmental Quality (Emission) Guidelines*, 2015.

(3) PM results from fugitive sources were multiplied by a factor of 0.35 to derive the PM_{10} fraction for comparison to the air quality standard *(USEPA AP-42 Emission Factor Database Chapter 13.2.4 Aggregate Handling and Storage Piles)*

Significance of the Impact

Based on the emissions inventory presented in *Table 9.15* and the modeling approach outlined in *Annex C2*, the results from the modelling exercise indicate that the emissions of $PM_{2.5}$ and PM_{10} during the normal operation of the Project will have a negligible impact on air quality at the sensitive receptors identified.

A summary of the impacts at the sensitive receptor locations is presented in *Table 9.20*.

Table 9.20 Assessment of Impact Related to PM_{10} and $PM_{2.5}$ during Operation

<table>
<tr><td>Impact</td><td colspan="5">Adverse impact to air quality from operational related activities at the coal mine and coal staging area</td></tr>
<tr><td rowspan="2">Impact Nature</td><td>Negative</td><td colspan="2">Positive</td><td colspan="2">Neutral</td></tr>
<tr><td colspan="5">Elevated ambient concentrations of PM_{10} and $PM_{2.5}$ from operational related activities will have a negative impact on air quality.</td></tr>
<tr><td rowspan="2">Impact Type</td><td>Direct</td><td colspan="2">Indirect</td><td colspan="2">Induced</td></tr>
<tr><td colspan="5">Elevated ambient concentrations of PM_{10} and $PM_{2.5}$ from operational related activities will have a direct impact on air quality.</td></tr>
<tr><td rowspan="2">Impact Duration</td><td>Temporary</td><td>Short-term</td><td colspan="2">Long-term</td><td>Permanent</td></tr>
<tr><td colspan="5">Potential impacts to air quality will occur throughout the operation phase and can therefore be described as long term in nature.</td></tr>
<tr><td rowspan="2">Impact Extent</td><td>Local</td><td colspan="2">Regional</td><td colspan="2">International</td></tr>
<tr><td colspan="5">Operational activities at the site have the potential to result in significant emissions of PM_{10} and $PM_{2.5}$ up to 5km from the project site boundary and can therefore be described as local.</td></tr>
<tr><td>Impact Scale</td><td colspan="5">The scale of the impact is likely to be up to 5km from the Project site boundary.</td></tr>
<tr><td>Frequency</td><td colspan="5">Impacts will arise continuously from construction related activities.</td></tr>
<tr><td rowspan="2">Impact Magnitude</td><td>Positive</td><td>Negligible</td><td>Small</td><td>Medium</td><td>Large</td></tr>
<tr><td colspan="5">Emissions of $PM_{2.5}$ will have a negligible impact on air quality at ASRs
Emissions of PM_{10} will have a negligible impact on air quality at ASRs</td></tr>
<tr><td rowspan="2">Receptor Sensitivity</td><td>Low</td><td colspan="2">Medium</td><td colspan="2">High</td></tr>
<tr><td colspan="5">When considering impacts to human health due to inhalation of airborne pollutants, all sensitive human receptors are defined as ‘medium’ sensitivity. This represents general populations and areas of habitation.</td></tr>
<tr><td rowspan="2">Impact Significance</td><td>Negligible</td><td>Minor</td><td>Moderate</td><td>Major</td><td>Critical</td></tr>
<tr><td colspan="5">Emissions of $PM_{2.5}$ will have a negligible impact on air quality at ASRs
Emissions of PM_{10} will have a negligible impact on air quality at ASRs</td></tr>
</table>

Mitigation

The following mitigation measures are considered good practice and should be used to minimize impacts to air quality during the operation of the coal mine and the associated stockpiling area;

- Water suppression should be used on unpaved roads and work areas in dry and windy conditions;
- Storage of dusty materials (i.e. stockpiles) should be enclosed or operated with efficient dust suppression measures;

- Stockpile heights should be kept to a minimum; and
- Drop heights during loading and transfer of materials should be minimized and shielded against the wind.

Residual Impact Significance

Based on the proposed emission inventory for the operation of the coal mine and associated stockpiling area the significance of the impacts to air quality at the sensitive receptors in the vicinity of the plant will be **Negligible**. The correct application of the above mentioned good practice measures will further support this outcome and reduce the likelihood of adverse impacts to air quality.

9.2 NOISE

9.2.1 Cement Plant

Potential Impacts

The operational phase noise impact assessment was conducted with reference to relevant international guidelines and local legislation, regulations, standards where available. Noise level guidelines given in IFC General EHS Guidelines: Environmental – Noise Management (2007) and the proposed noise criteria are given in *Section 8.2*.

The methodology adopted for the operational noise impact assessment is described in *Section 8.2.1*.

The nearest representative NSRs that may potentially affected by the noise impacts due to the operation of the Project are identified with locations shown in *Figure 6.10* and summarized in *Table 9.21* below:

Table 9.21 Representative Noise Sensitive Receivers

NSR	Description	Type of Uses
N1	Proposed Permanent Housing	Planned permanent residential
N2	Temporary Housing	Worker's camp during construction phase
N3	Temporary Housing	Will be removed when N1 is ready
N4	Existing Permanent Housing	Existing permanent residential

Note:

(b) As N2 and N3 are temporary housing during the construction phase, it is not included in the operational noise impact assessment.

The potential noise impacts arising from activities during the operation phase of the Project have been identified as the use of equipment for the operation of cement plant. The operation noise impact is predicted based on an indicative plant inventory provided by STC, as summarised in see *Table 9.22.*

The plant inventory will be confirmed by the EPC contractor during the detailed design stage. Should there be significant differences between the assumed plant inventory and that used on site, additional assessment may be needed and the proposed noise mitigation measures should be updated and implemented accordingly.

Table 9.22 Indicative Operation Plant Inventory

Plant Item	Reference (a)	Quantity during peak hour	On-time (d)	Unit SWL, dB(A)	Overall SWL, dB(A) (b) (c)
Existing Production Equipment					
Turbo-Generators Room	-	1	100%	93	110
Pulverised Coal Preparation System	-	1	100%	93	
Master Power Distribution Station	-	1	100%	93	
Raw Material Blending Station	-	1	100%	93	
Raw Mill Grinding and Treatment of Waste Gas at Kiln Inlet	-	1	100%	93	
Raw Mill Homogenising Silo	-	1	100%	93	
Kiln Inlet	-	1	100%	93	
Kiln Middle	-	1	100%	93	
Kiln Head and Clinker Conveying	-	1	100%	93	
Clinker Silo	-	1	100%	93	
Mixed Materials Store and Conveying	-	1	100%	93	
Cement Blending Station	-	1	100%	93	
Cement Grinding	-	1	100%	93	
Cement Silo and Bulking	-	1	100%	93	
Cement Packing	-	1	100%	93	
1#SP Waste Heat Boiler	-	1	100%	93	
2#AQC Waste Heat Boiler	-	1	100%	93	
Water Purifying Room	-	1	100%	93	
Coal Crushing and Conveying	-	1	100%	93	
Anxiliary Material Crushing	-	1	100%	93	
Anxiliary Material Prehomogenising Shed	-	1	100%	93	
Limestone Conveying	-	1	100%	93	
Limestone Crushing	-	1	100%	93	
Limestone Prehomogenising Shed	-	1	100%	93	
Additional Production Equipment					
Turbo-Generators Room	-	1	100%	93	
Chemical Water Treatment Room	-	1	100%	93	
Pulverised Coal Preparation System	-	1	100%	93	
Circulation Water Pump House	-	1	100%	93	
Master Power Distribution Station	-	1	100%	93	
Raw Material Blending Station	-	1	100%	93	
Raw Mill Grinding and Treatment of Waste Gas at Kiln Inlet	-	1	100%	93	
Raw Mill Homogenising Silo	-	1	100%	93	
Kiln Inlet	-	1	100%	93	
Kiln Middle	-	1	100%	93	
Kiln Head and Clinker Conveying	-	1	100%	93	
Clinker Silo	-	1	100%	93	

Plant Item	Reference (a)	Quantity during peak hour	On-time (d)	Unit SWL, dB(A)	Overall SWL, dB(A) (b) (c)
Mixed Materials Store and Conveying	-	1	100%	93	
Cement Blending Station	-	1	100%	93	
Cement Grinding	-	1	100%	93	
Cement Silo and Bulking	-	1	100%	93	
Cement Packing	-	1	100%	93	
Circulating Water Cooling Tower	-	1	100%	93	
1#AQC Waste Heat Boiler	-	1	100%	93	
1#SP Waste Heat Boiler	-	1	100%	93	
2#AQC Waste Heat Boiler	-	1	100%	93	
2#SP Waste Heat Boiler	-	1	100%	93	
Water Purifying Room	-	1	100%	93	
Coal Crushing and Conveying	-	1	100%	93	
Limestone Crushing	-	1	100%	93	
Limestone Conveying	-	1	100%	93	
Limestone Prehomogenising Shed	-	1	100%	93	

Notes:

(a) Reference for plant items is not available. Sound pressure level of 85 dB(A) at 1m is assumed for the plant items.

(b) The figures are rounded up to a whole number.

(c) The overall SWL represents the maximum potential noise impact during operation phase.

(d) All plant equipment is generally operated for 24-hour per day throughout the year, unless dispatched off-line by control centre or shut down for maintenance.

The results of the operational noise impact assessment are summarised in *Table 9.23*. Details of the calculations are presented in *Annex D*

Table 9.23 Predicted Operation Noise Levels at Representative NSRs

NSR	Predicted Noise Level (A), dB(A)	Averaged Background Noise Level (B), dB(A)		Cumulative Noise Level , dB(A) (a)		Increase in Background Noise, dB(A) (b)		Compliance (Yes/No)	
		D	N	D	N	D	N	D	N
N1	39	49	44	49	45	0	1	Yes	Yes
N4(e)	43	49	44	50	47	1	3	Yes	Yes

Notes:

(a) Cumulative Noise Level (C) = 10 x log ($10^{(A/10)}$+ $10^{(B/10)}$)

(b) With reference to assessment noise criterion of a maximum increase in background levels of not more than 3 dB(A).

(c) NSRs N2 and N3 will be relocated to permanent housing area during operation phase. Therefore, operation noise impact assessment is not required at these NSRs.

(d) D: Daytime (0700 hr - 2200 hr); N: Night-time (2200 hr - 0700 hr).

(e) The background noise level at N4 is assumed to be the same as that measured at N1 considering the noise environment of N1 and N4 is similar.

The predicted noise levels of 39 and 43 dB(A) comply with the WBG General EHS Guidelines during both daytime and night-time periods. The increase in background levels is not more than 3 dB(A) at all NSRs. Noise mitigation measures are considered not necessary for the operation of the Project.

As presented in *Table 9.23*, the predicted noise levels comply with the assessment noise criteria. The operational noise impact is considered to be of

negligible significance at the nearest receptor. An operational noise impact assessment summary is given in *Table 9.24.*

In the case of significant changes to the operation plant inventory and respective operating parameters from the current assumptions, re-assessment may be required to be conducted to confirm compliance with noise criteria.

Table 9.24 Assessment of Impact related to General Operation Noise (Cement Plant)

Impact	Noise impact from the fixed plant and machinery during operation phase.				
Impact Nature	**Negative**	Positive	Neutral		
	Noise impact from the operational activities is **negative**.				
Impact Type	**Direct**	Indirect	Induced		
	Noise impact from the operational activities is **direct**.				
Impact Duration	Temporary	Short-term	**Long-term**	Permanent	
	Noise impact from the operational activities is **long-term**.				
Impact Extent	**Local**	Regional	International		
	Noise impact from the operational activities is **local**.				
Impact Scale	Project area.				
Frequency	Throughout the operation period.				
Impact Magnitude	Positive	**Negligible**	Small	Medium	Large
	Considering the predicted noise levels comply with both the noise criteria. The magnitude of the noise impact is **negligible**.				
Receptor Sensitivity	Low	**Medium**	High		
	The identified NSR are residential, the sensitivity of the receptor is considered as **medium.**				
Impact Significance	**Negligible**	Minor	Moderate	Major	Critical
	As the impact magnitude is negligible and the receptor sensitivity is medium, the impact significance is considered as **negligible**.				

9.3 SURFACE WATER QUALITY

9.3.1 *Cement Plant*

Potential Impacts

Impacts to surface water courses in the vicinity of the cement plant may arise from the following sources:

- Runoff from the coal staging area and uncovered materials handling yards. As presented in *Section 6.2.1,* baseline water quality data collected in January 2017 indicated the level of TSS from the coal staging area exceeded both the WBG *EHS Guidelines for Cement and Lime Manufacturing* (2007) and WBG *General EHS Guidelines* (2007) for treated sanitary sewage discharge. The *E. coli* level also exceeded the WBG *General EHS Guidelines* (2007) for treated sanitary sewage discharge. These exceedances indicate contamination due to existing operations at the coal staging area through sediment loaded discharge and possibly sewage. In addition, higher COD levels were reported at the coal staging area when compared to other locations which indicated potential issues of contaminated run-off from the coal staging area;

- Runoff from the working areas and overburden dumps at the mudstone and limestone quarries;
- Bulk storage of fuels and chemicals;
- Untreated wastewater discharge; and
- Discharge of water from the reservoir adjacent to the plant during the wet season.

Drainage from STC's operations flows into the Kubyin River, except for water discharged from the reservoir which is flowing to the Pyi Nyaung River as report by the STC.

There is little in the way of in-place controls to manage impacts to surface water at the cement plant. Perimeter drains around the coal staging area discharge to a gully that ultimately joins Kubyin River and contamination is evident from the existing operations (see *Figure 9.7* ***Error! Reference source not found.***). In addition, the results of the baseline survey undertaken in January 2017 also indicated potential contamination from coal staging area discharge with relatively high levels of TSS, *E. coli* and COD recorded (*Section 6.2*)

The fuel storage area has limited spill control measures. The storage area is not adequately paved or bunded and there was no oil /water separation or lightening protection (see *Figure 9.8*).

Figure 9.7 Coal Staging Area and Surface Water Contamination

Figure 9.8 Fuel Storage Area at the Cement Plant

Runoff during rainfall events is likely to contribute to contamination of surface water from the above-mentioned sources. If a storage container was to fail at the fuel storage area there is no secondary containment and pollutants could easily run off into the nearby water courses.

In addition to potential runoff and spill impacts, the following types of routine discharges would arise from plant operation, which may lead to contamination of surface waters if not managed properly:

- Industrial wastewater discharge from the cement manufacturing process, material handling areas and bulk storage of fuels and chemicals;

- Domestic wastewater discharge generated from the workforce at office, canteen, staff accommodation quarters etc.

During the stakeholder consultation in January 2017, residents in Kubyin expressed their concerns on the release of water from the reservoir of the cement plant upstream during the wet season. Adverse water quality impact was reported by the resident. It is, however, confirmed by STC that excess water from the reservoir will overflow from the overflow weir to the natural creek which is flowing to Pyi Nyaung to the south of the plant rather than Kubyin which is located north of the plant. As such, adverse water quality impact reported by residents in Kubyin is more likely to be caused by contaminated run-off or wastewater discharge from the plant, rather than reservoir overflow.

The magnitude of this impact is medium; the receptor sensitivity is high given that the Kubyin River is used as a drinking water supply. The overall impact significance is therefore **major**.

Table 9.25 Surface Water Quality Impact Assessment

Impact	Deterioration of surface water quality in the Kubyin River and other surface streams resulting from uncontrolled runoff from the cement plant and associated quarries.				
Impact Nature	**Negative**	Positive	Neutral		
	Pollutants entering surface water courses would create a negative impact.				
Impact Type	**Direct**	Indirect	Induced		
	The impact would be directly upon surface water resources and on the residents of Kubyin Village that depend on water supplied from the Kubyin River.				
Impact Duration	Temporary	**Short-term**	**Long-term**	Permanent	
	If not managed, the impact would occur over the life of STC's operations.				
Impact Extent	**Local**	Regional	International		
	The extent of the impact would be limited to the water courses adjacent to the site that drain into Kubyin River.				
Impact Scale	Moderate				
Frequency	Runoff from the quarries, coal staging area and materials handling yards would occur routinely throughout the wet season. Loss of containment at the fuel storage area is expected to be infrequent.				
Impact Magnitude	Positive	Negligible	Small	**Medium**	Large
	The impact magnitude is **Medium**.				
Receptor Sensitivity	Low	Medium	**High**		
	The receptor sensitivity is **High**, given the year round dependence by residents of Kubyin Village on water from the Kubyin River.				
Impact Significance	Negligible	Minor	Moderate	**Major**	Critical
	The significance is **Major** in the absence of mitigation.				

Mitigation

The following mitigation is required:

<u>Limestone and Mudstone quarries</u>

- Construction of a dedicated drainage network to intercept and diver runoff;

- Divert runoff from the mudstone quarry to an appropriately sized and maintained sedimentation pond to allow adequate retention time for suspended solids to settle;

- Divert runoff from the limestone quarry to the wetland created by STC via a weir to remove suspended solids before entering the wetland;

- Baffles or other measures to reduce the velocity of runoff down hill slopes should be installed to minimise scouring;

- Exposed areas and overburden dumps should be revegetated as quickly as possible.

Coal Storage Are and Materials Handling Yards

- All areas used to store and/or handle coal, laterite and limestone should be paved and surrounded by perimeter drains;

- Perimeter drains should be diverted to a multi-stage sized sedimentation pond;

- Oil-water separator should be installed to at the outlet of the sedimentation pond; and

- Discharges from the coal staging area should be monitored monthly for compliance with Myanmar National Environmental Quality (Emissions) Guidelines for site runoff and wastewater discharges (for TSS, oil and grease, pH).

Fuel Storage Area

- Lightning protection should be installed at all areas used to store bulk fuel and other flammables;

- The fuel storage facility should be constructed on bunded hardstand with containment sufficient for 110% of the volume of the single largest tank;

- Discharges from this bunded area should pass through an oil-water separator;

- A Spill Response Plan should be developed and implemented; and

- Discharges from the coal staging area should be monitored monthly for compliance with Myanmar National Environmental Quality (Emissions) Guidelines for site runoff and wastewater discharges (for TSS, oil and grease, pH).

Industrial Wastewater from Cement Manufacturing Process

- Discharges from the cement manufacturing process should be treated and monitored monthly for compliance with effluent levels specified in WBG

EHS Guidelines for Cement and Lime Manufacturing (2007) (for pH, TSS and water temperature).

Sanitary Wastewater

- Sanitary wastewater (includes toilet, sink, shower, and kitchen flows) should not be directly discharged to any water bodies.
- Sanitary wastewater should be treated in septic system properly designed and maintained according to WBG Genera EHS Standards (2007) as follows:
  - STC shall undertake feasibility study of the proposed arrangements for treatment of sanitary wastewater from the new accommodation quarters;
  - Installed in areas with sufficient soil percolation for the design wastewater loading rate;
  - Installed in areas of stable soils that are nearly level, well drained, and permeable, with enough separation between the drain field and the groundwater table or other receiving waters;
  - Grease trap should be installed at sources where oily water is expected (e.g. kitchen); and
  - Residual sludge should be collected and disposed of properly.
- Should treated wastewater to be reused as spray water, they should be monitored monthly for compliance with Myanmar National Environmental Quality (Emissions) Guidelines for site runoff and wastewater discharges (for TSS, oil and grease, pH).

Residual Impact Significance

The recommended mitigation measures will reduce the likelihood of contaminated runoff entering surface streams that ultimately drain to the Kubyin River such that the, residual impact significance would be *Minor* to *Moderate*. Routine surface water quality monitoring will be initiated to monitor the effectiveness of the proposed mitigation measures which is discussed further in *Section 11- ESMP*.

9.3.2 Coal Mine

Potential Impacts

The existing access road to the coal mine is a seasonal road built by STM from unconsolidated material and without rock armoring or drainage. The road is washed away in the wet season and is rebuilt in November each year at the start of the dry season as part of the mine routine operation. The road follows the South Paluzawa Stream with multiple crossings in the section between the base camp and the coal mine.

During reconstruction and during periods of heavy rain, unconsolidated material from the road washes into the watercourse causing heavy sedimentation (*Figure 9.9*). Road crossings also disrupt the stream flow. Sedimentation of this stream affects aquatic ecology and was raised as an issue of concern by residents of Chaungzon Village who use this stream as a drinking water supply.

A second road is currently under construction from Nanmawke Village to the coal mine and is likely to cause similar issues to water courses without appropriate design and engineering measures.

Runoff from the coal mine itself is uncontrolled and enters the South Paluzawa Stream (*Figure 9.10*). Erosion at the mine and rehabilitated areas is severe and lacks any control.

The above impacts from erosion and runoff are also reflected in the January 2017 baseline monitoring results which indicated high SS levels at stream sections downstream of the coal mine and access road (*Section 6.2*).

In addition to the above, the fuel storage area and maintenance yard currently have limited spill control measures. As observed during the site visit in November 2016 and January 2017, these areas are not adequately paved or bunded and there were no oil /water separation or lightening protection (see (*Figure 9.11*). The coal staging area is also currently lacking any control on run-off. Contaminated run-off from these areas would be a source of pollution to the adjacent river waters.

The magnitude of the impact is considered large. Sedimentation in the South Paluzawa Stream is clearly visible at Chaungzon Village and detected during the baseline monitoring but is significantly diluted once it joins a larger stream at Chaungzon. Given its use as a drinking water supply, the receptor sensitivity is high and hence the overall impact significance is assessed as **critical**.

Figure 9.9 Erosion and Sedimentation Caused by Access Road Construction

Figure 9.10 Erosion at the Coal Mine

Figure 9.11 Fuel Storage Area and Maintenance Yard at Coal Mine Site with Limited Spill Control Measures

Table 9.26 Assessment of Impact related to Surface Water Quality During Mine Operations

Impact	Erosion of unconsolidated material from the access road and at the coal mine is causing sedimentation of water courses, impacting surface water quality, aquatic biodiversity and a nuisance to residents of Chaungzon Village who source drinking water from South Paluzawa Stream. Contaminated runoff from the site may also cause river water pollution.				
Impact Nature	**Negative**	Positive	Neutral		
Impact Type	**Direct**	Indirect	Induced		
	Sedimentation and contaminated runoff directly affects water quality and aquatic ecology.				
Impact Duration	Temporary	Short-term	**Long-term**	Permanent	
	The impact duration of sedimentation is largely seasonal therefore occurs for the period during which the road is in operation between December and May annually. Contaminated runoff is expected to occur more frequent during the wet season.				
Impact Extent	**Local**	Regional	International		
	It is considered that the extent of the impact would be local and confined to the water courses adjacent to the coal mine and road impacting users further downstream.				
Impact Scale	Moderate				
Frequency	The impact recurs on an annual basis during road construction and in the wet season.				
Impact Magnitude	Positive	Negligible	Small	Medium	**Large**
	The impact magnitude is **Medium**.				
Receptor Sensitivity	Low	Medium	**High**		
	The receptor sensitivity is **High**.				
Impact Significance	Negligible	Minor	Moderate	**Major**	**Critical**
	The significance is **Critical.**				

Mitigation

Access Road

- As a first priority STM will discontinue use of the seasonal access road from the base camp to the coal mine at the end of the dry season in May 2017 and instead use the existing access road that connects to Phase 1 of the coal mine.

- STC will retain a third party engineering firm to provide engineering and design input prior to re-construction of the seasonal access road and construction of the new access road from Namwake to Phase 3 of the mine;

- Drainage systems and stream crossings for all newly constructed and maintained access roads require external engineering and design input;

- Lining steep channel and slopes (e.g. use jute matting);

- In-stream construction activities to be undertaken in the dry season;

- Isolation techniques such as beaming or diversion during construction to limit the exposure of disturbed sediments to moving water;
- Access roads should be compacted and graded to limit erosion;
- Mulching to stabilize exposed areas; and
- Re-vegetating areas promptly.

Coal Mine

- Strip mine to be progressively vegetated using a mix of local species (i.e. not only teak);
- Final grading of disturbed areas, including preparation of overburden before application of the final layers of growth medium, should be along the contour as far as safe and practical;
- Final slopes should be less than 30 degrees;
- Drainage interception and diversion up gradient of topsoil and overburden storage; and
- Sedimentation ponds designed for mining area and up gradient contribution.

Fuel Storage Area

- Lightning protection should be installed at all areas used to store bulk fuel and other flammables;
- The fuel storage facility should be constructed on bunded hardstand with containment sufficient for 110% of the volume of the single largest tank;
- Discharges from this bunded area should pass through an oil-water separator; and
- Discharges from the fuel storage area should be monitored monthly for compliance with Myanmar National Environmental Quality (Emissions) Guidelines for site runoff and wastewater discharges (for TSS, oil & grease, pH).

Maintenance Yard

- The maintenance yard should be paved;
- Perimeter drains should be installed and diverted to a multi-stage sized sedimentation pond;
- Oil-water separator should be installed to at the outlet of the sedimentation pond; and

- Discharges from the maintenance yard should be monitored monthly for compliance with Myanmar National Environmental Quality (Emissions) Guidelines for site runoff and wastewater discharges (for TSS, oil & grease, pH).

Coal Staging Area

- All areas used to store and/or handle coal should be paved or compacted and surrounded by perimeter drains;
- Perimeter drains should be diverted to a multi-stage sized sedimentation pond;
- Oil-water separator should be installed to at the outlet of the sedimentation pond; and
- Discharges from the coal staging area should be monitored monthly for compliance with Myanmar National Environmental Quality (Emissions) Guidelines for site runoff and wastewater discharges (for TSS, oil & grease, pH).

Residual Impact Significance

If the recommended mitigation measures are implemented, residual impact significance would be *Minor* to *Moderate*.

9.4 BIODIVERSITY

9.4.1 *Cement Plant*

Loss of Habitat

The areas of Natural Habitat and Modified Habitat impacted during operation of the limestone quarry are shown in ***Table 9.27***. This assessment is based on an estimation of the size of impact within the Project area provided by STC.

Table 9.27 Natural Habitat and Modified Habitat

Project Area	Natural Habitat Area (ha)	Modified Habitat Area (ha)	Total (ha)
Limestone Quarry	235.58	118.79	354.37
Mudstone Concession	32.59	82.67	115.26
Total	**268.17**	**201.46**	**469.63**

The impacts from the loss of habitat within the concession during the operation phase will predominately be related to the operation of the limestone and mudstone quarries. The limestone quarry is located in Critical Habitat and the mudstone quarry is located in a mixture of Natural Habitat and Modified Habitat. It is therefore anticipated that impacts from these quarries may have a significant impact to biodiversity values. Limestone quarries are located within Critical Habitats.

Impacts from the limestone quarry include a loss of habitat for limestone dependent fauna, including endemic snail fauna. The limestone range is also likely to play host to endemic flora. Impacts due to limestone quarrying activities are the primary impact of concern.

Induced clearing and illegal logging may result in ongoing impacts to surrounding forested areas, including the Panlaung-Pyadalin Cave Wildlife Sanctuary which is 6km from the Project area.

The impact assessment summary for loss of habitat during the operation phase is outlined in ***Table 9.28***.

Table 9.28 Impact Assessment Summary – Permanent and Temporary Loss of Habitat

Impact	Permanent and temporary loss of habitat including transition of habitats from one habitat type to another during operation				
Impact Nature	Negative	Positive	Neutral		
	The impact on the terrestrial and aquatic biodiversity is negative				
Impact Type	Direct	Indirect	Induced		
	Direct terrestrial habitat loss in the Project Footprint in areas to be developed. Induced effects on remnant/ isolated habitats.				
Impact Duration	Temporary	Short-term	Long-term	Permanent	
	The impact will be ongoing during operations and is essentially a permanent change.				
Impact Extent	Local	Regional	International		
	The impact is expected to be local for habitats.				
Impact Scale	It is anticipated that the impact will be limited to the Limestone Quarry during operation, which occur in Critical Habitat. Some impacts to Natural Habitat may occur during operation of the Mudstone Quarry. Induced clearing and illegal logging may have impacts on the nearby protected area.				
Impact Magnitude	Positive	Negligible	Small	Medium	Large
	The magnitude of impact may affect an entire population of a species and possibly threaten the long term viability of that population.				
Receptor Sensitivity	Low	Medium	High		
	Given that impacts could occur on endemic flora and fauna, the receptor sensitivity is considered to be High. Impacts to the nearby protected area from induced clearing and illegal logging are also considered to be High.				
Impact Significance	Negligible	Minor	Moderate	Major	Critical
	The significance of this impact is **Critical** and requires biodiversity offsets (see *Annex F*)				

<u>Mitigation Measures</u>

The following mitigation measures will be applied to the Project:

- Rehabilitation of habitat will occur within the landscape disturbed by Project operations. All rehabilitation is to occur using native indigenous species. A nursery is to be established to propagate species. All rehabilitation is to be established in a progressive basis as quarrying activities occur. All rehabilitation will be monitored to determine the success/failure of different techniques. Rehabilitation will be adapted based on the results of the monitoring.

- All habitat clearance during quarrying/mining operations is to be clearly marked prior to excavation.
- A Wildlife clearance protocol (*Annex E4*) is to be applied during all operations that clear Critical Habitat and Natural Habitat.
- Education and awareness activities are to be undertaken with local people to provide information regarding illegal logging controls.
- Regular patrols (at least every month) of the Project boundary will be undertaken to identify any incursion by local people into the Project Area and surrounding forested area.

<u>Residual Impact Significance</u>

Residual impacts remaining after mitigation include the permanent loss of 32.59 ha of forested habitat from the mudstone quarry and 235.58 ha of limestone habitat from the limestone quarry. Biodiversity offsets are necessary to offset the permanent loss of habitats. Reference should be made to the Biodiversity Offset Strategy at *Annex F*. Ongoing impacts are likely regarding induced illegal logging and clearing. Monitoring of these impacts will be necessary to identify additional management measures that may be required.

Fragmentation and Edge Effects

Impacts from fragmentation and edge effects on resident species are likely to be similar to those described in the construction impact assessment (as discussed above).

It is anticipated that edge affect impacts during operation will continue to occur from the linear infrastructure such as the driving of vehicles along the access road and associated infrastructure. Additionally, edge effects will occur adjacent to all quarries. The edge impacts will be most significant within the limestone quarry areas which are Critical Habitat. The impacts will include dust, noise, vibration and light impacts on adjacent habitats. These edge effects will impact adjacent fauna and flora through disturbance and displacement and dust impacts on vegetation. It is likely that dust impacts will be limited to the dry season as rainfall will wash dust from vegetation during the wet season. Given that endemic flora exist adjacent to the limestone quarry, this is considered a sensitive receptor.

Impacts from fragmentation will occur within the limestone range as the quarry will reduce connectivity by removing a portion of the range. This will fragment currently joined habitats along the limestone range.

The impact assessment summary for impacts to habitats by edge effects during the operation phase is outlined in ***Table 9.29***.

Table 9.29 Impact Assessment Summary – Fragmentation and Edge effects

Impact	Impact to flora and fauna from edge effects and fragmentation during operation of the access roads, cement plant and limestone quarry				
Impact Nature	Negative	Positive	Neutral		
	The impact on the terrestrial biodiversity is negative				
Impact Type	Direct	Indirect	Induced		
	Direct impact to terrestrial flora and fauna, including areas of natural habitat adjacent to the mudstone quarry and Critical Habitat adjacent to the limestone quarry. Dust impacts will continue on Modified Habitats adjacent to roads. Fragmentation will occur within limestone hills.				
Impact Duration	Temporary	Short-term	Long-term	Permanent	
	The impacts will continue during operation and will be permanent.				
Impact Extent	Local	Regional	International		
	The impact is expected to be localised for habitats adjacent to quarries and alongside linear infrastructure components, including roads.				
Impact Scale	It is anticipated that the scale of impact will be limited to areas adjacent to quarries and along linear infrastructure components.				
Impact Magnitude	Positive	Negligible	Small	Medium	Large
	The impacts to areas of Natural Habitats adjacent to the quarries are considered to be Medium. The impacts to Critical Habitats are considered to be Medium. Impacts to Modified Habitats beside linear infrastructure are considered to be Small.				
Receptor Sensitivity	Low	Medium	High		
	Natural Habitats are considered to be High sensitivity as they play host to sensitive species of high biodiversity value.				
Impact Significance	Negligible	Minor	Moderate	Major	Critical
	The significance of this impact is **Moderate to Major**.				

Mitigation Measures

The following mitigation measures are recommended:

- Measures regarding managing dust, noise, vibration recommended in this ESIA are to be applied during operations in Critical Habitat and Natural Habitat.
- Design of lighting will be directed away from vegetated areas and habitats. Upward lighting will be avoided and lights will not be left on after hours when not required.

Residual Impact Significance

Mitigation measures during operation will reduce the severity of impacts of the loss of terrestrial and aquatic habitats so as to reduce the impact to minor (Magnitude Minor).

9.4.2 *Coal Mine*

Loss of Habitat

The areas of Natural Habitat and Modified Habitat impacted during operation of the coral mine are shown in ***Table 9.30***. STC estimates that 68% of the coal mine concession will be disturbed during operations. No specific footprint is available of the proposed mining operations. The total area of the concession has therefore been discounted to reflect the proportion of disturbance estimated by STC.

Table 9.30 Natural Habitat and Modified Habitat within Coal Mine Concession

	Natural Habitat	Modified Habitat	Total
Coal Mine Concession	884.95	2.95	887.9
Coal Mine Access Road from Namwake Village	15	-	15
Total	899.95	2.95	902.90

The impacts from the loss of habitat within the concession during the operation phase will predominately be related to the operation of the Coal Mine through the clearance of areas of vegetation prior to mining activities. The coal mine is located in areas of Critical Habitat and Natural Habitat. It is therefore anticipated that impacts may have a significant impact to biodiversity values.

Induced clearing and illegal logging may also occur during operation as a result of improved access to forested areas. These impacts can affect forested areas within the greater area of influence of the project.

The impact assessment summary for loss of habitat during the operation phase is outlined in ***Table 9.31***.

Table 9.31 Impact Assessment Summary – Permanent and Temporary Loss of Habitat

Impact	Permanent and Temporary Loss of Habitat				
Impact Nature	Negative	Positive	Neutral		
	The impact on the terrestrial and aquatic biodiversity is negative				
Impact Type	**Direct**	Indirect	**Induced**		
	Direct terrestrial habitat loss in the Project Footprint in areas to be developed. Induced effects on remnant/ isolated habitats.				
Impact Duration	Temporary	Short-term	Long-term	**Permanent**	
	The impact will be ongoing throughout the operations and is essentially a permanent change to habitat.				
Impact Extent	**Local**	Regional	International		
	The impact is expected to be local for habitats.				
Impact Scale	It is anticipated that the impact will be limited to the Production Areas proposed during operation, which occur in Critical Habitat and Natural Habitat. A total of 899.95ha of Critical Habitat will be lost progressively as the coal mine is developed. Induced clearing and illegal logging may cause a significant impact in surrounding forests in the Area of Influence.				
Impact Magnitude	Positive	Negligible	Small	Medium	**Large**
	The magnitude of impact may affect an entire population of a species and possibly threaten the long term viability of that population.				
Receptor Sensitivity	Low	Medium	High		
	Given that impacts could occur to Critical Habitat species, the receptor sensitivity is High.				
Impact Significance	Negligible	Minor	Moderate	Major	Critical
	The significance of this impact is **Critical** and requires biodiversity offsets (see ***Annex F***)				

Mitigation Measures

See recommended Mitigations for the Limestone Quarry Loss of Habitat measures listed above.

Residual Impact Significance

Residual impacts remaining after mitigation include the permanent loss of 899.95 ha of forested habitat. Ongoing impacts are likely regarding induced illegal logging,clearing and hunting. Monitoring of these impacts will be necessary to identify additional management measures that may be required. Offsets will be required to achieve a no-net-loss of biodiversity values for Natural Habitats. Critical Habitats will require demonstration of net-gain in biodiversity value. Reference should be made to the Biodiversity Offset Strategy at *Annex F*.

Degradation of Habitats: Invasive Species

Invasive species (flora and fauna) have the potential to be introduced or spread throughout the Project area through increased movement of people, vehicles, machinery, vegetation and soil. The impacts from the introduction and proliferation of invasive species will be the same as described during construction. Impacts within Natural Habitat areas adjacent to the coal mine will be susceptible. Invasive species detected within the Coal Mine's Area of Influence are identified in ***Table 9.32*** below.

Table 9.32 Invasive Species Identified within the Coal Mine Area

S/N	Scientific Name	Family
1	*Ageratum conyzoides*	Asteraceae
2	*Amaranthus spinosus*	Amaranthaceae
3	*Bidens pilosa*	Asteraceae
4	*Caesalpinia decapetala*	Caesalpinaceae
5	*Chromolaena odorata*	Asteraceae
6	*Hiptage benghalensis*	Malpighiaceae
7	*Imperata cylindrica*	Poaceae
8	*Mikania micrantha*	Asteraceae
9	*Mimosa pudica*	Mimosaceae
10	*Oroxylum indicum*	Bigoniaceae
11	*Paederia foetida*	Rubiaceae
12	*Ziziphus jujuba*	Rhamnaceae

Vehicle movement and activities may introduce a risk of invasion along access roads and the coal mine operation areas. The increase in human activity and movement across the landscape also is a consideration as well as the potential movement of weed seed and aquatic invasive species as a result of runoff. It is therefore likely that the primary transmission will be along linear infrastructure development, particular along the new access road being constructed from Nanmawke to the coal mine and along exposed soil surfaces within the coal mine itself.

The impact assessment summary for degradation of habitats by alien species during the operations phase is outlined in *Table 9.33*.

Table 9.33 Impact Assessment Summary – Degradation of Habitats: Invasive Species

Impact	Impact to habitats from invasive species				
Impact Nature	**Negative**	Positive	Neutral		
	The impact on the terrestrial and aquatic biodiversity is negative				
Impact Type	**Direct**	**Indirect**	Induced		
	Direct impact to terrestrial flora and fauna.				
Impact Duration	Temporary	Short-term	Long-term	**Permanent**	
	The impacts will continue during operation are essentially be permanent.				
Impact Extent	**Local**	Regional	International		
	The impact is expected to be localised for habitats downstream or alongside linear infrastructure components and activities. Impacts adjacent to the coal mine are also likely.				
Impact Scale	It is anticipated that the scale of impact will be limited to downstream areas and areas along access roads to the coal mine and at the mine itself.				
Impact Magnitude	Positive	**Negligible**	**Small**	Medium	Large
	The impacts to areas of Natural Habitats adjacent to the quarries are considered to be Small. Impacts to Modified Habitats beside linear infrastructure are considered to be **Negligible** to **Small**.				
Receptor Sensitivity	Low	Medium	**High**		
	Terrestrial habitats likely impacted will be predominately Critical Habitats which is considered to be a **High** sensitivity given the presence of Critical Habitat candidate species.				
Impact Significance	Negligible	Minor	**Moderate**	Major	Critical

Mitigation Measures

The following mitigation measures will be applied during operations to reduce impacts from the degradation of habitats:

- Invasive species management measures are to include vehicle wash-down for vehicles at the base camp maintenance area prior to them entering and leaving the Project Area.
- Appropriate use of herbicides may be used to control invasive species within Natural Habitats within the Project Area.
- Monitoring of invasive species is to occur within the Project Area on an annual basis. New infestations identified are to be controlled.

Residual Impacts

Mitigation measures during operation will reduce the severity of impacts of the loss of terrestrial and aquatic habitats so as to reduce the impact to within the normal range of variation (Magnitude Negligible).

Species Impacts

Coal Mine

The following fauna species were determined to be present at the coal mine and have been assessed based on the threats that are due to or operations. These species have the potential to be subject to indirect or induced impacts caused by increased access to forests in the DMU and project related operations such as increased hunting and poaching by local people and workers; road kills from vehicular traffic, excavators and machinery; changes in habitat extent and quality (including water quality impacts) and incidental deaths from treefall or other means.

- Chinese Pangolin *Manis pentadactyla* (CR) (Critical Habitat trigger);
- Western Hoolock Gibbon *Hoolock hoolock (*EN) (Critical Habitat trigger);
- Phayre's Langur *Trachypithecus phayrei phayrei* (EN);
- Dhole *Cuon alpinus* IUCN (EN);
- Gaur *Bos gaurus* (VU)
- Bengal Slow Loris *Nycticebus bengalensis* (VU);
- Southern Serow Capriconis sumatraensis (VU);
- Red Goral *Naemorhedus baileyi* (VU);
- Asiatic Black Bear *Ursus thibentanus* (VU); and
- Fishing Cat *Prionailurus viverrinus* IUCN (VU).

The following flora species were detected at the coal mine and have been assessed for impacts that may occur due to or be caused by operations. Increases in access to the Project area will enable continued illegal logging within and near to the concession. Direct threats also exist where a species may be removed due to project operations through clearing of the site for coal mining operations or road construction.

- *Dipterocarpus baudii* (CR) (Critical Habitat trigger); and
- *Dipterocarpus costatus* (EN).

The impact assessment summary for impacts to species during the operation phase is outlined in ***Table 9.34***.

Limestone Concession

Impacts to fauna species at the limestone concession will be similar to the impacts predicted for the coal mine. These include secondary hunting and poaching impacts due to access and direct impacts from fauna mortality.

The following species have been identified at the concession that may be impacted:

- Chinese Pangolin *Manis pentadactyla* (CR) (Critical Habitat trigger);
- Shan Langur *Trachypithecus phayrei shanicus* (EN) (Critical Habitat trigger);
- Eastern Hoolock Gibbon *Hoolock leuconedys* (VU);
- Bengal Slow Loris *Nycticebus bengalensis* (VU); and
- Hog Badger *Arctonyx collaris* (VU).

Impacts to flora species within the limestone concession will occur through increased access to the Project area. This will cause indirect impacts such as continued illegal logging and direct threats due to project operations through clearing of the site for quarrying operations or road construction. The species *Dalbergia oliveri* (EN) was identified within the Project Area.

Impacts to limestone dependent flora and fauna species are likely to occur through clearance of vegetation. The species that will be impacted include limestone dependent snails, reptiles and flora. Limestone dependent reptiles and flora will be subject to survey in April and May 2017. An update of the assessment will occur once this information is available.

Table 9.34 Impact Assessment Summary – Species Impacts

Impact	Impact to species within the DMU and Project Area during operation of the coal mine and limestone concession.				
Impact Nature	Negative	Positive	Neutral		
	The impact on threatened flora and fauna within the Project Area of the coal mine and limestone concession.				
Impact Type	Direct	Indirect	Induced		
	Direct impact to terrestrial and aquatic fauna and flora during operation.				
Impact Duration	Temporary	Short-term	Long-term	Permanent	
	The duration of impacts will be permanent				
Impact Extent	Local	Regional	International		
	The impact is expected to be localised for species.				
Impact Scale	It is anticipated that the scale of impact will be limited to areas within the Project Area and within the DMUs.				
Frequency	Operation is ongoing.				
Impact Magnitude	Positive	Negligible	Small	Medium	Large
	Considering the magnitude of impacts and that the majority of impact will be induced project related impacts through hunting/poaching and illegal logging the impact is likely to be **Negligible** to **Small**.				
Receptor Sensitivity	Low	Medium	High		
	Terrestrial and aquatic species likely impacted are considered to be a **High** sensitivity given the presence of Critical Habitat candidate species				
Impact Significance	Negligible	Minor	Moderate	Major	Critical
	The significance of this impact is **Moderate**.				

Mitigation Measures

The following additional mitigation measures will be applied during construction to reduce impacts from the degradation of habitats:

- A Biodiversity Action Plan is to be prepared to outline all mitigations to be applied to manage Critical Habitat species within the Project Area and Area of Influence. The management plan will address key threats to the species, including hunting, poaching, illegal logging, pollution and habitat destruction.
- Speed limits to maximum of 40 km/hr for construction vehicles will be enforced to minimise potential for fauna strike;
- Programs will be run with the community in conjunction with the Myanmar Government to reduce illegal logging.
- Commitment will be made to raise awareness of values of important species and habitat areas to construction work force and arrangements will be made for restriction of poaching and forest product collection by staff.
- All STC staff and contractors will be prevented from possession or collection of wildlife or timber products that are legally protected CITES listed, or classed as threatened by the IUCN Red List. If staff are caught with these species in their possession, they will subject to instant dismissal.
- Non-project related vehicles will be forbidden to access Company-operated roads..
- Hunting wild animals will be strictly prohibited for all staff and contractors.

Residual Impacts

Mitigation measures during operation will reduce the severity of impacts to species so as to reduce the impact to within the normal range of variation (Magnitude Negligible). Achievement of a Negligible residual impact on species is dependent on the success of biodiversity offsetting to compensate for the habitat and species values lost due to the Project. Please refer to *Annex F Biodiversity Offset Strategy* for further information.

9.5 WASTE MANAGEMENT

9.5.1 Cement Plant

Potential Impacts

Waste streams generated are expected to include:

- General wastes from the operation of the cement plant (packaging for consumables, sites waste, office waste etc.);
- General waste from the worker accommodation areas;
- Organic / food waste from workers accommodation;
- Hazardous wastes such as waste oil, lubricants and laboratory chemicals;
- Waste tyres;
- Spoil and overburden from the limestone and mudstone quarries; and
- Lime dust and alkali or chloride / fluoride containing dust build-up from the kiln (which should be able to be reintroduced into the manufacturing process)/

There are currently limited in place controls at the site for handling waste and there is no waste management plan. A basic landfill has been newly created at the cement plant for non-hazardous wastes (see *Figure 9.12*). This landfill is not lined with an impermeable layer and is therefore only suitable for inert (non-reactive) and non-hazardous waste. It is understood that residues from the ESP and baghouse are recycled into the manufacturing process and therefore do not leave the site as a waste product.

Figure 9.12 ***'Landfill' site located at the cement plant***

The impact magnitude is considered to be *medium* and the receptor sensitivity is considered to be *medium*. As such the impact significance associated with wastes generated during construction are considered to be *moderate*.

Table 9.35 Assessment of Impact related to Waste Management during the Operation

Impact	Waste generated during the operation at the cement plant may have a direct impact on the surrounding environment and secondary effects on the environment, workers and the community if not managed appropriately.				
Impact Nature	**Negative**	Positive	Neutral		
	There generation of waste is a **negative** impact from the Project.				
Impact Type	**Direct**	Indirect	Induced		
	May impact directly on the environment and have secondary effects on workers and the community.				
Impact Duration	Temporary	Short-term	Long-term	**Permanent**	
	Impacts from the use of a landfill at the site are essentially permanent.				
Impact Extent	**Local**	Regional	International		
	Impacts arising from waste management are likely to be local in nature.				
Impact Scale	Minor				
Frequency	Waste will be generated daily throughout the construction and operational phases.				
Impact Magnitude	Positive	Negligible	Small	**Medium**	Large
	The impact magnitude is expected to be **medium**				
Receptor Sensitivity	Low	**Medium**	High		
	The receptors include the environment around areas used for waste disposal areas. Waste disposal areas include the basic landfill as well as rock and overburden storage areas at the quarries. The receptor sensitivity is considered to be **Medium**.				
Impact Significance	Negligible	Minor	**Moderate**	Major	Critical
	The impact significance without further mitigation is considered to be **moderate.**				

Mitigation

A waste management plan (WMP) for the Project should be developed that shall include the following, as a minimum:

- A waste inventory should be created to establish the types of wastes;
- Identify disposal routes (including transport options and disposal sites) for all wastes generated;
- Segregate wastes and recycle wherever possible;
- Hazardous wastes should be segregated and disposed separately from non-hazardous wastes using a license contractor;
- Hazardous wastes shall be labelled and stored in sealed containers that are stored on bunded hardstand. Hazardous wastes that are unsuitable for disposal in the cement kiln (such as waste oil drums) shall be returned to the manufacturer or trucked to Mandalay for appropriate disposal at a hazardous waste facility;
- Waste oil should be used for kiln start-up;
- Organic waste for composting or use as animal feed in nearby villages;
- Waste suitable for use as fuel in the cement plant should be considered; and

- The existing landfill is not lined and should be only used for inert (non-reactive) and non-hazardous waste only.

Residual Impact Significance

By preparing a suitable WMP and ensuring its implementation throughout the operation phase the impact significance from waste generated during construction can be reduced from *moderate* to *minor.*

9.5.2 Coal Mine

Potential Impacts

The main waste generated at the mine is the removal of overburden material during the strip mining process. This overburden is set aside and used in the reinstatement of the mine area.

Other wastes generated at the mine site include small amounts general waste from the day to day operations of the mining staff.

A small amount of hazardous waste is generated at the maintenance area at the base camp from lubricating oils and equipment maintenance.

There is currently limited information regarding waste management at the coal mine.

The impact magnitude from waste generated at the coal mine is considered to be *small.* Due to the lack of information about sites for waste disposal during the operation at the coal mine the sensitivity of the receptor is considered to be *high* and therefore the impact significance is considered to be *moderate.*

Table 9.36 Assessment of Impacts related to Waste Management during the Operation

Impact	Wastes generated during the operation at the coal mine may have a direct impact on the surrounding environment and secondary effects on the environment, workers and the community if not managed appropriately.				
Impact Nature	**Negative**	Positive	Neutral		
	There generation of waste is a negative impact from the Project.				
Impact Type	**Direct**	Indirect	Induced		
	May impact directly on the environment and have secondary effects on workers and the community.				
Impact Duration	Temporary	Short-term	**Long-term**	Permanent	
	There is little information available regarding domestic waste management at the coal mine. Impacts on the environment from the storage of overburden at the mine would be long term.				
Impact Extent	**Local**	Regional	International		
	Impacts arising from waste management are likely to be local in nature.				
Impact Scale	Minor				
Frequency	Waste will be generated daily throughout the coal mine operation in the dry season. Disposal of this waste will be at regular intervals as required.				
Impact Magnitude	Positive	Negligible	**Small**	Medium	Large
	The impact magnitude is expected to be **small.**				
Receptor Sensitivity	Low	Medium	**High**		
	The waste disposal and treatment options are unknown therefore the receptor sensitivity is considered to be **high**.				
Impact Significance	Negligible	Minor	**Moderate**	Major	Critical
	The impact significance without further mitigation is considered to be **moderate.**				

Mitigation

A waste management plan (WMP) for the coal mine should be developed that includes the following, as a minimum:

- Hazardous wastes shall be transported via barge to an appropriate waste treatment facility in Mandalay;
- General waste: disposed in the local community waste facilities at the coal mine; in absence of appropriate waste sites a proper landfill should be constructed to handle inert (non-reactive) and non-hazardous waste;
- Organic waste: in small quantities may be suitable for composting or use as animal feed in nearby villages of Chaungzon and Paluzawa;

Residual Impact Significance

By preparing a suitable WMP and ensuring its implementation throughout the operation phase the impact significance from waste generated during construction can be reduced from *moderate* to *minor*.

9.6 *TRAFFIC AND TRANSPORT*

9.6.1 *Cement Plant*

Potential Impacts

Increased production at the cement plant will lead to more vehicles accessing the cement plant each day. An additional 400 vehicle movements (200 vehicles) per day to and from the site are estimated from deliveries of coal to the cement plant and the transportation of finished product.

A short traffic survey was conducted at the basecamp and access road to the Cement plant as shown in *Figure 9.13*Figure 9. the results of which are presented in *Table 9.37*. Vehicles were counted in and out of the basecamp for four representative two hour periods over 24 hours those being:

- 08:45-10:45
- 14:15-16:15
- 20:00-22:00
- 02:00-04:00

Also vehicles were counted in and out of the access road which runs from the main highway to the cement plant between the hours of 20:00 and 22:00.

Table 9.37 Traffic Survey Results

			Motorcycle		**Small Car**		**Small Truck**		**Medium Truck**		**Heavy Truck**		**Total**	
Date	Period	Location	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out
23-01-2017	08:45-10:45	Basecamp	99	112	31	52	27	39	29	27	39	26	225	256
19-01-2017	14:15-16:15	Basecamp	89	139	57	32	25	22	32	41	54	56	257	290
19-01-2017	20:00-22:00	Basecamp	20	28	25	23	17	16	15	34	43	103	120	204
20-01-2017	02:00-04:00	Basecamp	1	5	11	1	2	5	14	13	69	31	97	55
20-01-2017	20:00-22:00	Access Road	10	10	1	1	0	0	4	7	8	14	23	32

It is assumed that on the basis of efficiency the additional vehicles will fall into the category of 'heavy truck's' (those being of a gross vehicle weight greater than 32 t spread over at least three axels.

Figure 9.13 Location of Traffic Survey

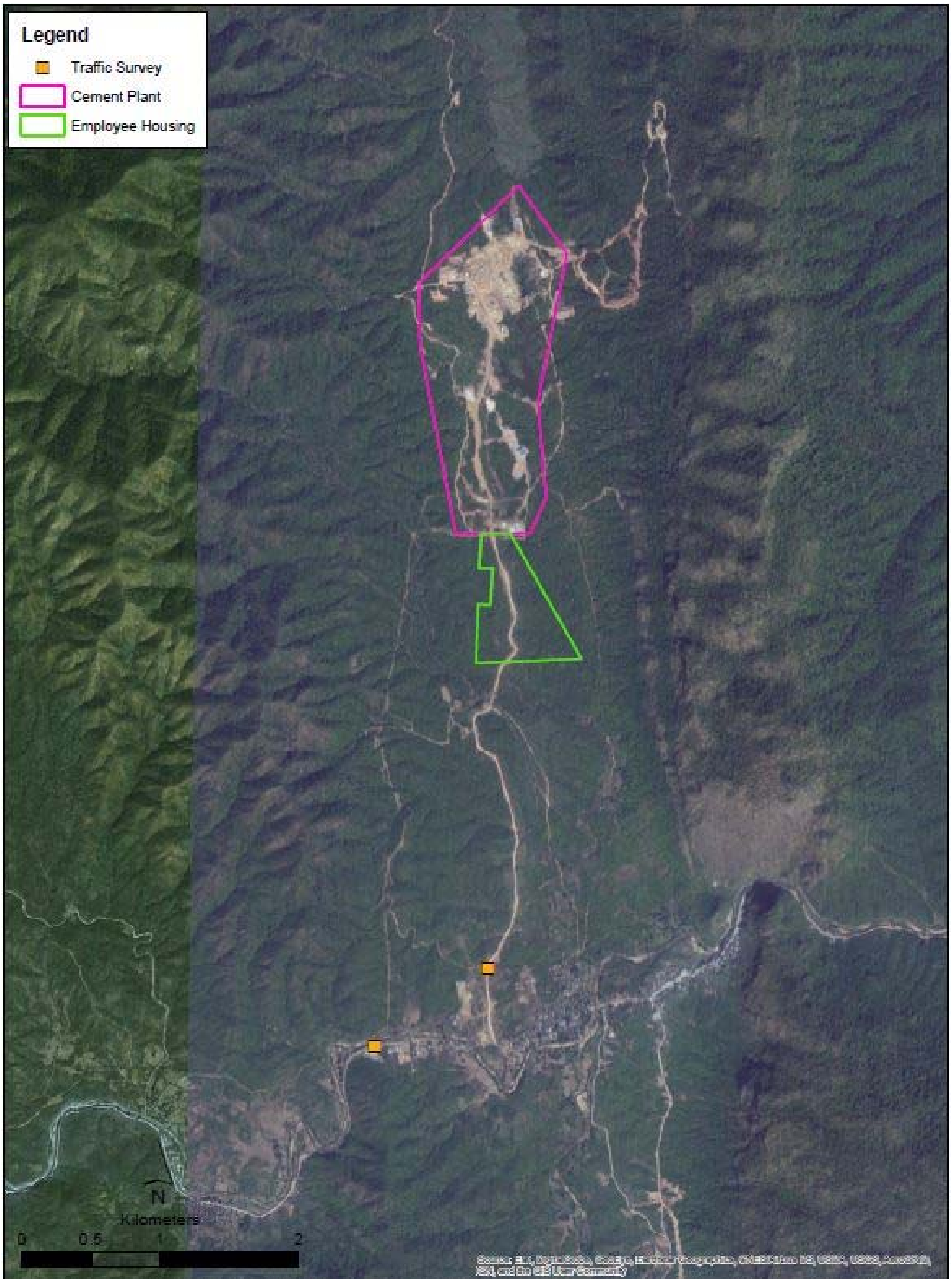


Figure 9.14 Example of a "Heavy Vehicle"

As the cement plant operation and fuel delivery is continuous, it is assumed that, for the purpose of assessment, the delivery of fuel and other consumables, and the transport of finished product is a constant flow to and from the site. As such the additional vehicles associated with the expansion to the plant will result an average of 8.3 vehicle movements per hour in both directions.

To assess the increase in relation to the baseline figures shown in *Table 9.37* we have applied the additional number of vehicles to the heavy vehicles categorisation and the total number of vehicles for the period assessed. Namely we have added 17 inbound and outbound vehicle movements to each category to assess the impact on the main road. The results are shown in *Tables 9.38-9.*

Table 9.38 Increase in heavy vehicle movements resulting from the increase on cement plant capacity

Period	**Location**	**Heavy Truck**				
		In	Out	Increase	Increase In %	Increase Out %
08:45-10:45	Basecamp	39	26	17	44%	65%
14:15-16:15	Basecamp	54	56	17	31%	30%
20:00-22:00	Basecamp	43	103	17	40%	17%
02:00-04:00	Basecamp	69	31	17	25%	55%
20:00-22:00	Access Road	8	14	17	213%	121%
Notes:						

Table 9.39 Increase in total vehicle movements resulting from the increase on cement plant capacity

Period	Location	Total Vehicles				
		In	Out	Increase	Increase in %	Increase Out %
08:45-10:45	Basecamp	225	256	17	8%	7%
14:15-16:15	Basecamp	257	290	17	7%	6%
20:00-22:00	Basecamp	120	204	17	14%	8%
02:00-04:00	Basecamp	97	55	17	18%	31%
20:00-22:00	Access Road	23	32	17	74%	53%
Notes:						

STC has taken measures to limit the amount of traffic during the construction and operation phases by providing workers accommodation blocks at the site minimising the need for daily transport to and from the plant for the workforce.

The increase in overall traffic numbers along the main highway adjacent to the basecamp from Mandalay through the village on Pyi Nyaung is thought to be well within the capacity of the road and although increases in terms of percentages look to be large for the heavy vehicle class, increases for the total number of vehicles are less pronounced and, in terms of total vehicles added to the roads the assessment would suggest that any increase overall is *moderate* at worst.

Table 9.40 Assessment of Impacts related to Traffic during the Construction

Impact	Increased traffic movements to and from the cement plant.				
Impact Nature	**Negative**	Positive	Neutral		
	Increased traffic is a negative impact from the Project.				
Impact Type	**Direct**	Indirect	Induced		
	The impact is direct on the road network.				
Impact Duration	Temporary	Short-term	Long-term	**Permanent**	
	Throughout the operation phase of the Project.				
Impact Extent	**Local**	**Regional**	International		
	The impacts will be on the local and regional road network.				
Impact Scale	Minor, 300 vehicles per day.				
Frequency	As the operation is 27/7 the impact will be daily.				
Impact Magnitude	Positive	Negligible	Small	**Medium**	Large
	The impact magnitude is expected to be **medium.**				
Receptor Sensitivity	Low	**Medium**	High		
	The road network is considered to be under capacity and therefore the receptor sensitivity is **medium.**				
Impact Significance	Negligible	Minor	**Moderate**	Major	Critical
	The impact significance is considered to be **moderate.**				

Mitigation

The following features should be incorporated into the access roads to counteract any direct and indirect impacts associated with the increase in traffic:

- Speed limits of 30 km/hr along the Access Road;
- The addition of driver amenities (toilets, rest area, convenience store, restaurant) at the site for drivers to prevent parking of large vehicles along the access road;
- Staging areas for deliveries and planned queueing areas for peak delivery times. For these areas,
    - Perimeter drains should be diverted to a multi-stage sized sedimentation pond;
    - Oil-water separator should be installed to at the outlet of the sedimentation pond; and
    - Discharges should be monitored monthly for compliance with Myanmar National Environmental Quality (Emissions) Guidelines for site runoff and wastewater discharges (for TSS, oil and grease, pH).
- Measures to prevent the development of illicit activities along the road side.

Residual Impact Significance

The residual impact significance is *minor.*

9.7 AUTO-IGNITION OF COAL AT STAGING AREAS

9.7.1 Coal Mine

Potential Impacts

Coal is stockpiled at Staging areas 1 and 2 along the Chindwin River over the dry season mining period. Coal stockpiled at these staging areas is susceptible auto oxidation resulting in heating and eventually in its ignition. This presents a health and safety risk to workers at the coal staging area and odour and air emissions from previous instances of coal fires at the coal staging area was raised as one of the main concerns during consultation with residents in Paluzawa and Nanmawke Villages. This could also be a potential concern for the coal stockpiles at the cement plant and the assessment and mitigation below are thus considered applicable to the cement plant as well.

The coal staging areas are uncovered and were expanded in 2016 to accommodate the anticipated ramp up in mining over the 2016-17 dry season.

The magnitude of the impact would be Medium as it would be relatively small scale and limited to the staging area with a low risk of spreading. Workers at the coal staging areas and local residents would be most likely to experience nuisance from odour and air emissions and are considered medium sensitivity in that they could readily avoid impacts by moving upwind in the event of occurrence. Therefore the significance of the impact is assessed to be *Moderate*.

Table 9.41 Assessment of Impact related to Spontaneous Combustion of Coal at the Staging areas

Impact	Spontaneous combustion of coal at staging areas giving rise to health and safety risks for workers and nuisance to local communities.				
Impact Nature	**Negative**	Positive	Neutral		
	The impact from the spontaneous combustion of coal would be negative.				
Impact Type	**Direct**	Indirect	Induced		
	The impact is direct on the environment.				
Impact Duration	**Temporary**	Short-term	Long-term	Permanent	
	Only applies during an incident of spontaneous combustion.				
Impact Extent	**Local**	Regional	International		
	Impact extent from air quality and safety perspective would be local				
Impact Scale	Limited to the				
Frequency	This type of incident would be **infrequent.**				
Impact Magnitude	Positive	Negligible	Small	**Medium**	**Large**
	The impact magnitude is expected to be **large.**				
Receptor Sensitivity	Low	**Medium**	High		
	Receptor sensitivity is considered to be **medium**.				
Impact Significance	Negligible	Minor	**Moderate**	Major	Critical
	The impact significance without mitigation is considered to be **moderate.**				

Mitigation

To minimise the likelihood of spontaneous combustion of coal at the staging areas and on barges, STC and its contractors shall implement the following measures:

- Coal stockpiles should be tightly packed to avoid air circulation;
- Packed in horizontal layers (up to 1 m high) and levelled by scraping and compacted by rolling to distribute the coal evenly;
- Follow "first in, first out" rule of using stock;
- The height of un-layered and un-compacted coal stockpiles < 4.5 m;
- The height of layered and packed coal stockpiles < 8m;
- Appropriate fire-fighting equipment maintained at the coal staging areas;
- Regular inspections of the coal mass including, where possible, the use of temperature probes to identify hot spots; and
- If issue of auto ignition of coal persisted after implementation of the above meaures, coal staging area should be covered to avoid direct sunlight and moisture ingress;

Residual Impact Significance

Implementation of the above measures will reduce the likelihood of spontaneous combustion and the associated risks to workers and local residents from *moderate* to *minor.*

9.8 *EXTRACTION OF FOREST RESOURCES*

9.8.1 *Cement Plant & Coal Mine*

Potential Impacts & Benefits

The operation of the existing cement plant and planned expansion as well as the operation of the coal mine is likely to have both benefits and impacts to local communities. The consultation undertaken for the ESIA indicates that communities in Pyi Nyaung appreciate the employment benefits that the project has (and will) bring and also the investments that STC has made in the local clinic and other community infrastructure. In Kubyin, Chaungzon and Paluzawa, virtually all residents were satisfied with the improved access that upgrading of the road has provided in terms of improving access. This has created significant economic opportunity for residents Kubyin, Chaungzon and Paluzawa particularly in relation to the extraction of timber, firewood and other forest resources.

Concerns were raised from community members in Kubyin and Pyi Nyaung in particular in relation to improved access to forest resources in and beyond Kubyin to outsiders leading to logging.

Deforestation is one of Myanmar's most pressing environmental issues. The Food and Agriculture Organization of the United Nations reports that Myanmar lost almost 1% of its forest per year between 1990 and 2010. Much of the timber extracted is destined for export markets in neighboring Thailand and China. In 2014, Myanmar banned export of raw timber logs to slow the rate of deforestation across the country.

Both legal and illegal timber extraction have been occurring in the vicinity of the cement plant for decades before the start of the project. However, the upgrading of the access road has improved access to forest resources. The introduction of vehicles and machinery to areas that were previously inaccessible or accessible only by bullock cart has resulted in rapid deforestation at both sites. Residents in Kubyin reported an increase in "outsiders" coming to the area in search of timber (in particular, teak) since Shwe Taung had constructed and/or upgraded access roads.

The economic incentives of illegal timber extraction are compelling for local residents as evidenced by the fact that no residents of Kubyin village (the closest village to the cement plant) are employed by / willing to work with STC. Residents reported that incomes are readily available through the extraction of timber via roads that have been built or upgraded by Shwe Taung (see ***Table 9.42***).

Table 9.42 Market Price of Forest Products vs Wages at STC

Item	Market Price (MMK)
Length of regular bamboo	100
Length of elephant bamboo	1,500
Small tree (kiln fuel)	5,000
Large teak tree	120,000-150,000
Minimum Daily Wage at STC	3,600-5,000

Source: Interviews with residents in Kubyin Village, 2016

However, improved access has also resulted in increased timber extraction by both residents in Kubyin and Pyi Nyaung Villages and those from further afield. In 2015-16, Kubyin residents cut a road along further north from Kubyin Village along the valley floor to access new forest resources due to the depletion of large trees around Kubyin Village. Residents in Kubyin reported that the rate of timber extraction is now unsustainable.

The increase in timber extraction north of the Kubyin Forest Reserve and in the vicinity of the coal mine is considered by ERM to be an induced impact of the Project, facilitated by the upgrading of the road between Pyi Nyaung and the cement plant and the construction of the bypass road to Kubyin Village and construction of the proposed road from Namwake to the coal mine. The magnitude of the impact is Medium and the sensitivity is High, giving rise to an impact of Major significance.

Table 9.43 Assessment of Impact related to Extraction of Forest Products

<table>
<tr><td>Impact</td><td colspan="5">Extraction of timber, firewood and other forest products impacts biodiversity</td></tr>
<tr><td rowspan="2">Impact Nature</td><td>Negative</td><td colspan="2">Positive</td><td colspan="2">Neutral</td></tr>
<tr><td colspan="5"></td></tr>
<tr><td rowspan="2">Impact Type</td><td>Direct</td><td colspan="2">Indirect</td><td colspan="2">Induced</td></tr>
<tr><td colspan="5">The impact is induced by the activities of Shwe Taung Group by upgrading roads and facilitating access to forest resources by local residents and those from further afield.</td></tr>
<tr><td rowspan="2">Impact Duration</td><td>Temporary</td><td>Short-term</td><td colspan="2">Long-term</td><td>Permanent</td></tr>
<tr><td colspan="5">The impact would occur on a long-term to permanent basis</td></tr>
<tr><td rowspan="2">Impact Extent</td><td>Local</td><td colspan="2">Regional</td><td colspan="2">International</td></tr>
<tr><td colspan="5">The availability of forest products via the upgraded access roads is attracting outsiders from larger regional centres to Project sites in search of hardwood timber, in particular.</td></tr>
<tr><td>Impact Scale</td><td colspan="5">The scale of the impact is generally limited to within 5-10km of project facilities.</td></tr>
<tr><td rowspan="2">Impact Magnitude</td><td>Positive</td><td>Negligible</td><td>Small</td><td>Medium</td><td>Large</td></tr>
<tr><td colspan="5">Impact is of Medium magnitude.</td></tr>
<tr><td rowspan="2">Receptor Sensitivity</td><td>Low</td><td colspan="2">Medium</td><td colspan="2">High</td></tr>
<tr><td colspan="5">Given the ecological sensitivity of the areas impacted and the presence of EN and CR species, the sensitivity of the receptor is considered high.</td></tr>
<tr><td>Impact Significance</td><td>Negligible</td><td>Minor</td><td>Moderate</td><td>Major</td><td>Critical</td></tr>
</table>

Mitigation

STC shall:

- Develop and implement a corporate policy to prohibit the extraction, purchase, use or trade of illegal timber;

- Prevent access to the following Company managed roads to <u>mechanised logging vehicles/equipment:</u>

    - coal mine access road;

    - limestone & mudstone quarry roads; and

    - existing and future revegetated/offset areas.

- *Note: This restriction is not intended to prevent collection of firewood and non-timber forest products by local residents.*

- Recognising that the road between Pyi Nyaung Village and the cement plan is a public road, STC will discuss and agree with Forest Department how the Company can support the Forest Department prevent access by illegal loggers.

- Where appropriate to do so, STC will support efforts to assist local communities to transition from illegal logging to more sustainable livelihoods through job training, sustainable forest product harvesting programmes, or other means.

- It is recommended that Shwe Taung study all feasible alternatives to construction of a new access road from Namwake Village to the coal mine, including transportation of coal from the mine to the river port via the existing access road via Phase 1 of the mine. In addition to the loss of some 15ha of Natural Habitat, construction of this road is likely to indirectly open access to logging and hunting.

Residual Impact

Implementation of the mitigation measures above will prevent extraction of timber using STC owned/managed roads. It is considered that this can be reduced to a Moderate level within STC's controlled area, on the basis that small scale extraction of forest products will still occur by local residents. While STC will support the Forest Department to control logging within its sphere of influence (ie public roads used and maintained by STC), the residual impact is likely to remain Major in the absence of equivalent alternative income generating opportunities for this currently involved in the extraction and/or trade in timber.

9.9 INFLUX MANAGEMENT

Project induced influx (in-migration) can be a significant issue for the construction and operation of capital projects in developing countries, straining local infrastructure and often causing tension with local residents. Based on a screening level assessment of the factors that indicate a heightened level of influx as identified in IFC's *Handbook for Addressing Project-Induced In-*

Migration (2009), ERM considers that influx is not likely to be a significant ongoing issue for the project, because:

- There is little evidence of ongoing influx at the existing STC plant that suggests that influx is likely to be, at worst, a construction phase issue for the Phase 2 expansion. Within accommodation area for the families of temporary workers to the west of the guardhouse, three of four families operate small shops and tea houses that serve workers and contractors. These are all within the designated area for workers' families.

- A lack of alternative employment opportunities in the wider area increases the risk of project induced influx. While important for the local economy, STC is not the major employer within the Village Tract or wider area. STC employs only 17 permanent workers from Pyi Nyaung Village and none from Kubyin, since there are other economic opportunities available in the wider area, including lime manufacturing in Pyi Nyaung Village and extraction of forest resources in the wider area.

- During consultation, local residents raised concerns about "outsiders" coming to the area, however, this was in the context of those seeking to exploit forest resources. Those seeking to exploit forest resources may camp for several days in remote parts of the forest but do not settle near STC's plant or in the nearby villages;

- In-migration to Kubyin is tightly controlled by the Forest Department.

Table 9.44 Assessment of Impacts Related to Project Induced Influx

Impact	Impacts associated with Project-induced influx include a strain on infrastructure, law and order issues and tension with local residents				
Impact Nature	**Negative**	Positive	Neutral		
	Project induced influx tends to have a negative effect in low income countries				
Impact Type	Direct	Indirect	**Induced**		
	The impact may be induced by the demand for goods and services for the expansion of the STC plant during both the construction and operation phases.				
Impact Duration	Temporary	Short-term	**Long-term**	Permanent	
	The impact may range from a temporary over the construction period to a longer-term issue during operations if those migrating to the area decide to settle.				
Impact Extent	**Local**	Regional	International		
	At worst, the impact would affect the immediate area around the cement plant and Pyi Nyaung. Migration into Kubyin is not expected as migration to this area is strictly controlled by the Forest Department.				
Impact Scale	The scale of the impact is generally limited to within 5-10km of project facilities.				
Impact Magnitude	Positive	Negligible	**Small**	Medium	Large
	Impact is of **Small** magnitude.				
Receptor Sensitivity	Low	**Medium**	High		
	Those most likely to be affected would be STC workers living in the worker camps and newly constructed accommodation quarters and are of medium to low sensitivity.				
Impact Significance	Negligible	**Minor**	Moderate	Major	Critical

Mitigation

While the impact is predicted to be *Minor,* both the construction and operations phases will see an increased demand for workers, goods and services that will need to be met and it would be prudent for STC to follow good practice to reduce the likelihood of influx during construction and operations, as follows:

- Advertise employment positions (both permanent jobs and day labour during construction) in Pyi Nyaung and do not employ casual day labour at the gate. Cascade this requirement to construction contractors.
- During construction, all workers to be housed in construction camps within the cement plant. Temporary workers and day labourers will not be employed from any informal settlements on the road between Pyi Nyaung and the cement plant, should these appear.
- During operations, staff will be housed in the new staff accommodation quarters within the plant or hired from neighbouring villages. Staff will not be employed from any informal settlements on the road between Pyi Nyaung and the cement plant, should these appear.
- Truck parking bays shall be provided on the inside of the guardhouse. Toilets and basic facilities shall be provided for drivers to rest outside their trucks.
- STC should liaise with the local government to discourage informal settlements on the road from Pyi Nyaung to the cement plant. Guards at the plant guardhouse shall discourage the setting up of settlements or businesses within the vicinity of the guardhouse.

Residual Impact

The residual impact is considered *Negligible*.

10 LAND ACQUISITION REVIEW

10.1 LIVELIHOOD IMPACTS FROM CEMENT PLANT AND ASSOCIATED QUARRIES

The following sections describe the use of the site by local residents based on information provided by STC, observations on site and consultation with village leaders and a sample survey of 100 households.

There was no physical resettlement at any of the sites currently occupied and none will be required for the Phase 2 expansion. All land occupied and to be occupied in the future was leased from the Forest Department (now part of MONREC).

Cement Plant: The site occupies an area of approximately 400 acres and was extended by 55 acres for the new worker accommodation quarters to the south of the existing guardhouse. The site was leased from the Forest Department for ten years (extendable) and was previously part of the Kubyin Forest Reserve. A small part of the site was replanted teak protection area and this was excised by the Forest Department. The site had been logged (legally and illegally) for decades. There was also a small amount of farmland on the valley floor being used by residents of Pyi Nyaung Village, however land ownership belonged to the Forest Department. It is understood that three to four households received compensation for land and crops from STC when constructing the access road to the cement plant site commenced. According to the leader of Pyi Nyaung Village, residents were satisfied with the arrangements since they received compensation for loss of crops and also partial compensation for land which was owned by the Forest Department but that was reportedly compensated by STC as a goodwill gesture. These households were not able to be identified during the household surveys undertaken for the Supplementary ESIA.

The Phase 2 expansion of the cement plant will extend the existing footprint to the east towards the limestone quarry to accommodate a new primary crusher, conveyor and storage area. The kiln and main processing facilities will be constructed within the existing footprint. The Phase 2 expansion will be entirely within the existing concession and is not used by local residents.

While logging was illegal at the site prior to STC's leasing of the site, the area was previously used to collect firewood by residents of Kubyin and Pyi Nyaung Villages for domestic use and for fuel for lime kilns in Pyi Nyaung Village. Prior to STC's purchase of the site, it was accessible to residents of Kubyin (64 households) of Pyi Nyaung (605 households) only on foot or bullock cart. The main plant site and Phase 2 expansion area is not presently used by local residents since access is restricted by a guardhouse. Please refer to *Section 9.8* for assessment of impacts related to extraction of forest resources.

Mudstone Quarry: STC has a mudstone quarry concession leased from the Forest Department for 10 years. It is directly west of the cement plant and occupies an area of 165 acres. This is currently being operated and will be extended downslope towards the cement plant in the future.

The concession was leased from the Forest Department. Once operational, STC must pay the Forest Department to offset the loss of forest cover with an area equal to 20% of the concession that is to be planted with teak forest. This area has been established on the west side of the road opposite the guardhouse. Note that this offset is considered as a forestry offset and is not for the purposes of biodiversity offsetting.

The forest area in the vicinity of the mudstone quarry is accessed through the by-pass road to collect bamboo and firewood by residents of Kubyin and Pyi Nyaung Villages for domestic use and (mainly by Pyi Nyaung residents) for fuel of lime kilns in Pyi Nyaung Village. The by-pass road was built by STC for improving safety and infrastructural development for the population in Kubyin village as part of STC's CSR programme.

Limestone Quarry: STC's limestone quarry concession is 600 acres (25 years) occupying the ridgeline to the east of the cement plant. At present, the company has quarried one of four hills. The quarry will be expanded first to the south of the existing worked area, followed by the hill to the north. The quarry area itself was previously inaccessible and hence operations of the limestone quarry did not result in impacts to the livelihoods of local residents.

STC has applied to the Forest Department to offset the loss of forest cover with an area equal to 20% of the limestone concession that is required. This land has not yet been allocated.

Summary: The cement plant and mudstone quarry concession are among several areas that households in Kubyin and Pyi Nyaung Village collect firewood for domestic use and, more intensively, for fuel for the lime kilns in Pyi Nyaung Village. The establishment of STC has affected those collecting firewood for limekilns both positively and negatively. On the one hand, access to forest resources northwest of Pyi Nyaung Village has been improved by the construction of a concrete access road. Residents can now access the area by small motor vehicles which are much more efficient than the bullock-carts previously used. STC also employs 17 permanent workers from Pyi Nyaung Village and employed over 100 for the construction phase. On the other hand, STC's cement plant and mudstone quarry may have resulted in a loss of resources for residents. The 6 km distance between the plant and Pyi Nyaung Village and the fact that residents collect wood from several different areas, suggest that the dependency of Pyi Nyaung Village residents on the forest resources occupied by STC is likely low to moderate. This was confirmed by discussions with village leaders and through the engagement with 50 households in Kubyin and Pyi Nyaung villages who generally confirmed that they collect firewood from multiple locations and are not heavily dependent on any given area.

Improved access has also resulted in increased timber extraction (as opposed to firewood collection) which is understood to be a main source of income for Kubyin Village and a significant source of income for residents of Pyi Nyaung Village. Based on observations and discussions with village leaders and local residents, it is ERM's view that loss of income from restriction of access to the forest resources that now comprise STC's concessions for the plant and mudstone quarry has been more than offset by the employment offered at STC's operations and the improved access to forest resources that the concrete access road has provided. While it is unknown what portion of the income generated from timber extraction is captured by local residents as opposed to "outsiders" those consulted generally stated that a higher income could be generated from timber extraction than from working at STC's plant.

10.2 LIVELIHOOD IMPACTS FROM THE COAL MINE

Land leased for the mine concession and associated facilities is as follows:

- **Mine Concession:** 3,378.2 acres leased from the Ministry of Mines for a mining concession of 25 years (extendable in ten year intervals). This includes all currently worked areas and future phases of the strip mine.

- **Base Camp:** 8 acres leased for base camp leased from Union Forest Department (now MONREC).

- **Permanent Coal Staging Area #1:** 14 acres in Paluzawa Village for the permanent coal dump leased from the Department of Agricultural Land Management and Statistics. Previously pastureland and there were no crops and hence no compensation paid.

- **Permanent Coal Staging Area #2.** An area of 2.54 acres of farmland in Nanmawke Village was converted for use by Shwe Taung and standing crops were compensated. These households were not identified during baseline surveys.

- **Access Roads:** Both the existing access road and new road under construction require a permit from the Forest Department but do not need a formal lease agreement or compensation paid to the Forest Department.

While all land was leased from government departments, there is understood to have been a small portion of the overall lease holdings that were used for cropping. It is understood that land in Nanmawke was used for shifting cultivation by local farmers who did not have land ownership certificates. This land was transferred to Shwe Taung by the Department of Land Administration and Statistical Department of Kalaywa Township.

Summary: Prior to the commencement of mining at Shwe Taung's concession, the coal mine concession itself was previously inaccessible to local communities (1) and hence ERM does not consider that there has been (or will be) livelihood impacts as a result of loss of forest resources from the coal concession. There is no need for additional livelihood restoration measures at the coal mine concession.

A small portion of Shwe Taung's total lease holding in Nanmawke Village was previously used for shifting cultivation. It is understood that this may have affected less than 10 households however ERM was not able to identify these households during baseline surveys.

(1) Kokent Golden Dragon Company upgraded an existing logging road running from Paluzawa Village to Shwe Taung's Base Camp to access a separate concession. Shwe Taung Group subsequently constructed the section from the base camp to Phases 3 and 4 of the concession which have been mined to date. .

11 *ENVIRONMENTAL AND SOCIAL MANAGEMENT PLAN*

Through a systematic assessment, the Supplementary ESIA has identified a number of significant environmental and social impacts that are predicted to result from the construction and operation of the Project. In order to manage and mitigate these impacts, a range of measures have been developed to reduce the overall residual impacts to acceptable levels and as low as reasonably practicable. These measures are contained within this Environmental and Social Management Plan (ESMP) that will be used by STC to implement and track the effect of these management and mitigation measures included in the Supplementary ESIA.

11.1 *OBJECTIVES*

The key objectives of this ESMP are to:

- Collate the various mitigation and management measures developed throughout the EIA into a single point;
- Identify all of the detailed management plans which will need to be developed for implementation throughout the construction and operation phases of the Project;
- Define monitoring requirements to determine the efficiency of all mitigation and management measures; and
- Provide clarity to all stakeholders as to what impacts have been identified, how they will be mitigated and managed, and through what means.

11.2 *SCOPE OF THIS ESMP*

The scope of this ESMP covers both construction and operation phases of the Project, which have the potential to affect, positively or negatively, the environment and communities in which the Project will operate.

As required by this ESMP, various management plans will be developed and implemented for each specific phase of the Project. The responsibility for the implementation of these plans will lay variously with the STC and contractors. It is noted that this is only a framework ESMP into which the full range of management and monitoring activities will eventually fit into.

11.3 *SUMMARY OF IMPACTS AND MITIGATION MANAGEMENT MEASURES*

A summary of mitigation measures identified for the construction and operation phases of the Project is presented in *Table 11.1*. This also identifies lead responsibility for implementing the mitigation measures. Many of the mitigation measures are associated with good construction, operation and/or housekeeping practices.

STC will be responsible for ensuring that the mitigation measures in the ESMP are implemented throughout the life span of the Project.

11.4 DETAILED MANAGEMENT PLAN

Based upon the outcomes of the EIA, detailed management plans are required to guide STC and its contractors in the implementation of all mitigation and management measures. This is essential to ensure that the key outcomes of the impact assessment process are put in place throughout the life of the Project, and their overall efficacy tracked. These detailed management plans will be used by contractors to develop their own management plans.

As identified with the summary of impacts and mitigation and management measures, the following detailed management plans are considered necessary to effectively implement the outcomes of the EIA throughout the life of the Project:

- Contractor Management Plan;
- Biodiversity Action Plan;
- Spill Response Plan;
- Waste Management Plan;
- Mine and Quarry Rehabilitation Plan; and
- Environmental and Social Monitoring Plan.

It is intended that these documents will be prepared to cover the construction and operation phase of the Project. Specific plans will be disclosed to stakeholders at the appropriate time, which should be determined within the individual plans.

Table 11.1 Environmental and Social Management Plan of the Project

Item No.	Affected Aspect	Affected Area	Potential Impacts	Proposed Mitigation Measures (if applicable)	Implementation Schedule	Responsibility for Mitigation Implementation	Responsibility for supervision of mitigation implementation	Reporting Requirements
A	**Construction Phase**							
1	Air Quality	Cement Plant and associated quarries	Dust impacts	Dust suppression procedures so minimise impacts to air quality shall include: • Water suppression should be used on exposed open earthworks when rainfall is less than 0.25 mm in a 24 hour period and wind speeds are forecast to be more than 19 kph; • Where unpaved roads are utilised by vehicles, water suppression at a rate of 2 litres/m2/hr should be used where rainfall of less than 2 mm in the last hour has occurred; • Wheel washing bays shall be installed at the cement plant guardhouse before to avoid construction vehicles tracking dirt onto public sealed roads and generating dust; • Vehicles transporting dusty materials should be covered; • Stockpiling of material, for example, rocks, sand and soils should be minimised; • Design of stockpiles should be optimised to retain a low profile with no sharp changes in shape; and • Drop heights of material should be minimised.	Construction	Contractor	STC HSE Department	Monthly Report
2	Waste Management	Cement Plant and associated quarries	Waste management	A waste management plan (WMP) for the Project should be developed that sets out plans and actions for construction waste as follows: • Good housekeeping practices for waste storage and handling referencing GIIP; • The WMP should include a waste inventory developed in the planning stage, in discussion with the engineers, to establish the types of wastes expected from the construction and to identify appropriate disposal routes; • Construction materials will be managed in a way to avoid over-ordering, poor storage and maintenance, mishandling as well as improper operation procedures; • Construction wastes will be separated into reusable items and materials to be disposed of or recycled whenever possible; • Waste suitable for reuse will be stored on site and reintroduced to the construction process as and when required; • The WMP will identify disposal routes (including transport options and disposal sites) for all wastes generated during the construction phase; • A hazardous waste management system covering waste classification, separation, collection, storage, transfer and disposal should be set up and operated. The waste management system will comply with applicable regulation of the government, if any, or in its absence, GIIP; • Hazardous waste will be stored in such a way as to prevent and control accidental release to the environment (e.g. secondary containment, sealed containers); • Wastewater should be stored in such a way as to avoid contaminating surface and groundwater sources. It should be collected regularly and taken offsite for treatment at a suitable facility; • Waste will be collected regularly by reputable waste collectors; • Recyclables such as scrap steel, metals, plastics, and paper items will be collected for recycling wherever possible; • Disposal of construction waste in or off the construction site should be prohibited; • Chain of custody documents should be used for construction waste to monitor disposal; and • Waste segregation should be practiced at the workers camps with an emphasis placed on reducing, reusing and recycling of waste streams as appropriate.	Construction	Contractor	STC HSE Department	WMP Monthly Report
3	Biodiversity	Limestone Quarry and within existing right of way for 66kV transmission line	Permanent and temporary loss of habitat during construction	The following mitigation measures will be applied in relation to the permanent and temporary loss of habitat during construction: • Education of staff and workers of all rules, regulations and information concerning the	Construction	Contractor	STC HSE Department	Biodiversity Action Plan Monthly Report

Item No.	Affected Aspect	Affected Area	Potential Impacts	Proposed Mitigation Measures (if applicable)	Implementation Schedule	Responsibility for Mitigation Implementation	Responsibility for supervision of mitigation implementation	Reporting Requirements
			Degradation of habitats	restriction clearing outside of the Project footprint is to occur; • Application of the Clearance Protocol (Annex E4) is to be applied to all clearance activities; • The planned clearance area for the construction works shall be clearly identified and marked to avoid accidental clearing; • Construction Contractor will schedule and implement routine inspection program throughout construction period to monitor clearing extent; • Use of the access road should be restricted to construction vehicles only. Checkpoints should be used to manage access and inspect vehicles for timber and wood products. The following additional mitigation measures will be applied during construction to reduce impacts from the degradation of habitats: • Wheel wash bays will be installed at the guardhouse at the cement plant to remove dirt and plant material from vehicle wheels prior to entering and leaving the Project Area. • Invasive species within Natural Habitats should be eradicated where possible. Appropriate use of herbicides may be used to control invasive species within the Project Area in accordance with the safe use and label directions of the herbicides. • Monitoring of invasive species is to occur within the Project Area on an annual basis. New infestations identified are to be controlled. • A Biodiversity Action Plan will be required for Critical Habitat triggers. This plan is to be prepared to outline measures to be applied to manage these species within the Project Area and Area of Influence. The management plan will address key threats to the species, including hunting, poaching, illegal logging, pollution and habitat destruction. Speed is to be limited to 40 km/hr for construction vehicles on company operated roads to minimise potential for fauna strike; • Commitment will be made to raise awareness of values of important species and habitat areas to construction work force and arrangements will be made for restriction of poaching and forest product collection by staff. Hunting wild animals will be strictly prohibited for all staff. • Non-project related vehicles will not be permitted to enter company-operated roads during construction.				
4	Waste Management	Coal Mine	Waste Management	• If suitable waste disposal sites are not available in the locale of the coal mine then this waste should be transported back to Mandalay where more suitable recycling, treatment and disposal facilities can be found.	Construction	Contractor	STC HSE Department	Monthly Report
B	**Operation Phase**							
1	Air Quality	Cement Plant – Kiln System	Stack emission	• The discharge to the kiln stack at both the new and existing plant will be fitted with continuous emission monitoring capable of real-time measurement of NO_2, SO_2, Particulate Matter and O_2 and transmitted to the operator control room. • The new kiln stack shall be fitted with sampling platform and two sampling ports at 90 degrees. Sampling ports should be four-inch (minimum) inner diameter threaded pipe connections with a cap. • Emission concentrations of NOx, SO_2 and PM from the existing and proposed kiln system and clinker cooler will not exceed those outlined in the Myanmar national Environmental Quality (Emission) Guidelines (2015) for cement and lime manufacturing and should be further reduced as far as practicable. • NOx emissions from the kiln system should be controlled by maintaining secondary air flow as low as possible and using low NOx burners to avoid localized emission hot spots..	Operation	Cement Plant Design and Operation Teams	STC HSE Department	Design specifications of new plant Monthly Report Monitoring Report
2	Air Quality	Cement Plant - Material Handling and Storage of Raw and	Dust impacts	• Reduce the number of martial transfer points by simple, linear layout for material handing operations; • Use of enclosed belt conveyors for material transportation and emission controls at	Operation	Operation Team	STC HSE Department	Monthly Report

Item No.	Affected Aspect	Affected Area	Potential Impacts	Proposed Mitigation Measures (if applicable)	Implementation Schedule	Responsibility for Mitigation Implementation	Responsibility for supervision of mitigation implementation	Reporting Requirements
		Finished Materials		transfer points; • Regular cleaning of conveyor belt systems; • Crushed and blended raw materials should be stored in covered or closed bays; • Pulverized coal should be stored in silos; • Clinker should be stored in covered or closed bays or silos with dust extraction; • Routine plant maintenance to keep air leaks and spills to a minimum; • Material handling processes including crushing operations, raw milling and clinker grinding should be undertaken in enclosed systems maintained under negative pressure by exhaust fans. Dust should be removed using cyclones and bag filters; and • Implementation of automatic bag filling and handling systems.				
3	Air Quality	Cement Plant - Kiln Systems, Clinker Coolers and Mills	Dust impacts	• The use electrostatic precipitators (ESPs) or fabric filter systems to collect and control fine suspended particulate emissions in the kiln gases; • -The use of cyclones to separate larger particulates of cooler gases followed by fabric filters; and finally • Mill dust should be captured and recycled using fabric filters within the mill.	Operation	Operation Team	STC HSE Department	Monthly Report
4	Air Quality	Limestone and Mudstone Quarries	Dust impacts	• Water suppression should be used on unpaved roads and work areas in dry and windy conditions; • Storage of dusty materials (i.e. stockpiles) should be enclosed or operated with efficient dust suppression measures; • Stockpile heights should be kept to a minimum; and • Drop heights during loading and transfer of materials should be minimized and shielded against the wind.	Operation	Operation Team	STC HSE Department	Monthly Report
5	Waste Management	Cement Plant and associated Quarries	Waste Management	A waste management plan (WMP) for the Project should be developed that shall include the following, as a minimum: • A waste inventory should be created to establish the types of wastes; • Identify disposal routes (including transport options and disposal sites) for all wastes generated; • Segregate wastes and recycle wherever possible; • Hazardous wastes should be segregated and disposed separately from non-hazardous wastes using a license contractor; • Hazardous wastes shall be labelled and stored in sealed containers that are stored on bunded hardstand. Hazardous wastes that are unsuitable for disposal in the cement kiln (such as waste oil drums) shall be returned to the manufacturer or trucked to Mandalay for appropriate disposal at a hazardous waste facility; • Waste oil should be used for kiln start-up; • Organic waste for composting or use as animal feed in nearby villages; • Waste suitable for use as fuel in the cement plant should be considered; and • The existing landfill is not lined and should be only used for inert (non-reactive) and non-hazardous waste only.	Operation	Operation Team	STC HSE Department	Monthly Report
6	Biodiversity	Cement Plant and associated Quarries	Permanent and temporary loss of habitat and fragmentation and edge effect	The following mitigation is required for permanent and temporary loss of habitat • Rehabilitation of habitat will occur within the landscape disturbed by Project operations. All rehabilitation is to occur using native indigenous species as appropriate. A nursery is to be established to propagate species. All rehabilitation is to be established in a progressive basis as quarrying activities occur. All rehabilitation will be monitored to determine the success/failure of different techniques. Rehabilitation will be adapted based on the results of the monitoring. • All habitat clearance during quarrying/mining operations is to be clearly marked prior to excavation. • A Wildlife clearance protocol (Annex E4) is to be applied during all operations that clear Critical Habitat and Natural Habitat. • Education and awareness activities are to be undertaken with local people to provide	Operation	Operation Team	STC HSE Department	Monthly Report

Item No.	Affected Aspect	Affected Area	Potential Impacts	Proposed Mitigation Measures (if applicable)	Implementation Schedule	Responsibility for Mitigation Implementation	Responsibility for supervision of mitigation implementation	Reporting Requirements
				information regarding illegal logging controls. • Regular patrols (at least every month) of the Project boundary will be undertaken to identify any incursion by local people into the Project Area and surrounding forested area. The following mitigation is required for fragmentation and edge effects: • Measures regarding managing dust, noise, vibration recommended in this ESIA are to be applied during operations in Critical Habitat and Natural Habitat. • Design of lighting will be directed away from vegetated areas and habitats. Upward lighting will be avoided and lights will not be left on after hours when not required.				
7	Traffic	Cement Plant and associated Quarries	Increase in traffic	• Speed limits of 40 km/hr along the Access Road. • The addition of driver amenities (toilets, rest area, convenience store, restaurant) at the site for drivers to prevent parking of large vehicles along the access road. • Staging areas for deliveries and planned queueing areas for peak delivery times, For these areas, o Perimeter drains should be diverted to a multi-stage sized sedimentation pond; o Oil-water separator should be installed to at the outlet of the sedimentation pond; and o Discharges should be monitored monthly for compliance with Myanmar National Environmental Quality (Emissions) Guidelines for site runoff and wastewater discharges (for TSS, oil and grease, pH). • Measures to prevent the development of illicit activities along the road side.	Operation	Operation Team	STC HSE Department	Monthly Report
8	Surface Water Quality	Cement Plant - Limestone and Mudstone quarries	Surface runoff	• Construction of a dedicated drainage network to intercept and diver runoff; • Divert runoff from the mudstone quarry to an appropriately sized and maintained sedimentation pond to allow adequate retention time for suspended solids to settle; • Divert runoff from the limestone quarry to the wetland created by STC via a weir to remove suspended solids before entering the wetland; • Baffles or other measures to reduce the velocity of runoff down hill slopes should be installed to minimise scouring; • Exposed areas and overburden dumps should be revegetated as quickly as possible.	Operation	Operation Team	STC HSE Department	Monthly Report
9	Surface Water Quality	Cement Plant - Coal Storage Are and Materials Handling Yards	Surface runoff	• All areas used to store and/or handle coal, laterite and limestone should be paved and surrounded by perimeter drains; • Perimeter drains should be diverted to a multi-stage sized sedimentation pond; • Oil-water separator should be installed to at the outlet of the sedimentation pond; and • Discharges from the coal staging area should be monitored monthly for compliance with Myanmar National Environmental Quality (Emissions) Guidelines for site runoff and wastewater discharges (for TSS, oil and grease, pH).	Operation	Operation Team	STC HSE Department	Monthly Report Monitoring Report
10	Surface Water Quality	Cement Plant - Fuel Storage Area	Spill and surface runoff	• Lightning protection should be installed at all areas used to store bulk fuel and other flammables; • The fuel storage facility should be constructed on bunded hardstand with containment sufficient for 110% of the volume of the single largest tank; • Discharges from this bunded area should pass through an oil-water separator; • A Spill Response Plan should be developed and implemented; and • Discharges from the coal staging area should be monitored monthly for compliance with Myanmar National Environmental Quality (Emissions) Guidelines for site runoff and wastewater discharges (for TSS, oil and grease, pH).	Operation	Operation Team	STC HSE Department	Monthly Report Monitoring Report Spill Response Plan
11	Surface Water Quality	Cement Plant	Industrial wastewater discharge	• Discharges from the cement manufacturing process should be treated and monitored monthly for compliance with effluent levels specified in WBG EHS Guidelines for Cement and Lime Manufacturing (2007) (for pH, TSS and water temperature).	Operation	Operation Team	STC HSE Department	Monitoring Report
12	Surface Water	Cement Plant	Sanitary wastewater	• Sanitary wastewater (includes toilet, sink, shower, and kitchen flows) should not be	Operation	Operation Team	STC HSE Department	Monthly Report

Item No.	Affected Aspect	Affected Area	Potential Impacts	Proposed Mitigation Measures (if applicable)	Implementation Schedule	Responsibility for Mitigation Implementation	Responsibility for supervision of mitigation implementation	Reporting Requirements
	Quality			directly discharged to any water bodies. • Sanitary wastewater should be treated in septic system properly designed and maintained according to WBG Genera EHS Standards (2007) as follows: o Installed in areas with sufficient soil percolation for the design wastewater loading rate; o Installed in areas of stable soils that are nearly level, well drained, and permeable, with enough separation between the drain field and the groundwater table or other receiving waters; o Grease trap should be installed at sources where oily water is expected (e.g. kitchen); and o Residual sludge should be collected and disposed of properly. • Should treated wastewater to be reused as spray water, they should be monitored monthly for compliance with Myanmar National Environmental Quality (Emissions) Guidelines for site runoff and wastewater discharges (for TSS, oil and grease, pH).				Monitoring Report
13	Air Quality	Coal Mine and associated Stockpiling Area	Dust impacts	• Water suppression should be used on unpaved roads and work areas in dry and windy conditions; • Storage of dusty materials (i.e. stockpiles) should be enclosed or operated with efficient dust suppression measures; • Stockpile heights should be kept to a minimum; and • Drop heights during loading and transfer of materials should be minimized and shielded against the wind.	Operation	Operation Team	STC HSE Department	Monthly Report
14	Biodiversity – degradation of habitats	Coal Mine	Degradation of habitats	• Rehabilitation of habitat will occur within the landscape disturbed by Project operations. All rehabilitation is to occur using native indigenous species as appropriate. A nursery is to be established to propagate species. All rehabilitation is to be established in a progressive basis as quarrying activities occur. All rehabilitation will be monitored to determine the success/failure of different techniques. Rehabilitation will be adapted based on the results of the monitoring. • All habitat clearance during quarrying/mining operations is to be clearly marked prior to excavation. It is understood that approximately 32% of the coal mine site will be set aside during operation. • A Wildlife clearance protocol (*Annex E4*) is to be applied during all operations that clear Critical Habitat and Natural Habitat. • Education and awareness activities are to be undertaken with local people to provide information regarding illegal logging controls. • Regular patrols (at least every month) of the Project boundary will be undertaken to identify any incursion by local people into the Project Area and surrounding forested area. • Invasive species management measures are to include vehicle wash-down for vehicles at the base camp maintenance area prior to them entering and leaving the Project Area. • Appropriate use of herbicides may be used to control invasive species within Natural Habitats within the Project Area. • Monitoring of invasive species is to occur within the Project Area on an annual basis. New infestations identified are to be controlled. • A Biodiversity Action Plan is to be prepared to outline all mitigations to be applied to manage Critical Habitat species within the Project Area and Area of Influence. The management plan will address key threats to the species, including hunting, poaching, illegal logging, pollution and habitat destruction. • Speed limits to maximum of 40 km/hr for construction vehicles will be enforced to minimise potential for fauna strike; • Programs will be run with the community in conjunction with the Myanmar Government to reduce illegal logging. • Commitment will be made to raise awareness of values of important species and habitat areas to construction work force and arrangements will be made for restriction of poaching and forest product collection by staff.	Operation	Operation Team	STC HSE Department	Monthly Report Biodiversity Action Plan

Item No.	Affected Aspect	Affected Area	Potential Impacts	Proposed Mitigation Measures (if applicable)	Implementation Schedule	Responsibility for Mitigation Implementation	Responsibility for supervision of mitigation implementation	Reporting Requirements
				• All STC staff and contractors will be prevented from possession or collection of wildlife or timber products that are legally protected CITES listed, or classed as threatened by the IUCN Red List. If staff are caught with these species in their possession, they will subject to instant dismissal. • Non-project related vehicles will be forbidden to access Company-operated roads.. • Hunting wild animals will be strictly prohibited for all staff and contractors.				
15	Waste Management	Coal Mine	Waste Management	A waste management plan (WMP) for the coal mine should be developed that includes the following, as a minimum: • Hazardous wastes shall be transported via barge to an appropriate waste treatment facility in Mandalay; • General waste: disposed in the local community waste facilities at the coal mine; in absence of appropriate waste sites a proper landfill should be constructed to handle inert (non-reactive) and non-hazardous waste; • Organic waste: in small quantities may be suitable for composting or use as animal feed in nearby villages of Chaungzon and Paluzawa;	Operation	Operation Team	STC HSE Department	Monthly Report WMPM
16	Air Quality	Coal Mine – Coal Staging Areas and Coal Barges	Risk of spontaneous combustion of coal	• Coal stockpiles should be tightly packed to avoid air circulation; • Packed in horizontal layers (up to 1 m high) and levelled by scraping and compacted by rolling to distribute the coal evenly; • Follow "first in, first out" rule of using stock; • The height of un-layered and un-compacted coal stockpiles < 4.5 m; • The height of layered and packed coal stockpiles < 8m; • Appropriate fire-fighting equipment maintained at the coal staging areas; • Regular inspections of the coal mass including, where possible, the use of temperature probes to identify hot spots; and • If issue of auto ignition of coal persisted after implementation of the above meaures, coal staging area should be covered to avoid direct sunlight and moisture ingress;	Operation	Operation Team	STC HSE Department	Monthly Report
17	Surface Water Quality	Coal Mine – Access Road	Soil erosion and runoff	• As a first priority STM will discontinue use of the seasonal access road from the base camp to the coal mine at the end of the dry season in May 2017 and instead use the existing access road that connects to Phase 1 of the coal mine. • STC will retain a third party engineering firm to provide engineering and design input prior to re-construction of the seasonal access road and construction of the new access road from Namwake to Phase 3 of the mine; • Drainage systems and stream crossings for all newly constructed and maintained access roads require external engineering and design input; • Lining steep channel and slopes (e.g. use jute matting); • In-stream construction activities to be undertaken in the dry season; • Isolation techniques such as beaming or diversion during construction to limit the exposure of disturbed sediments to moving water; • Access roads should be compacted and graded to limit erosion; • Mulching to stabilize exposed areas; and • Re-vegetating areas promptly.	Operation	Access Road Design and Operation Teams	STC HSE Department	Engineering design documentation for access road Monthly Report
18	Surface Water Quality	Coal Mine	Soil erosion and runoff	• Strip mine to be progressively vegetated using a mix of local species (i.e. not only teak); • Final grading of disturbed areas, including preparation of overburden before application of the final layers of growth medium, should be along the contour as far as safe and practical; • Final slopes should be less than 30 degrees; • Drainage interception and diversion up gradient of topsoil and overburden storage; and • Sedimentation ponds designed for mining area and up gradient contribution.	Operation	Operation Team	STC HSE Department	Monthly Report
19	Surface Water Quality	Coal Mine – Fuel Storage Area	Spill and surface runoff	• Lightning protection should be installed at all areas used to store bulk fuel and other flammables; • The fuel storage facility should be constructed on bunded hardstand with containment	Operation	Operation Team	STC HSE Department	Monthly Report Monitoring Report

Item No.	Affected Aspect	Affected Area	Potential Impacts	Proposed Mitigation Measures (if applicable)	Implementation Schedule	Responsibility for Mitigation Implementation	Responsibility for supervision of mitigation implementation	Reporting Requirements
				sufficient for 110% of the volume of the single largest tank; • Discharges from this bunded area should pass through an oil-water separator; and • Discharges from the fuel storage area should be monitored monthly for compliance with Myanmar National Environmental Quality (Emissions) Guidelines for site runoff and wastewater discharges (for TSS, oil & grease, pH).				
20	Surface Water Quality	Coal Mine – Maintenance Yard	Spill and surface runoff	• The maintenance yard should be paved; • Perimeter drains should be installed and diverted to a multi-stage sized sedimentation pond; • Oil-water separator should be installed to at the outlet of the sedimentation pond; and • Discharges from the maintenance yard should be monitored monthly for compliance with Myanmar National Environmental Quality (Emissions) Guidelines for site runoff and wastewater discharges (for TSS, oil & grease, pH).	Operation	Operation Team	STC HSE Department	Monthly Report Monitoring Report
21	Surface Water Quality	Coal Mine – Coal Staging Area	Surface runoff	• All areas used to store and/or handle coal should be paved or compacted and surrounded by perimeter drains; • Perimeter drains should be diverted to a multi-stage sized sedimentation pond; • Oil-water separator should be installed to at the outlet of the sedimentation pond; and • Discharges from the coal staging area should be monitored monthly for compliance with Myanmar National Environmental Quality (Emissions) Guidelines for site runoff and wastewater discharges (for TSS, oil & grease, pH).	Operation	Operation Team	STC HSE Department	Monthly Report Monitoring Report
22	Surface Water Quality, Waste, Biodiversity,	Coal Mine, Limestone Quarry and Mudstone Quarry	Surface runoff, erosion, waste management, residual biodiversity impacts	STC shall prepare a Mine and Quarry Rehabilitation Plan that details the following: • Plans for sequential rehabilitation of mined/quarries areas; • Final landform, including benching and slopes not exceeding 30 degrees; • Diversion of runoff around rehabilitated areas; • Spreading of a minimum layer of 0.3 m of topsoil over waste rock and mined out areas; • Use of geotextile to prevent top soil from being washed away; • Planting with a mix of local species; and • Periodic monitoring of the progress of rehabilitation over the duration of operations.	Ongoing during operations	STC	STC	N/A
23	Extraction of Forest Resources	Cement Plant & Associated Quarries & Coal Mine	Extraction of Forest Resources	STC shall: • Develop and implement a corporate policy to prohibit the extraction, purchase, use or trade of illegal timber; • Prevent access to the following Company managed roads to mechanised logging vehicles/equipment: o coal mine access road; o limestone & mudstone quarry roads; and o existing and future revegetated/offset areas. • Note: This restriction is not intended to prevent collection of firewood and non-timber forest products by local residents. • Recognising that the road between Pyi Nyuang Village and the cement plan is a public road, STC will discuss and agree with Forest Department how the Company can support the Forest Department prevent access by illegal loggers. • Where appropriate to do so, STC will support efforts to assist local communities to transition from illegal logging to more sustainable livelihoods through job training, sustainable forest product harvesting programmes, or other means.	Construction and Operation	STC	STC	Monthly Report
24	Influx Management	Cement Plant & Associated Quarries & Coal Mine	Influx Management	• Advertise employment positions (both permanent jobs and day labour during construction) in Pyi Nyaung and do not employ casual day labour at the gate. Cascade this requirement to construction contractors. • During construction, all workers to be housed in construction camps within the cement plant. Temporary workers and day labourers will not be employed from any informal settlements on the road between Pyi Nyaung and the cement plant, should these appear. • During operations, staff will be housed in the new staff accommodation quarters within the plant or hired from neighbouring villages. Staff will not be employed from any	Construction and Operation	STC	STC	Monthly Report

Item No.	Affected Aspect	Affected Area	Potential Impacts	Proposed Mitigation Measures (if applicable)	Implementation Schedule	Responsibility for Mitigation Implementation	Responsibility for supervision of mitigation implementation	Reporting Requirements
				informal settlements on the road between Pyi Nyaung and the cement plant, should these appear. • Truck parking bays shall be provided on the inside of the guardhouse. Toilets and basic facilities shall be provided for drivers to rest outside their trucks. • STC should liaise with the local government to discourage informal settlements on the road from Pyi Nyaung to the cement plant. Guards at the plant guardhouse shall discourage the setting up of settlements or businesses within the vicinity of the guardhouse.				

11.5 *ENVIRONMENTAL AND SOCIAL MONITORING PROGRAMME*

Monitoring is a means of verifying the effectiveness of the management and mitigation measures contained within the management plans listed above. Key objectives of the monitoring process are to:

- Confirm effectiveness of management and mitigation measures;
- Ensure compliance with Applicable Standards (i.e. IFC Performance Standards, IFC EHS Guidelines and Myanmar National Environmental Quality (Emissions) Guidelines);
- Monitoring the status of, and impacts on, identified sensitive receptors;
- Provide an early warning that any of the control measures or practices are failing to achieve their desired performance and ensure changes can be implemented to remedy these practices;
- Determine whether environmental and social changes are attributable to Project activities, or as a result of other activities or natural variation; and
- Provide a basis for continual review and improvements to Project design and execution.

11.5.1 *Performance Indicators and Monitoring Schedule*

Physical, biological and social environmental management components of particular significance have been identified as performance indicators. A comprehensive monitoring plan for each performance indicator has been prepared for all phases of the Project and is presented in *Table 11.2*.

This includes the tentative parameters to be measured, methods to be utilised, sampling locations, frequency of measurements, detection limits and responsibilities for implementation and supervision.

It is to be noted that the detailed and specific monitoring measures will be developed and included within the Environmental Monitoring Plan. The monitoring components will be refined and finalised during plan development.

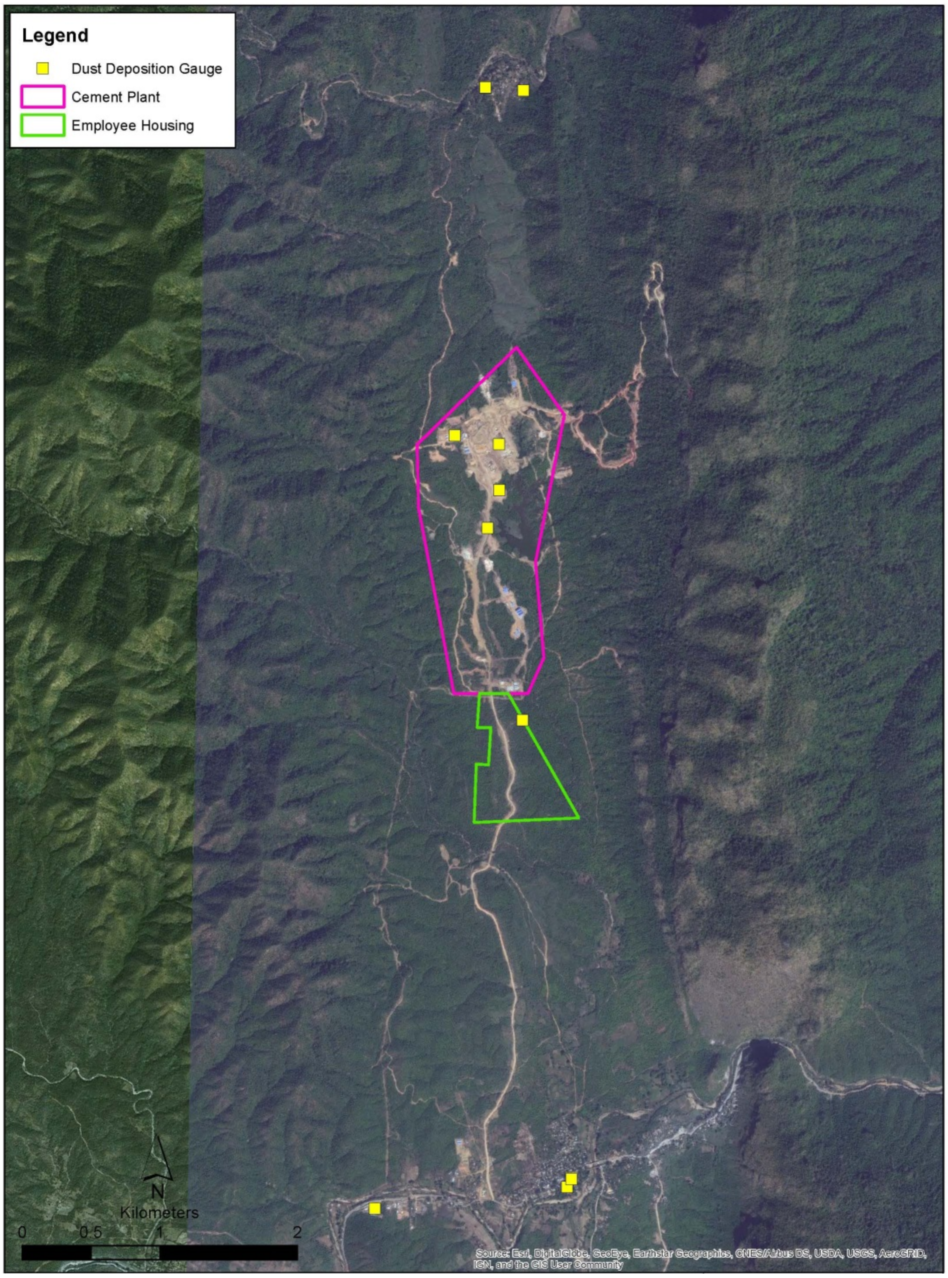
Impact monitoring will be undertaken during the life of the Project to verify the predicted levels of residual impacts from the Project and the effectiveness of the various management plans and mitigation measures.

Table 11.2 Environmental and Social Monitoring Programme (Construction and Operation Phase)

Project Stage/ Component	Potential Impact	Parameters to be Monitored	Location	Measurements	Frequency	Responsibility
Construction and Operation / Cement Plant and Coal Mine	Inspection of mitigation compliance	General compliance with mitigation measures presented in the ESMP.	Project activity areas	Visual inspection of all active work areas and inspection of records	Weekly	HSE Team of Appointed Contractor and On site HSE team of STC
Operation / Cement Plant	Stack emission from kiln system.	NOx, SO_2, $PM_{2.5}$, PM_{10} and O_2	Discharge to kiln stack at new and existing plant	Real-time monitoring system	Continuous monitoring	STC Operation Team
Operation / Cement Plant	Stack emission from kiln system.	Check compliance with Myanmar National Environmental Quality (Emission) Guidelines (2015) for Cement and Lime Manufacturing (for NOx, SO_2, $PM_{2.5}$, PM_{10})	Stack emissions from existing and new kilns.	Standard analytical methods	Monthly	STC HSE Team
Operation / Cement Plant	Dust impacts	Dust deposition	Cement Plant, Kubyin and Pyi Nyaung Villages (*Figure 11.1*)	Dust deposition gauge	Monthly	STC HSE Team
Operation / Cement Plant	Discharge of treated wastewater and runoff.	Check compliance with Myanmar National Environmental Quality (Emissions) Guidelines for site runoff and wastewater discharges (for BOD, COD, TSS, oil and grease, pH, total coliform bacteria, total	Treated wastewater discharge points at: 1. Coal Storage Area and Materials Handling Yards 2. Fuel Storage Area 3. Treated sanitary wastewater	Standard analytical methods	Monthly	STC HSE Team

Project Stage/ Component	Potential Impact	Parameters to be Monitored	Location	Measurements	Frequency	Responsibility
		nitrogen, total phosphorus)	treatment facility; and 4. Reservoir			
Operation / Cement Plant	Discharge of treated wastewater.	Check compliance with effluent levels specified in Myanmar National Environmental Quality (Emission) Guidelines (2015) for Cement and Lime Manufacturing (for TSS, pH, temperature increase)	Treated industrial wastewater discharge point from cement manufacturing process.	Standard analytical methods	Monthly	STC HSE Team
Operation / Coal Mine	Discharge of treated wastewater and runoff.	Check compliance with Myanmar National Environmental Quality (Emissions) Guidelines for site runoff and wastewater discharges (for BOD, COD, TSS, oil and grease, pH, total coliform bacteria, total nitrogen, total phosphorus)	Treated wastewater discharge points at: 1. Coal Storage Areas 2. Fuel Storage Areas 3. Maintenance Yard	Standard analytical methods	Monthly	STC HSE Team

Figure 11.1 Locations of Dust Deposition Gauges



11.5.2 *Reporting Mechanism for Environmental and Social Monitoring Programme*

A robust reporting system will provide the Project with the necessary feedback mechanisms to ensure quality and timely implementation of the works. The reporting system will provide a mechanism to ensure that the measures proposed in the Project's ESMP are implemented.

Prior to the commencement of the construction and operation activities, STC will finalise the format and frequency for reporting on the status and progress of environmental and social monitoring. The format will be designed to meet all the compliance conditions associated with the local and international requirements. The contractor will be required to submit the duly completed reporting form on the agreed frequency to STC.

11.6 *INSTITUTIONAL SETTING AND IMPLEMENTATION ARRANGEMENTS*

11.6.1 *Environmental Management Organisation*

STC is committed to providing resources essential to the implementation and control of the ESMP. Resources include the appropriate human resources and specialised skills. The structure for the organisation responsible for environmental and social management and implementation of the ESMP is depicted in *Table 11.3.*

Table 11.3 Environmental Management Organisation Roles and Responsibilities

Position	Responsibility
STC	
General Manager	Oversee and coordinate all activities pertaining to the Project; ultimately responsible for environmental and social issues. Ensure delivery by the asset of its environmental, social and operational targets. Ensure effective communication with all stakeholders.
Chief Engineer	Technical aspects of the Project including supervision during construction and operations.
HSE Officers	Ensuring that the Project and contractors operate in accordance with applicable regulatory environmental and social requirements and plans. Monitor implementation of environmental and social protection measures.
Community Liaison Officer	Liaise with local communities and government regulators on the project's behalf. Implement environmental and social awareness and education programmes with communities.
Contractor	
Project Manager	Responsible for subcontractor technical performance and compliance.
HSE Manager	Ensure that environment and social regulatory requirements are met and that ESMP requirements are properly implemented.

11.6.2 *Construction Phase*

The ESMP will be included in the construction contract and the contractor will be responsible for implementation of the measures associated with design and construction through supervision by their Project Manager and HSE Manager. STC's staff, specifically the Chief Engineer and HSE Officers of the Project Management team, will monitor the implementation of these mitigation measures by the contractors at the site.

The roles and responsibilities of STC and the Contractor for implementation and monitoring have been outlined in *Table 11.4*.

Table 11.4 Roles and Responsibilities of STC and Contractor

STC	Contractor
Obtaining statutory clearances required during pre-construction stage of the Project	Obtaining permits required during the construction stage
Overall Project co-ordination and management through Contractor and supported by the third party environmental consultants	Joint verification with STC and Third Party Environmental Consultant for review of ESMP implementation
Confirmation of reporting format and frequency	Filling of reporting formats as per the reporting schedule and submission to STC
Effective implementation of ESMP and monitoring of ESMP implementation	Environmental monitoring through Third Party Environmental Laboratory
Carryout verification/supervision exercises during the construction phase of the Project for implementation of ESMP	Preparation of various plans for effective implementation of ESMP
Overall supervision of ESMP implementation	Management of worker camp and to provide drinking water, sanitation facility
Approval of plans prepared by the Contractor	
Addressing grievances of local community and information dissemination	
Environmental monitoring through laboratory	

While the contractor or a particular party is responsible for physical implementation of the mitigating measures, the whole implementation process requires supervision, checking, documentation and verification so that problems are identified and properly addressed before they get out of hand. In order to ensure proper execution of the ESMP, implementation reviews will be conducted by the HSE Officers / Chief Engineer by various means including weekly construction meetings, review of construction log book, monthly and other construction reports etc. Records of these minutes of the weekly meeting, monthly reports and special reports on implementation of the mitigating measures will also be maintained and available for review by the Project management. It is suggested to identify documents and records that require templates and accordingly suitable templates should be developed, which should include but not limited to policies, procedures and work instructions, meeting minutes, monitoring results, training attendance records, emergency contract lists, action plans etc. Further, all templates should be communicated to all potential users. All these records will be archived at the Project office and will be maintained by the HSE Officer. All documents and records shall be archived with a unique identifier so that they can be distinguished from any other material and can be easily retrieved.

11.6.3 Operation Phase

The operation team of STC will be responsible for implementation of the associated mitigation measures during the operation phase. STC's staff, specifically the HSE Officer and Chief Engineer, will monitor the implementation of these mitigation measures. As for the construction phase, this will be achieved through implementation reviews conducted by the HSE Officers / Chief Engineer by various means including weekly operation meetings, review of operation log book, monthly and other operation reports etc. The documentation, reporting and communication requirements will be the same as those for the construction phase as presented above.

11.7 TRAINING

11.7.1 Construction Phase

Prior to commencement of major civil works at site, a suitably qualified in-house/external expert will be appointed by the contractor in consultation with the STC to develop and deliver a training program on implementation of the ESMP, monitoring and reporting will be conducted in line with the applicable reference framework for the Project. The training will include the following topics:

- Environment, Health and Safety Policy of the contractor;
- Environment and fundamentals of environmental pollution in relation to the Project;
- HSE management plans prepared by the Contractor;
- Do's and Don'ts for the construction workers;
- Safety procedures and guidelines;
- Internal reporting and response system;
- Hazardous chemicals and waste handling;

In addition, specific training will be provided to the team involved in environmental and social monitoring and reporting, which will include:

- Applicable environmental and social guidelines and standards;
- Sampling site selection guidelines in line with environmental monitoring plan;
- Sample collection, storage, transportation and analysis procedures;
- Solid and hazardous waste management;
- Quality assurance and quality control; and
- Environmental monitoring report preparation.

The training will help in capacity building and implementation of the ESMP during the construction phase of the Project. It will also help in ensuring internal and external monitoring and verification of the environmental and social performance of the Project. The timeframe for reporting and verification during the construction phase will be agreed between the STC and contractor.

11.7.2 Operation Phase

Prior to the commencement of the Project operation, a suitably qualified in-house/external environmental expert will be engaged by the STC to develop and deliver a training programme on operation phase environmental and social monitoring and reporting. The topics will be mostly same as that during the construction phase.

The training will help in capacity building and implementation of the ESMP during the operation phase of the Project. It will also help in ensuring internal and external monitoring and verification of the environmental and social performance of the Project.

11.8 UPDATE OF THE ESMP

This ESMP will be updated, revised and reviewed internally on a regular basis to ensure its effectiveness in monitoring the environmental and social performance of the Project. The ESMP of the Project will be reviewed on an annual basis.

Furthermore, in the event of an unanticipated impact and design change with respect to the Project standards (including Myanmar Government and IFC requirements), the ESMP would be updated as necessary.

12 CONCLUSION AND RECOMMENDATIONS

12.1 SUMMARY OF FINDINGS

The Project involves the brownfield expansion of cement production via a second kiln and associated infrastructure, and the extraction of raw materials, at STC's existing cement plant in Pyi Nyaung Village, Thazi Township in the Mandalay region of Myanmar. It also includes a coal mine in the Kalaywa Township of the Sagaing region of Myanmar which produces coal exclusively for use as fuel for the cement kiln.

A Supplementary ESIA has been conducted for Project in accordance with relevant environmental and social guidelines of the International Finance Corporation with an overall objective to ensure acceptable environmental and social performance of the Project. The Supplementary ESIA identified potential impacts 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 and social resources or receptors. Interactions which may generate potentially significant environmental and social impacts have been further assessed in the EIA, with appropriate mitigation and enhancement measures recommended for alleviating potential negative impacts or enhancing potential positive impacts from the Project. It is concluded in the Supplementary ESIA that with proper implementation of the recommended mitigation measures, the residual environmental and social impacts causing by the construction and operation of the Project would be of no larger than moderate significance, as summarised in *Tables 12.1-2*, except for the loss of habitat due to operation of the quarries and coal mine which are of critical significance and required to be offset.

To ensure proper delivery of the committed mitigation measures identified in the EIA Study, an Environmental and Social Management Plan has been prepared for the Project which provides the procedures and processes to be applied to the Project activities in order to check and monitor compliance and effectiveness of the mitigation measures during the construction and operation of the Project. In addition, this ESMP will be used to ensure compliance with statutory requirements and corporate safety and environmental policies. Overall, it is expected that the Project will be constructed and operated with acceptable environmental and social performance under proper implementation of the ESMP.

Table 12.1 Summary of Impact Assessment for the Construction and Operation of the Cement Plant and associated Quarries

Issue	Impact Summary	Impact Significance *(prior to implementation of Mitigation and Management Measures)*	Residual Impact Significance *(after implementation of Additional Mitigation and Management Measures)*
Air Quality	Dust emissions associated with construction of the cement plant.	Moderate	Minor
	Air quality impacts due to cement plant emission	Minor to Negligible	Minor to Negligible
Noise & Vibration	Noise generation due to use of PMEs during construction activities.	Negligible	Negligible
	Noise generation due to operation of fixed plant and machinery during operation	Negligible	Negligible
Surface Water Quality	Impacts to surface water quality due to wastewater and runoff during operation.	Major	Minor to Moderate
Waste	Impacts from waste management during construction	Moderate	Minor to Moderate
	Impacts from waste management during operation	Moderate	Minor to Moderate
Biodiversity	Permanent and Temporary loss of habitat due to construction.	Moderate	Minor
	Degradation of habitats due to construction.	Moderate	Negligible
	Impacts to species during construction	Moderate	Negligible
	Permanent and Temporary loss of habitat due to operation.	Critical	Critical
	Fragmentation and edge effects due to operation.	Moderate to Major	Minor
Traffic and Transport	Increased in traffic volume due to operation.	Moderate	Minor
Extraction of Forest Resources	Extraction of forest resources	Major	Moderate (within STC's controlled area) Major (within Project's area of influence)
Influx Management	Project induced influx during construction and operation	Minor	Negligible

Table 12.2 Summary of Impact Assessment for the Construction and Operation of the Coal Mine

Issue	**Impact Summary**	**Impact Significance** *(prior to implementation of Mitigation and Management Measures)*	**Residual Impact Significance** *(after implementation of Additional Mitigation and Management Measures)*
Air Quality	Dust emissions associated with operation of the coal mine	Negligible	Negligible
	Auto-ignition at coal staging areas	Moderate	Minor to Moderate
Noise & Vibration	Noise generation due to use of PMEs during construction activities.	Negligible	Negligible
Surface Water Quality	Impacts to surface water quality due to wastewater, runoff and soil erosion during operation.	Critical	Minor to Moderate
Waste	Impacts from waste management during construction	Moderate	Minor to Moderate
	Impacts from waste management during operation	Moderate	Minor to Moderate
Biodiversity	Permanent and Temporary loss of habitat due to operation.	Critical	Critical
	Degradation of habitats due to operation.	Moderate	Negligible
	Impacts to species during operation	Moderate	Negligible
Extraction of Forest Resources	Extraction of forest resources	Major	Moderate (within STC's controlled area) Major (within Project's area of influence)
Influx Management	Project induced influx during construction and operation	Minor	Negligible

12.2 *RECOMMENDED FURTHER STUDY*

There are a number of areas that ERM recommends further study in order to understand environmental impacts and the mitigation measures that will be necessary to manage potential impacts that may arise from the future operations of STC's cement plant and associated facilities. These include:

- Surveys of flora and reptiles in the limestone concession at the cement plant during the wet season. These are scheduled to occur in May 2017;
- A hydrogeological investigation to determine the sustainability of the expanded Project's water use and effect on existing users. There are several options to secure the necessary water supply of 3,400 m^3 / day. These include extraction from the Kubyin River and from the Myitta Stream to the east of the limestone range;
- Third party engineering studies to properly design access roads to the coal mine, including the optimal alignment, slope protection and drainage measures. ERM recommends that the existing seasonal access road from the base camp to Phase 3 of the mine be discontinued at the end of the 2017 dry season and that alternatives to the proposed access road from Namwake to the coal mine be explored, including transportation of all coal to the river port via Phase 1 of the mine; and
- Engineering studies to confirm the suitability of the proposed arrangements to dispose of sewage from the new worker accommodation quarters to septic tanks.

Annex A

ESIA Terms of Reference

1 ESIA SCOPE OF WORK

1.1 AIR

1.1.1 *Potential Impacts*

The construction and operation of the proposed cement manufacturing facility, the associated quarry, and the coal mine has the potential to result in significant impacts on air quality both at human and ecological receptors.

Coal Mine

Strip mine operations will involve the removal of overburden, extraction of ore, crushing and screening of ore, stockpiling and loading onto trucks. In addition, the movement of coal trucks to/from site may give rise to dust impacts. Key sources of emissions will be:

- Mining activities: Stripping, extraction, overburden placement and hauling of coal/overburden may all result in emissions of dust, PM_{10} (and $PM_{2.5}$).

- Excavators, trucks and potentially diesel power generation onsite would generate emissions to air of NO_2, NO_x, SO_2, PM_{10}, $PM_{2.5}$.

Cement Manufacturing and Associated Quarries

Potential construction phase impacts include land clearance, construction of infrastructure, transport of materials to site, etc. Key construction phase emissions will be PM_{10} and dust as a result of dust raised by vehicles moving over open surfaces and disturbance of surface materials.

During the operational phase, the primary emissions from the manufacture of Portland cement include:

- Quarries: dust and particulate matter (PM_{10} and $PM_{2.5}$) generated from quarrying (blasting and extraction) and crushing.

- Kilns: nitrogen oxides (NO_x) and sulphur dioxide (SO_2), carbon monoxide (CO) and PM_{10} and $PM_{2.5}$ from coal combustion. Potentially also volatile organic compounds (VOC), ammonia (NH_3), chlorine, and hydrogen chloride (HCl) may also be emitted. Possible emissions of metal compounds from cement kilns (partitioning of these in the gas/solid phases is a function of kiln operating conditions).

1.1.2 *Baseline and Assessment Methodology*

Cement Manufacturing and Associated Quarries

- ERM will assist STC to install 10 dust deposition gauges at locations around the plant and at the nearest sensitive receptor in Kubyin Village, 3km from the plant. Materials to construct these deposition gauges will be sourced locally by STC. Deposition gauges will be used to collect dust samples on a monthly basis (analysis can likely be done at the onsite laboratory). The intention is that these would form part of a long term monitoring programme that would continue beyond the EIA and be managed by STC. ERM proposes to analyse one set of samples for a typical suite of metals over the duration of the baseline sampling programme.

- Three locations will be sampled for NO_x, NO_2, SO_2 using diffusion tubes for a period of one week in locations around the plant.

Coal Mine

- No baseline air sampling will be conducted

Assessment Methodology

The potential impacts of the construction activities will be assessed in a qualitative manner and standard mitigation measures developed. Emissions of site based vehicles and plant during construction is expected to make a negligible contribution to air quality impacts and will not be assessed.

An emissions inventory for both the cement manufacturing plant and coal mine will be developed. These inventories will primarily be developed from guidance set out in NPI produced by the Australian Government and USEPA AP-42 emissions database. Key input data will include the tonnages of coal produced, vehicle specifications, distances travelled by vehicles, and fuel specifications and use.

On the basis of the emissions inventory, dispersion modelling will be utilised to quantify the magnitude of impacts arising from the key sources of emissions at both the cement manufacturing plant and coal mine. This approach is utilised to ensure robust quantification of impacts and ascertain the effectiveness of mitigation and emissions controls. The USEPA AERMOD dispersion model will be utilised; this model is widely recognised as being appropriate for this type of scheme by several agencies including the IFC, USEPA and UK Environment Agency. In addition to consideration of emissions, the model also considers local meteorology (using MM5 simulation), local topography, and the locations of nearby receptors.
ERM will model the following:

- **Coal Mine:** Particulate matter modelled as an area source from the mine.

- **Cement Plant and Quarries:** Particulate matter, NOx and SO_2. ERM will model one set of operating conditions for both point and area sources at the cement plant. Particulate matter from the quarries will be modelled as an area source.

1.2 BIODIVERSITY AND ECOSYSTEM SERVICES

1.2.1 *Potential Impacts*

ERM notes that species of conservation significance were recorded at the Cement Plant/Quarry and Coal Mine area, including: Chinese pangolin, *Manis pentadactyla* (CR); and *Dalbergia oliera* (Plant) (EN). Records indicate that the area may contain species of primate, including Hoolock Gibbon (*Hoolock hoolock*). Forest areas are also likely to contain species of *Dipterocarps* that may also be listed on the IUCN Red List as Endangered. It is also reported that part of the quarry is located within a forest reserve area.

Limestone karst dependent fauna are also likely present, including potentially new-to-science of reptile and snail species recently detected in the vicinity by Flora and Fauna International (FFI). The FFI surveys however did not target invertebrates and flora.

Given the methodology used for baseline surveys in the EIAs, it is considered likely that other fauna of conservation significance are present within the Area of Influence (AOI) of the Project Areas.

The primary impacts from the Project will be loss of habitat as a result of mining and quarrying activities and the associated disturbance and displacement impacts on flora and fauna species.

Preliminary information is available within the EIAs on potential impacts to Ecosystem Services from the Project. Further scoping and screening is necessary to determine whether further assessment is required.

1.2.2 *Baseline and Impact Assessment Methodology*

Scoping Phase- Task 1

ERM propose to undertake the following during Scoping:

- Literature review of existing studies, scientific literature or any other type of pre-existing biodiversity assessments available for the project area; national or regional plans; existing conservation programs or initiatives in the area and its surroundings.

- Stakeholder consultation with NGOs and Government representatives to collect relevant data for the project site. The exercise will:

    - Carry out interviews with relevant government representatives, universities and conservation organisations (in particular FFI, but also WCS, WWF, Biodiversity and Nature Conservation Association of Myanmar (Birdlife International representative) and Myanmar

Environment Rehabilitation-conservation Network and Government of Myanmar Ministry of Natural Resources and Conservation). The purpose of the consultation will be to fill data gaps, understand the regional context of the project AOI in terms of its importance to biodiversity conservation (e.g., ecosystems, threatened species, endemic species and/or migratory species) as well as occurrence of invasive species;

- Undertake a scoping and screening exercise and coordinate with social impact assessment efforts (if necessary) to determine if there are any biodiversity in terms cultural or human use value to local communities (ecosystem services).

- Use existing data (e.g., collected as part of local EIA assessments, IUCN Red List of Threatened Species, Global Invasive Species Database, IUCN Species Action Plans and nationally protected species lists and that gained through consultation), to identify if there are any known or potentially occurring threatened species (CR and EN listed species), endemic species (such as invertebrates, reptiles, flora and cave dwelling bats) and/or migratory species associated within the project study area;

- Use existing data to identify any potential invasive species in the project AOI and the surrounding landscape;

- confirm and map the boundary of any habitats of conservation significance, including World Heritage Areas; Protected Areas; local forest designations, Key Biodiversity Areas (Important Plant Areas, Important Bird Areas and Alliance for Zero Extinction sites) in relation to the Project area;

Habitat Characterisation and Classification- Task 2

Based on the information obtained during Scoping, ERM will prepare an analysis of the distribution of land classes and Natural and Modified Habitats within the Project Area and AOI. A Discrete Management Unit (DMU) will be determined for Critical Habitat candidate species.

Biodiversity Field Surveys – Task 3

The purpose of biodiversity field surveys would be to obtain further information on existing known biodiversity values, focusing on values that may trigger Critical Habitat thresholds in the project study area and to further refine maps of Modified and/or Natural Habitat, as required.

Targeted biodiversity surveys will be conducted in early December or March to June to capture potential seasonality constraints (particularly for invertebrates and flora).

<u>Limestone Hill Surveys</u>

Surveys are to be conducted of the limestone hills within the concession to determine the presence of site endemic invertebrates, molluscs, reptiles, mammals and flora.

At least 3 suitable reference locations along the same limestone range are also to be surveyed to determine the likely distribution of any species detected.

Surveys will focus on: caves and fissures within the limestone hills; varying microclimate conditions including: varying aspects, soil conditions, slopes and depositional areas; and downslope areas below cliffs.

Soil samples should be taken in depositional areas, caves and fissures to detect molluscs. Inspections of caves and fissures should be conducted to detect invertebrates and reptiles. Surveys are to be conducted at dawn and dusk to detect crepuscular species at entrances to caves and fissures. Flora transects should be conducted in accessible areas in varying micro-habitat conditions.

Surveys should be conducted in dry conditions over a period of 5-7 days.

<u>Forested Habitats</u>

The following surveys will occur in forested areas at both Project sites:

- Interviews are to be undertaken with local people (hunters, NTFP collectors) to determine contemporary sightings (within the last 12 months) of fauna of conservation significance likely to occur within the Project Area (CR, EN and VU species). Data should be provided on: species; number of sightings; location of siting; condition of individual.

- Diurnal and nocturnal transects are to be undertaken for a minimum of 2 hours in the morning <u>and</u> evening for a period of 5 days per Project area. The transects will cover a range of forest cover types aspects and slope. These inspections will target birds, herpetofauna and arboreal mammals/primates and ground dwelling mammals. Inspections of any habitat features (nests, roosts and dens) are to occur if detected. Tracks and traces are to be noted, photographed and GPS reference point taken.

- A flora survey will occur along transects within the Project area to determine the distribution and abundance of species of conservation significance (CR, EN and VU listed flora) and invasive species. A minimum of 1 transect per hectare will be applied. The distribution of records will be marked on a map and GPS referenced.

- Vegetation class mapping will be undertaken to show the type, condition and distribution of vegetation classes within the Project area. This mapping may occur through satellite image/aerial photograph interpretation and a series of inspections to confirm vegetation distribution.

The following surveys will occur at the coal mine site only:

- A targeted survey for fauna will be undertaken using infra-red camera traps. These traps will be placed based on likely fauna movement pathways and key attractants (water bodies, salt licks). The traps will remain in place for at least 10 days. A minimum of 10 camera traps will be placed per 2 hectares (this may be varied based on the terrain).

- A targeted listening survey will be conducted at dawn and dusk for gibbons. Listening posts will be set up near to potential/confirmed habitat for at least 2 hours at dawn and dusk. The calls will be recorded for future reference (if possible), the direction and approximate distance of individuals will be recorded.

All fauna and flora surveys will be completed within a maximum period of 15 days. Two teams may be used to cover both sites.

Critical Habitat Determination- Task 4

A Critical Habitat (CH) Screening Assessment is to be undertaken in relation to any CH triggers identified during Tasks 1-3. The assessment will determine the presence or not of biodiversity values that meet CH thresholds. The CH assessment will be peer reviewed by local, regional and species experts to ensure the accuracy of the findings are validated.

Mitigation and Management Measures- Task 5

An impact assessment will be conducted to determine the impacts to biodiversity values and recommend mitigation or management measures to reduce overall impacts to biodiversity values. The approach will involve using the mitigation hierarchy: avoid, minimize, mitigate and offset. Avoidance, mitigation and management measures will be made that explicitly address project risks and impacts to biodiversity values that are known or likely to occur at the project study area. Mitigation will take a precautionary approach given the need for assessment to provide final confirmation or refinement.

The consultant will work with the client to identify sensitive biodiversity receptors that should be avoided through changes in footprint or design, of possible. Further measures will be recommended to input into the design processes to mitigate impacts through practical design measures.

Development of a Biodiversity Offset Strategy – Task 6

A Biodiversity Offset Strategy will be prepared to determine the potential biodiversity offset size, candidate locations, costs and implementation/management mechanisms required.

A Biodiversity Action Plan and Biodiversity Offset Plan for the selected biodiversity offset site would need to be undertaken as a commitment to meet IFC standards and have not been included in the scope of the Phase 2 ESIA.

1.3 TRAFFIC AND TRANSPORT

1.3.1 *Potential Impacts*

During operations, transportation of coal, clay and other raw materials to the cement plant and transportation of Portland cement product to market will involve the use of a large number of heavy vehicles.

Vehicle movements may give rise to dust and pose a risk to other road users and communities through which they pass, such as Pyi Nyaung Village, located approximately 6 km south of the cement facility. Both road dust and road safety associated with the movement of coal trucks were raised by concerns of local residents in relation to the coal mine according to the Regulatory EIA submission.

Similarly construction activities will require the use of trucks to transport plant and equipment to site. Impacts during the construction phase are not expected to differ significantly with operational phase impacts and will be assessed in parallel.

1.3.2 *Baseline and Assessment Methodology*

ERM will make an inventory of existing road traffic related to the project and the future projected traffic once the expanded facility comes into operation. The adequacy of existing infrastructure (roads, staging areas, "pinch-points") to accommodate the projected increase in road traffic will be assessed qualitatively.

A Traffic and Transportation Management Plan will be developed that will include measures to minimize dust, safety, traffic congestion and ensuring drivers have access to adequate facilities (e.g., ablutions) as well as any other issues that are raised during engagement with external parties.

1.4 WATER

1.4.1 *Potential Impacts*

Cement Plant/Quarry

It is understood that water for dust suppression and to supply the workforce/families (approximately 500-600 people) is drawn from a small reservoir onsite and passed through an RO treatment plant. A dry manufacturing process is used and hence the operational water need is not anticipated to be significant.

Runoff from quarrying operations, coal storage areas and waste stockpiles may become contaminated and enter surface streams and/or groundwater and flow downstream to Kubyin Village which uses the stream as a drinking water supply. The bulk storage of fuel at the also poses a risk to surface and groundwater contamination.

Coal Mine

It is understood that the coal seam mined is shallow and there is no need for dewatering. Water for the mine employees and for dust suppression is drawn from the South Paluzawa stream. This stream is also the water source for local residents who have stated that there is a lack of water for three months during the dry season and hence the potential for competition for water supply needs to be assessed.

Runoff from coal staging areas and overburden dumps may become contaminated and enter surface streams and/or groundwater. The bulk storage of fuel at the base camp and barging area in Paluzawa also poses a risk to surface and groundwater contamination.

1.4.2 *Baseline and Assessment Methodology*

Cement Plant/Quarry

ERM will verify the volume of water currently used (for consumption, dust suppression and process use) and assess the capacity of the existing reservoir to supply the projected future water demand of the expanded facility (predicted to be approximately 700,000 tpa in the Regulatory EIA). Given the relatively low volume of water expected to be used an operational water balance is not proposed.

ERM will review STC's plans for runoff control at the quarry and plant. Particular attention will be paid to the lower reaches of hill slopes and around stockpiles, staging and disposal areas. Where necessary, ERM will make recommendations to improve stormwater management at the quarry and cement plant aligned with accepted industry practice. While sources of waste water are limited e.g., related to sewerage, waste water from canteens and vehicle washing areas, recommendations to ensure good practice is applied to such aspects will also be provided.

Four water samples (at the Mudstone Quarry area, at two surface water drainage locations downgradient from the coal storage area and at the Kubyin Stream at Kubyin Village) will be taken and analysed for typical inorganic compounds and metals.

Coal Mine

ERM will assess the volume of water abstracted from the South Paluzawa stream by the mining operations as a proportion of total flow to assess the potential for competition for water with local communities. Three water samples (one upstream of the mine highwall, one downstream of the mine and upstream of the base camp and one at Chuanzong Village) will be taken and analysed for typical inorganic compounds and metals.

STC's plans for runoff control at the mine and coal stock pile areas adjacent to the river will be reviewed. Particular attention will be paid to the overburden dumps which may contaminate surface streams or groundwater.

Where necessary, ERM will make recommendations to improve stormwater management at the coal mine and coal stockpiling areas to ensure alignment with accepted industry practice Similarly, the approach to the management of sewerage / other ounces of waste water will also be considered to ensure this is aligned with good practice.

1.5 NOISE

1.5.1 *Potential Impacts*

During the construction of the Project, the key noise sources will be from blasting (if any), excavation work, site formation, the use of mobile machinery and construction plant items.

During the operational phase, noise emissions will be generated from the operation of the proposed coal mine, including clearing of vegetation, excavation of coal, loading, and transportation of coal to stock yard. For the operation of the proposed cement plant, noise will be generated from the unloading hopper, crushing of limestone, material transportation use pf wheel loaders and conveyors, material blending station, ball mill, preheater, coal burner and cement kiln.

1.5.2 *Baseline and Assessment Methodology*

Noise monitoring will be carried out for the purposes of establishing the existing ambient noise levels in the area of the proposed facility and whether or not workers or nearby residents are affected by current noise levels. Baseline noise monitoring is proposed to be conducted in a minimum of 3 monitoring locations in the vicinity of the cement plant (at the existing and newly constructed accommodation quarters and at the guard house). Baseline noise measurements will not be undertaken at the coal mine given that the distance to the nearest residents in several kilometres. Noise monitoring will be carried out using a Type 1 or 2 sound level meter.

An operational noise impact assessment will be carried out for the cement plant based on project information provided by STC and the results of baseline sampling. The noise assessment will be undertaken based on standard acoustics principles, in accordance with the British Standard, BS5228: Part 1: 2009 *Noise and Vibration Control on Construction and Open Sites, Part 1. Code of Practice for Basic Information and Procedures for Noise and Vibration control*. The procedures of the assessment are summarised as follows:

- identify representative Noise Sensitive Receivers (NSRs) that may be affected by the works;
- assign Sound Power Level (SWL) to each plant item proposed and calculate the overall SWL associated with the proposed plant inventory;
- determine the distance between the approximate geometric centre of the works site;
- apply the correction factors based on the distance and façade correction as appropriate, in accordance with BS5228: Part 1: 2009; and
- predict the construction and operational noise levels on the basis of the plant activity and any in built design controls, if any.

The sensitivity of NSRs will be determined as high, medium and low based on the effects of noise on health in consideration of annoyance, speech intelligibility, communication interference, disturbance of information extraction, sleep disturbance, and hearing impairment.

The magnitude and significance of the construction and operational noise impacts will be determined in consideration of the sensitivity of the NSRs and the levels of predicted noise impacts below or above the assessment noise criteria. Appropriate noise mitigation measures will be recommended if results indicate noise exceedance over the assessment noise criteria.

1.6 SOCIAL IMPACT ASSESSMENT

1.6.1 *Potential Impacts*

Cement Plant & Quarries

Expansion of the cement plant is likely to bring about both benefits in terms of employment and spending in local communities and negative impacts such as environmental nuisance, increased traffic and possible influx. The Area of influence would include:

- Pyi Nyaung Village Tract: 6km south of the cement plant (200 households).
- Kubyin Village: approximately 4km north of the cement facility (approximately 60 households).

Previous consultation was undertaken in March 2014 and December 2015 for the regulatory EIAs. The only specific concern raised was that that the operations do not affect the rearing of livestock in forest areas. Residents in Kubyin also expressed a desire for assistance with potable water supply and electricity.

In addition to environmental nuisance and traffic/road safety, it is possible that expansion of the cement plant may result in an influx of people, resulting in fenceline communities that would be at greater risk of environmental nuisance from the mine and that couple pose an operational and/or safety risk. It is noted that Kubyin Village was only formerly recognised in 2014 after an initially small number of households relocated from the larger settlement of Pyi Nyaung as early as 1978 due to overcrowding..

Coal Mine

The base camp is located approximately 1 km form Chaungzon village (Paluzawa area), Ywar Thar village Tract, Kalaywa Township, 6 km west of the Chindwin River. The company has also a base camp at Paluzawa village 2 miles east on the Kalaywa-Maw Lite Road. Chaungzon village has 19 households and a population of 80. It is noteworthy that the mine does not employ any residents of Chaungzon village, whose residents appear dependent on subsistence cropping and logging.

Previous consultation undertaken was undertaken for the Regulatory EIA in November 2015. Issues raised include:

- Water availability during the dry season. South Paluzawa stream is the water source for both employees at the mine and the village. Local residents have stated that there is a lack of water for three months during the dry season and hence the potential for competition for water supply needs to be addressed.

- Dust from the movement of coal trucks;
  Road safety and concerns about driver conduct.

1.6.2 *Social Impact Assessment Methodology*

ERM expects that consultation and baseline socio-economic surveys would be undertaken at Pyi Nyaung Village Tract and Kuybin Village for the cement plant and at Paluzawa, Chaungzon and Namwake Village at the coal mine. During the surveys, ERM will seek to identify those that may be particularly vulnerable to the proposed developments, especially through restriction of access to forests, waterways or other communal resources.

Based on the results of the consultation (see ***Task 5, Section*** *Error! Reference source not found.*) and household surveys, ERM will undertake an assessment of the likely social impacts from the project. This will include both those arising from planned events (eg dust from traffic movements) and unplanned but predictable events (eg in-migration). Where necessary, recommendations to minimize adverse social impacts will be recommended. This will include the preparation of a Grievance Procedure for STC.

An important part of this process will be developing measures to maximize local economic benefits, for example through employment and the procurement of goods and services.

Once the draft EIA is prepared, there will be a second townhall meeting to share feedback with those who provided input to the process prior to disclosure of the ESIA, ESMP and LRP.

1.7 CONTRACTOR MANAGEMENT

1.7.1 *Potential Impacts*

Construction of the expanded manufacturing facility will involve a range of local and international contractors, as well as local labour. While the project will provide local employment opportunities, it is anticipated that the majority of the contractor workforce would be drawn from larger cities in Myanmar.

Potential impacts form large groups of imported labour include cultural differences, communicable diseases, and hygiene and security issues from contractor camps, workshops and lay down areas. Similarly, the potential impacts from contractors' EHS, labour and social management practices could significantly impact the project's performance.

1.7.2 *Baseline and Assessment Methodology*

Contractor Management Capacity Assessment

It is important that the company has a robust system in place for contractor selection, management and performance evaluation. Contractors' environmental, health and safety management capacity and labour practices could potentially could have significant impacts on the project's EHS and social impacts.

A capacity assessment will be carried out to assess the company's process and procedure and personnel in place for contractor management during construction and operational phases. Through interviews with relevant personnel and document review, the company's current contractor management practices will be evaluated. ERM will identify gaps with reference standards and recommend actions to be undertaken to bridge the gaps.

ERM anticipates preparing a contractor management procedure as part of the overarching ESMP to be implemented at both the cement plant and the coal mine.

1.8 WASTE MANAGEMENT

1.8.1 *Potential Impacts*

Waste sources will include:
Coal Mine

- Hazardous Wastes (oils, hydraulic fluids, etc);
- Construction waste (off cuts, spoilage, packaging);
- Waste from Construction/Worker Camps;
- Vegetation from surface stripping;
- Overburden; and
- Coal dust.

Cement Plant/Quarries

- Cement kiln dust and clinker waste;
- Office wastes;
- Domestic waste (460 employees / families);
- Hazardous waste (oils, hydraulic fluids, etc);
- Construction waste (off cuts, spoilage, packaging); and
- Waste from Construction/Worker Camps.

1.8.2 *Baseline and Assessment Methodology*

Waste Inventory
A waste inventory will be created for both the cement plant and the coal mine and will include estimates of all waste types, quantities and sources based on the information available from any feasibility studies, the EIA and benchmarks for the cement manufacturing / coal mining industry at similar scales to the proposed facilities.

Waste Capacity Assessment

A capacity assessment will be carried out to identify the waste management facilities available to the cement plant and the coal mine. The capacity assessment will aim to identify all waste facilities that could be practicably used for waste disposal at a local, regional and national level for the identified waste streams.

Waste Management Plan
ERM will review STC's existing waste management plans for the cement plant and coal mine and propose recommendations for improvement, where necessary.

Materials handing at the cement plant (eg raw material and coal stockpiles) will be reviewed and recommendations made in line with good international industry practice to minimise the risks of air and water quality impacts.

1.9 CUMULATIVE IMPACT ASSESSMENT

It is understood that there are other cement plants owned by Htoo, Max Myanmar, YIG and Asia World within the vicinity of the STC plant. Where applicable, cumulative impacts arising from the combination of the expansion of the STC plant with other developments in the vicinity will be assessed. The most likely aspects that could be subject to cumulative impacts include: air quality, traffic and transport, pressure on communal resources (eg areas to rear livestock) in-migration and biodiversity.

Based on ERM's previous experience, information may not be shared among operators in Myanmar and as such the cumulative impact assessment will likely be qualitative in nature.

1.10 ENVIRONMENTAL AND SOCIAL MANAGEMENT PLANS

ERM will prepare an Environmental and Social Management Plan(s) (ESMP) to address the key risks and impacts identified by the ESIA. The format of these will be agreed with STC and may be either standalone documents or component parts of an integrated ESMP for the various project components. It is envisaged that the following issues would be addressed through the ESMPs:

- Biodiversity;
- Waste management (based on STC's existing Management Plan)
- Traffic and Transport;
- Air;
- Noise;
- Influx;
- Contractor management;
- Runoff; and
- Grievance redress.

1.11 LAND ACQUISITION REVIEW

The objectives of the Land Acquisition Review are as follows:

1. Assess the processes and outcomes of historical (or ongoing) land acquisition for the purpose of setting up (or expanding) all direct project components, against requirements of IFC PS5 and relevant parts of PS1. This will include looking at PS5 impacts arising from involuntary restrictions on land use and access to natural resources (e.g. forests).

2. Identify gaps and propose corrective actions to bring the Project in line with the Applicable Standards.

3. Screen for the presence of Indigenous Peoples communities at the project sites which can be expected to be adversely impacted by the project, and propose corrective actions to meet PS7 requirements. ERM understands that it is IFC's preliminary assessment that while Indigenous Peoples may be present, the affected land is not subject to customary use nor do affected areas include areas of indigenous cultural heritage significance. However this needs to be further screened by ERM and we assume that securing FPIC is not required as part of this scope.

4. Screen project sites to identify potential cultural heritage as defined in paragraph 3 of IFC PS8, and if identified, assess whether the project meets PS8 requirements and propose appropriate mitigations.

5. Screen for potential human rights (HR) risks, impacts, and violations associated with the project against relevant national and international HR principles, and propose appropriate mitigations as needed.

ERM has presented preliminary findings of the land acquisition review in the scoping report. These findings are based on a brief scoping visit in November 12016 and will need to be confirmed through the Household Surveys and further Consultation that will be undertaken as part of the ESIA.

It is understood that a small portion of Shwe Taung's total lease holding at the coal mine (in Nanmawke Village and possibly at Chuangzon and Paluzawa Villages) was previously used for shifting cultivation. It is understood that this may have affected less than 10 households that did not hold land use certificates. ERM will undertake consultation with each of these households during baseline studies to assess the adequacy of compensation payments. The Land Acquisition Review will be updated for the ESIA Report.

1.12 LIVELIHOOD RESTORATION PLAN (LRP)

Based on the results of ERM's Scoping Study, we do not consider that there have been significant adverse impacts to the livelihoods of local residents based on the project to date. Furthermore, it is understood that no physical or economic displacement is required for the expansion of the project. As such, we do not consider that a Livelihood Restoration Plan will be necessary for the project and this has been excluded from our scope of work. Shoul this be necessary based on the results of the baseline social surveys undertaken for the ESIA, this would be agreed separately with Shwe Taung.

Annex B

Impact Assessment Methodology

1 IMPACT ASSESSMENT METHODOLOGY

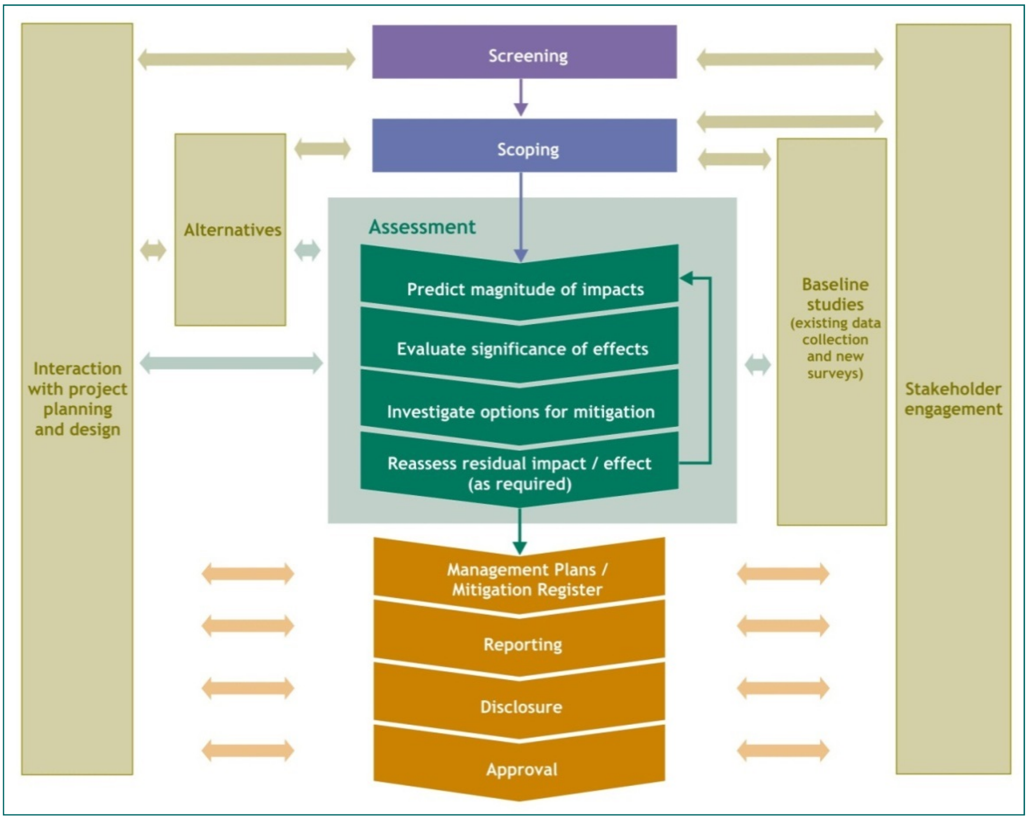
1.1 INTRODUCTION

This section of the EIA presents the methodology used to conduct the impact assessment. This methodology has been developed by ERM and is based on international best practice. The following approach is considered applicable to meet both Myanmar national and IFC requirements on environmental and social performance of the Project.

1.2 IMPACT ASSESSMENT METHODOLOGY

The impact assessment (IA) methodology follows the overall approach illustrated in *Figure B1.* The IA has been undertaken following a systematic process that predicts and evaluates the impacts the Project could have on aspects of the physical, biological, and social/ socio-economic environment, and identifies measures that the Project will take to avoid, minimise/reduce, mitigate, offset or compensate for adverse impacts; and to enhance positive impacts where practicable. The stages of the IA process are described below and further explained in the subsequent sections.

Figure B1 Impact Assessment Process



1.2.1 *Scoping*

Scoping has been undertaken to identify the potential Area of Influence (AOI) for the Project (and thus the appropriate Study Area), to identify interactions between the Project and resources/receptors in the AOI and the impacts that could result from these interactions, and to prioritize these impacts in terms of potential significance.

This phase is intended to ensure that the IA focuses on those issues that are most important for design, decision-making and stakeholder interest.

Scoping also has the benefit of identifying those impacts which are not likely to be significant and hence which warrant little or no further consideration or associated data gathering.

A scoping exercise was undertaken as part of EIA of the Project and the results are presented in *Section 4* of the EIA Report. The scoping of impacts indicates that the majority of identified potential impacts are not expected to be significant (i.e. those scoped out above). For activities predicted to have no significant impact (i.e. those in white in the Matrix), no detailed quantification or further assessment will be conducted in this EIA Report. For activities where possible significant effects could occur, these interactions will be assessed in more detail in *Sections 8-9* of this EIA Report

1.2.2 *Project Description*

The Project Description sets out the scope of the Project features and activities, with particular reference to the aspects which can impact on the environment. Details of the Project facilities' design characteristics, as well as Project activities, are provided in *Section 2* of this EIA Report.

1.2.3 *Stakeholder Engagement*

An effective IA Process requires engagement with relevant stakeholders throughout the key stages. This assists in informing stakeholders about the Project, understanding stakeholder views on the Project and in identifying issues that should be taken into account in the prediction and evaluation of impacts.

Details of the stakeholder engagement activities undertaken for this Project are presented in *Section 5* of this EIA report

1.2.4 *Baseline Environment*

To provide a context within which the impacts of the Project can be assessed, a description of physical, biological and social/socio-economic conditions that would be expected to prevail in the absence of the Project is characterized. The baseline includes information on all resources/receptors that were identified during scoping as having the potential to be affected by the Project.

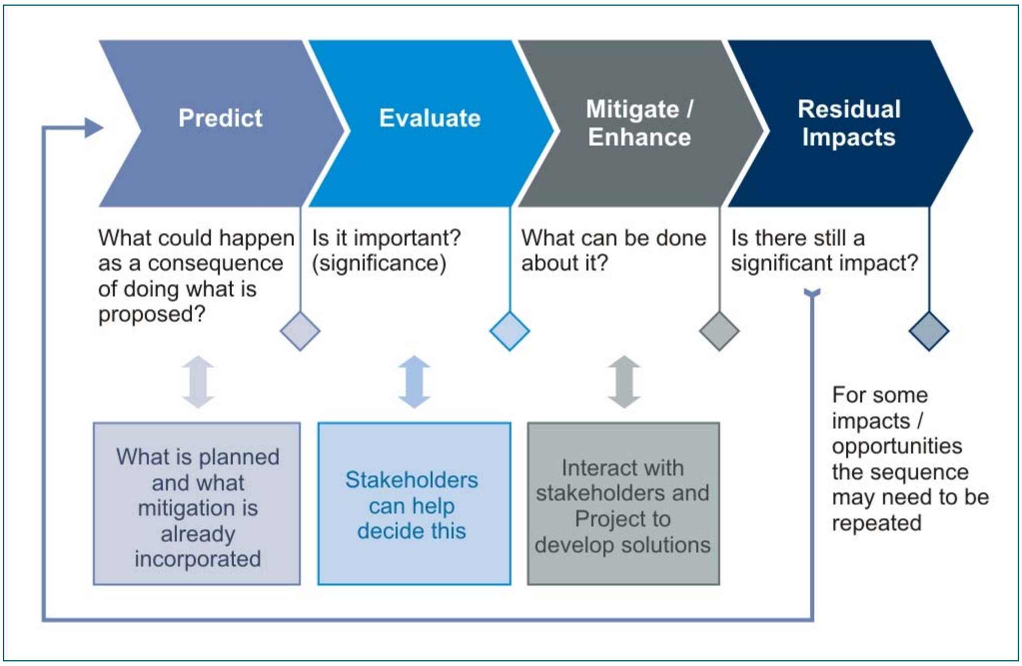
The baseline environment characterization is reported in *Sections 6-7* of this EIA Report.

1.2.5 *Impact Assessment*

Impact identification and assessment starts with scoping and continues through the remainder of the IA Process. The principal IA steps are summarized in *Figure B2* 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 B2 *Impact Assessment Workflow*



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 B1.*

Table B1 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 B2*. Definitions for the other designations are resource/receptor-specific, and are discussed in the resource/receptor-specific sections.

Table B2 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 <u>only to unplanned events</u> is *likelihood*. The *likelihood* of an unplanned event occurring is designated using a qualitative scale, as described in *Table B3*.

Table B3 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 sections. 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 B3.*

Figure B3 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	Critical

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 B1 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.

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).

Box B1 ***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.

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.

An ESMP, which contains a summary of all actions which the Project Proponents have committed to executing with respect to environmental/social/health performance for the Project, is also included as part of the EIA Report. The ESMP includes mitigation measures, compensatory measures and offsets and management and monitoring activities.

Annex C

Air Quality Impact Assessment (AQIA) Technical Inputs

Annex C1

AQIA Criteria

1 AIR QUALITY IMPACT ASSESSMENT CRITERIA

1.1 OVERVIEW

With regard to air quality, there is no project specific approach for determining magnitude and significance of impacts. There is, therefore, a need to make specific consideration of the guidance set out by the IFC when defining the magnitude and significance of impacts.

The significance criteria to be used for the air quality impact assessment are therefore discussed in this section, as these significance criteria were applied for assessing impacts to air quality in the ESIA.

1.2 AIR QUALITY ASSESSMENT SIGNIFICANCE CRITERIA

The *magnitude* of impacts during the operational phase was quantified using predictive techniques based on detailed dispersion modelling. The magnitude of the impact was ascertained by means of comparison to air quality standards (AQS) and guidelines and is based upon whether or not the impacts result in air quality standards being exceeded or contribute a substantial proportion of airborne pollutants in the local airshed. Magnitude is based on both the 'Project Contribution (PC)'; this is the impact arising solely from project related emissions, and the Predicted Environmental Concentration (PEC); this is the PC added to the existing baseline.

In order to determine the *significance* of those impacts, consideration is then required to the sensitivity of the area in question, based on sensitivity of human health within the general population. There are a small number of specific cases where the sensitivity may be defined as 'High'; these include hospitals where there are intensive care units or high dependency wards. In general, the approach used in this assessment assumes that sensitivity within the general human population is 'Medium'. Under no circumstances is the sensitivity for human health described as 'Low'.

The IFC make a differentiation in the significance of impacts, based upon the existing baseline. Essentially, this is whether air quality standards are exceeded or not due to baseline concentrations.

The IFC General EHS Guidelines state:

> *"Projects with significant sources of air emissions, and potential for significant impacts to ambient air quality, should prevent or minimize impacts by ensuring that:*
>
> - *Emissions do not result in pollutant concentrations that reach or exceed relevant ambient quality guidelines and standards by applying national legislated standards, or in their absence, the current WHO Air Quality Guidelines, or other internationally recognized sources.*

- *Emissions do not contribute a significant portion to the attainment of relevant ambient air quality guidelines or standards. As a general rule, this Guideline suggests 25 percent of the applicable air quality standards to allow additional, future sustainable development in the same airshed [i.e. in an undegraded airshed]".*

And:

> *"An airshed should be considered as having poor air quality [degraded] if nationally legislated air quality standards or WHO Air Quality Guidelines are exceeded significantly".*

The IFC guidelines further state:

> *"Facilities or projects located within poor quality airsheds, and within or next to areas established as ecologically sensitive (e.g. national parks), should ensure that any increase in pollution levels is as small as feasible, and amounts to a fraction of the applicable short-term and annual average air quality guidelines or standards as established in the project-specific environmental assessment."*

The significance of impacts is therefore defined in terms of the magnitude of impacts (i.e. the PEC), the sensitivity of the receptors, and whether the baseline pollution concentrations are above or below the air quality standards. Using this approach, the significance criteria for air quality have been defined. Based upon these considerations the magnitude and significance of impacts for un-degraded and degraded airsheds has been derived and presented in *Table 1.1* and

Table 1.2 respectively.

Table 1.1 *Magnitude Criteria for Assessment of Air Pollutants*

Magnitude of impact	Undegraded airshed (i.e. baseline < AQS)	Degraded airshed (i.e. baseline > AQS)
Negligible	PC <25% of AQS	PC <10% of AQS
Small	PC between 25% and 50% of AQS and PEC <100% of AQS	PC between 10% and 30% of AQS
Medium	PC between 50% and 100% of AQS, and PEC <100% AQS; or PC between 25% and 50% of AQS, and PEC >100% of AQS	PC between 30% and 50% of AQS
Large	PC > 100% of AQS; or PC > 50% of AQS, and PEC >100% of AQS	PC > 50% of AQS
PC: Process Contribution PEC: Predicted Environmental Concentration AQS: Air Quality Standard		

Table 1.2 Determination of Significance

Magnitude	Sensitivity		
	Low	***Medium***	***High***
Negligible	Negligible	Negligible	Negligible
Small	Negligible	Minor	Moderate
Medium	Minor	Moderate	Major
Large	Moderate	Major	Major

Box 1.1 provides a context for what the various impact significance ratings signify.

Box 1.1 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.

With regard to dust deposition there is no clear consensus as to the level of dust deposition that is likely to result in nuisance issues. However, on the basis of pragmatic consideration of the various guidelines used internationally, the following magnitude criteria have been developed relating to dust deposition:

- Negligible: <120mg/m^2/day;
- Small: 120 – 200 mg/m^2/day;
- Medium: 200 – 350 mg/m^2/day; and
- Large: >350mg/m^2/day.

Significance is defined on the basis of the matrix set out in *Table 1.1*. However, for dust 'high sensitivity' receptors for dust include: hospitals, schools, and sensitive commercial properties; 'medium sensitivity' receptors include residential properties, recreational areas, public open spaces and markets and shopping areas; 'low sensitivity' receptors represent other locations, in particular agriculture and industrial areas. Furthermore, the significance of impacts associated with dust deposition is assessed in terms of the PC only. Impacts associated with deposition of dust relate to the potential to cause nuisance issues, with this being related to dust deposition over and above that which already exists. Therefore the guidelines refer to increased deposition only; this is in contrast to other pollutants where the total concentration is considered, as impacts are assessed against an absolute health based standard.

Annex C2

AQIA Detailed Methodology

1 *OPERATIONAL PHASE AIR QUALITY IMPACT ASSESSMENT METHODOLOGY*

1.1 *CEMENT PLANT & ASSOCIATED LIMESTONE AND MUDSTONE QUARRY*

1.1.1 *Overview*

The Project will emit a number of pollutants during normal operation which could potentially lead to significant impacts on air quality at sensitive receptors. These are primarily nitrogen dioxide (NO_2), sulphur dioxide (SO_2), and particulate matter (PM_{10} and $PM_{2.5}$) from the cement manufacturing process including quarrying and mining. Potential impacts to air quality during this phase of the Project were quantified using detailed dispersion modelling.

The process of deriving emissions from the proposed activities and equipment, and subsequently informing the dispersion model, is highly complex. The overarching approach is set out here, and the detailed calculations are set out in *Annex A3.*

1.1.2 *Assumptions and Limitations*

A number of assumptions have been made for determining impacts to air quality during the operational phase of the Project and include:

- The baseline surveys were undertaken during a period at the time when the existing 1,500 tonnes per day (tpd) cement plant was operational. The results, therefore, are expected to reflect a measure of the concentrations associated to the existing operation. As a conservative approach, the baseline results were treated as indicative of the baseline and all modelled concentrations cumulatively added to derive the predicted environmental concentration (PEC). This is considered a worst case approach as some double counting of species concentrations is likely.

- The daily operation of the cement plant will generate some additional traffic on the local road network; however, the number of vehicle movements is anticipated to be sufficiently small to not result in a significant impact on air quality.

- Fugitive emissions from the cement plant and quarry sites have been modelled as three (3) individual and spatially separate volume sources. This approach incorporates emissions from all identified activities within the cement plant and quarries into one consolidated source and assumes a continuous emission throughout the year. In practice, emissions will be more isolated to specific process areas, such as crushers and grinding mills, for example, or spatially variable and transient in the case of quarries where processing of raw materials would be undertaken in different parts of the quarry throughout the year. This approach, therefore, has some inherent inaccuracy depending on where receptors are spatially located relative to the volume source. Predicted concentrations at receptors close to the volume source are likely to be over or underestimated depending on the specific processes being undertaken and its relative distance from the receptor. The approach, however, is considered acceptable given the information type available, the scale of the operation, and the relative distance of receptors to the fugitive sources. The exception is the worker accommodation identified within 500m of the cement plant. Pollutant plumes would merge with distance from the volume source, therefore the accuracy of the model findings would increase with increasing distance from the source.

1.1.3 *Proposed Project Activities*

The main sources of atmospheric emissions from the cement plant and quarries during operations are presented in *Table 1.1*.

Table 1.1 Project Activities

Project Component	Activity	Pollutants of Interest
Cement Plant	• the kiln systems and clinker coolers; • material transfers and handling including loading and loading crushers and stockpiles; • the crushing, milling and grinding of auxiliary materials and cement; and • the onsite storage of auxiliary material and clinker.	NO_x, NO_2, SO_2, Dust, PM_{10} and $PM_{2.5}$
Limestone Quarry	• clearing and excavating of surface materials; • bulldozing surface materials; • drilling; • blasting; • loading and unloading haul trucks with limestone and waste rock; • vehicle movements over unpaved surfaces; • wind erosion from limestone and waste rock stockpiles.	Dust, PM_{10} and $PM_{2.5}$
Mudstone Quarry	• clearing and excavating of surface materials; • bulldozing surface materials; • drilling; • blasting; • loading and unloading haul trucks with mudstone and waste rock; • vehicle movements over unpaved surfaces; • wind erosion from mudstone and waste rock stockpiles.	Dust, PM_{10} and $PM_{2.5}$

1.1.4 *Impact Assessment Methodology*

Detailed Modelling

The model used in the assessment is the USEPA AERMOD dispersion model. AERMOD is a state of the art detailed dispersion model that can be used to represent complex multiple emission sources and predicting air quality at receptor locations taking into account meteorology. The model is widely recognised for use in this type of application, including by the IFC, US Environmental Protection Agency, UK Environment Agency and Australian Environmental Protection Agency.

Detailed dispersion modelling has been used to predict concentrations of pollutants at ground level locations outside the site boundaries of the project and at sensitive human receptors. Five years of hourly sequential meteorological data have been used, so that inter annual variability is incorporated in the model. The results of the assessment are based upon the highest ground level concentration converted to the 95 percentile result for any of the five meteorological years used for each of the receptors considered. The dispersion modelling has considered a number of committed mitigation measures and the presented predicted impacts have assumed implementation of the committed mitigation measures. Based upon the results of the modelling, further mitigation is investigated where required.

Assessment Scenario

The potential impacts from the cement plant and quarries were based on emission associated with the cement plant operating at 5,500tpd capacity.

The modelling scenario was developed to reflect net emissions from all the sources operating simultaneously over one entire year which comprises of 365 days for modelling purposes.

Defining Sources

The representation of emission sources in AERMOD has been based upon the nature of the source being considered and takes into account the fact that pollutant emissions are generated by different mechanisms:

- Emissions of dust (total suspended particulates - TSP) and PM_{10}/$PM_{2.5}$ generated from mechanical sources such as ore handling and processing, waste handling, and cement manufacturing, for example, were modelled and treated as volume sources within the dispersion model. The volume source is defined as a three-dimensional source of diffuse air pollutant emissions where there is an initial emission height. The volume sources have been used to represent activities in the cement manufacturing area and the limestone and mudstone quarry areas where emissions are subject to an initial lift from mechanical processes such as the transferring of raw materials used for the cement production process. The dimensions of the volume sources were assumed based on the expected size of the pit required to generate an additional 2.2 million tons per annum (mtpa) of limestone and 262,260 tons per annum (tpa) of mudstone. See *Annex A3* for more information regarding these assumptions.

- Emissions of NO_x, SO_2 PM_{10} and $PM_{2.5}$ occur from the operation of kiln systems and clinker coolers. These emissions are distinctly different from emissions of fugitive dust described previously in that they occur at elevated temperature and therefore have thermal buoyancy and have an upward momentum provided by the flow of gases from the stack. Therefore, these sources were treated in the model as point sources, in which stack parameters such height of emission, temperature and exit velocity are defined.

The use of these different approaches ensures that the different emission sources are suitably reflected in the modelling approach.

Defining Emissions

Emissions arising from the activities during the lifetime of the proposed Project have been defined based on a detailed review of the proposed Project activities. Where necessary, emissions have been derived using the following sources of information:

- the National Pollution Inventory (NPi) emission estimation technique manuals [(1)] produced by the Australian Government, which includes typical emissions from mining and cement manufacturing activities, and other relevant sources referenced in this report; and

- the USEPA AP-42 emission factor database for Portland Cement Manufacturing [(2)] and Aggregate Handling and Storage Piles [(3)].

NPi and AP42 provide the most recently published consolidation of suitable emissions data, and although derived from Australia and US sources, is considered to be robust and suitable for use in this assessment. The NPi takes into consideration local meteorological effects and provides opportunity to take into consideration site specific factors such as silt content and distances travelled on roads. Where it is appropriate to take into account local conditions in the estimation of emissions careful consideration has been given to the climate and geology of Myanmar.

The NPi and AP-42 guidance documents have been used as the basis for the following:

- scoping significant emission sources;

- estimating emissions from the identified significant sources; and

- identifying the reductions in emissions achievable with mitigation measures, where necessary.

The emission rates applied to both point and volume sources are summarised and presented in *Table 1.2.* The detailed emission inventory including source

(1) Australian Government (2012) National Pollution Inventory Emission Estimation Technique Manual [online] Available from: http://www.npi.gov.au/reporting/industry-reporting-materials/emission-estimation-technique-manuals [Accessed 01 March 2017]

(2) United States Environmental Protection Agency (USEPA) (1995) Fifth Edition, Volume 1, Chapter 11.6: Portland Cement Manufacturing

(3) United States Environmental Protection Agency (USEPA) (1995) Fifth Edition, Volume 1, Chapter 13.2.4: Aggregate Handling And Storage Piles

paramaters, emission factors and methodology to estimated emission rates from each source type are presented in more detail in *Annex A3.*

Table 1.2 ***Applied Emission Rates***

Project Component	Source Type	Source Description	Pollutant Type	Emission Rate (g/s)
Cement Plant	Volume	Fugitive emission from 5,500tpd process	PM	3.28
	Point	Preheater stack (1,500tpd)	NO_x	40.7
			SO_2	0.881
			PM	6.78
	Point	Grate cooler stack (1,500tpd)	PM	1.56
	Point	Preheater stack (4,000tpd)	NO_x	70.0
			SO_2	46.6
			PM	3.50
	Point	Grate cooler stack (4,000tpd)	PM	3.62
Limestone Quarry	Volume	Fugitive emission from 5,500tpd process	PM	2.06
Mudstone Quarry	Volume	Fugitive emission from 5,500tpd process	PM	1.05

Land Use and Terrain

The land use and terrain around the Project will affect dispersion. Airflow over the ground is disturbed by protuberances into the air, for example buildings, trees and vegetation. The surface roughness length is a representation of the disruption of airflow close to the ground due to these obstructions. In this case, the land use type is primarily characterised by forest. The albedo, bowen ratio and surface roughness used in AERMOD to characterise the above-mentioned environment is presented below in *Table 1.3.*

Table 1.3 ***Land Use Characteristics***

Land Use Type	Albedo	Bowen Ratio	Surface Roughness
Deciduous forest	0.215	0.875	0.9

Hills, mountains and valleys can affect dispersion by directing the plume. The terrain pre-processor AERMAP using the Shuttle Radar Topographic Mission (SRTM) 90 x 90m imagery was run to provide information on the a) base elevation of each receptor and source defined in the model; and b) the terrain height that has the greatest influence on dispersion for each individual receptor, otherwise known as the hill height scale. Both the base elevation and hill height scale were incorporated into AERMOD.

Receptor Grid

The dispersion model uses a nested cartesian grid centred on cement plant and extending up to 5km in each direction to determine the maximum PC and the PC arising at sensitive receptors and in each receptor classification. The receptor spacing varies with distance from the cement plant in order to provide sufficiently dense receptors close to the site, and suitable spatial coverage further afield. The spacing of receptors is as follows:

- 50 meter spacing from 0 to 500 meters;
- 100 meter spacing from 500-1000 meters;
- 150 meter spacing from 1000 meters to 2000 meters; and
- 300 meter spacing from 2,000 meters to 5,000 meters.

Meteorological Data

The meteorological data used in the model must be reflective of the local conditions. There is very little meteorological data available for Myanmar, and that which was identified was not considered robust due to missing and incomplete data. Therefore five years of meteorological data were modelled using a 12km x 12km grid resolution using the Weather Research and Forecasting Model (WRF) [(1)]. The WRF model is a next-generation mesoscale numerical weather prediction system designed for both atmospheric research and operational forecasting needs. The model is extensively validated using actual observations to ensure the best possible accuracy and precision.

Conversion of NO_x to NO_2

Emissions from the Project contain oxides of nitrogen, occurring as both nitric oxide (NO) and NO_2. The ratio of these two gases in the exhaust gases from combustion processes varies, but is typically in the ratio of 90-95% NO to 5–10% NO_2. With regard to the assessment of impact on human health NO_2 is the pollutant of interest as NO has little effect on human health at concentrations typically encountered in ambient air.

Within the atmosphere various processes oxidise NO to create NO_2 but these processes will not occur quickly or completely before the plume reaches ground level. Therefore it is overly pessimistic to assume 100% conversion from NO to NO_2, and it is necessary to use a factor to estimate ground level concentrations of NO_2 based upon total NO_x emitted.

A number of international agencies have developed guidelines for including in assessments the conversion of NO to NO_2. A summary of selected

(1) Skamarock, W. C., J. B. Klemp, J. Dudhia, D. O. Gill, D. M. Barker, M. G Duda, X.-Y. Huang, W. Wang, and J. G. Powers, 2008: A Description of the Advanced Research WRF Version 3. NCAR Tech. Note NCAR/TN-475+STR, 113 pp.

guidelines are set out below in *Table 1.4* which indicates that a wide range of ratios to convert NO to NO_2 are recommended by a variety of agencies.

Table 1.4 Recommended NO to NO_2 Conversion Ratio

Country	Averaging period	Recommended NO to NO_2 conversion ratio
United States	1 hour	80%
	Annual	75%
Germany	24 hour	60%
	Annual	60%
United Kingdom	Short term (1 hour)	35%
	Annual	70%
Hong Kong	24 hour	20%
	Annual	20%
Ontario, Canada	24 hour	52%
	Annual	68%

On the basis of those factors identified, the worst cases are those derived by the USEPA. On this basis, an 80% conversion rate was used for short term and a 75% conversion rate was used for long term. These conversion factors have been applied in the results interpretation.

It should be noted that the USEPA discusses NO_x to NO_2 conversion approaches in detail in a March 2011 memorandum [(1)]. According to this memorandum, the approaches can be characterised in terms of tiers that correspond to decreasingly conservative, but increasingly accurate and scientifically justifiable, methods. Tier 1 assumes 100% conversion to NO_2. Tier 2 applies an Ambient Ratio Method (ARM) of 80% (1-hour) and 75% (annual) conversion, and Tier 3 uses the NO_x to NO_2 conversion algorithms built into AERMOD. The Tier 3 methods built into AERMOD include the Ozone Limiting Method (OLM) and Plume Volume Molar Ratio Method (PVMRM). Both OLM and PVMRM require the user to specify ozone concentrations that can vary in several different ways, ranging from a single value to hourly concentrations that need to be developed and processed for model input. According to EPA, the use of OLM or PVMRM must be justified on a case-by-case basis but these techniques are considered to be generally accurate and justifiable. The selection of a Tier 2 approach for this study (near-field and far-field) provides a conservative assessment.

Buildings

When air flow passes over buildings, a phenomenon known as building downwash occurs where the air is entrained in the lee of the building and drawn down to ground level. This effect can bring the plume from the stack down to ground level quicker than would otherwise be the case, and therefore increase the ground level concentration relative to a case where there are no

(1) USEPA, 2011. Memorandum - Additional Clarification Regarding Application of Appendix W Modeling Guidance for the 1-hour NO_2 National Ambient Air Quality Standard. United States Environmental Protection Agency, March 01 2011.

buildings. Building effects are typically a consideration where the buildings are greater than one third the height of the stacks.

No detailed information regarding the dimensions of buildings was available therefore no buildings were included within the model setup.

1.2 *COAL MINE AND ASSOCIATED COAL STOCKPILING AREA*

1.2.1 *Overview*

The Project will emit a number of pollutants during normal operation which could potentially lead to significant impacts on air quality at sensitive receptors. At the coal mine site, these are primarily dust, PM_{10} and $PM_{2.5}$ from the mining of coal and the associated activities including the transportation and handling of ore and waste materials and stockpiling.

The process of deriving emissions from the proposed activities and equipment, and subsequently informing the dispersion model, is highly complex. The overarching approach is set out here, and the detailed calculations are set out in *Annex A3.*

1.2.2 *Assumptions and Limitations*

A number of assumptions have been made for determining impacts to air quality during the operational phase of the coal mine and include:

- the daily operation of the mine will generate some additional traffic on the local road network; however, the number of vehicle movements is anticipated to be sufficiently small to not result in a significant impact on air quality.

- fugitive emissions from the coal mine and stockpile areas have been modelled as two (2) individual and spatially separate volume sources. This approach incorporates emissions from all identified activities within the coal mine and stockpiling area into one consolidated source and assumes a continuous emission throughout the year. In practice, emissions will be more isolated to specific processing areas or spatially variable and transient in the case of the coal mine where processing of raw materials would be undertaken in different parts of the mine footprint throughout the year. This approach, therefore, has some inherent inaccuracy depending on where receptors are spatially located relative to the volume source. Predicted concentrations at receptors close to the volume source are likely to be over or underestimated depending on the specific processes being undertaken and its relative distance from the receptor. The approach, however, is considered acceptable given the information type available, the scale of the operation, and the relative distance of receptors to the volume sources. The exception is Paluzawa identified within 50m of the coal stockpiling areas at the closest point. Pollutant plumes would merge with distance from the volume source, therefore the accuracy of the model findings would increase with increasing distance from the source.

1.2.3 *Proposed Project Activities*

The main sources of atmospheric emissions from the coal mine and stockpiling area during operation have been identified and are presented below in *Table 1.5.*

Table 1.5 Project Activities

Project Component	Activity	Pollutants of Interest
Coal Mine	• clearing and excavating of surface materials; • bulldozing surface materials; • loading and unloading haul trucks with coal and waste rock; • wind erosion from waste rock stockpiles; • vehicle movements over unpaved surfaces.	Dust, PM_{10} and $PM_{2.5}$
Coal Stockpiling Area	• unloading haul trucks with coal; • loading ships with coal; • vehicle movements over unpaved surfaces; • wind erosion from coal stockpiles.	Dust, PM_{10} and $PM_{2.5}$

1.2.4 *Impact Assessment Methodology*

Detailed Modelling

The detailed modelling approach is the same as that used for estimating emissions from the cement plant and associated quarry sites, however the results of the assessment are based upon the worst case result for any of the five meteorological years used for each of the receptors considered, as opposed to the 95 percentile applied at the cement plant. Refer to *Section 1.1.4* for further information.

Assessment Scenario

The potential impacts from the coal mine and stockpiling area were based on emissions associated with the coal mine producing 100,000tpa of coal.

The modelling scenario was developed to reflect net emissions from all the sources operating simultaneously over one entire year which comprises of 365 days for modelling purposes. It is noted that the coal mine is only active for six months of the year from December through May therefore this scenario is considered a worst case approach.

Defining Sources

The representation of emission sources in AERMOD has been based upon the nature of the source being considered and takes into account the fact that pollutant emissions are generated by different mechanisms:

- Emissions of dust (total suspended particulates - TSP) and PM_{10}/$PM_{2.5}$ generated from mechanical sources such as ore handling and processing and waste handling, for example, were modelled and treated as volume sources within the dispersion model. The volume source is defined as a three-dimensional source of diffuse air pollutant emissions where there is an initial emission height. The volume sources have been used to represent activities in the coal mine and stockpiling area where emissions are subject to an initial lift from mechanical processes such as the transfer and stockpiling of materials. The dimensions of the volume sources were based on the current size of the coal mine and the stockpile area. See *Annex A3* for further more detailed information regarding source type and characteristics.

Defining Emissions

Emissions arising from the activities during the lifetime of the proposed Project have been defined based on a detailed review of the proposed Project activities. Where necessary, emissions have been derived using the following sources of information:

- the National Pollution Inventory (NPi) emission estimation technique manual for mining (1) produced by the Australian Government, which includes typical emissions from mining activities.

The NPi provide the most recently published consolidation of suitable emissions data, and although derived from Australia sources, is considered to be robust and suitable for use in this assessment. The NPi takes into consideration local meteorological effects and provides opportunity to take into consideration site specific factors such as silt content and distances travelled on roads. Where it is appropriate to take into account local conditions in the estimation of emissions careful consideration has been given to the climate and geology of Myanmar.

The NPi guidance document has been used as the basis for the following:

- scoping significant emission sources;
- estimating emissions from the identified significant sources; and
- identifying the reductions in emissions achievable with mitigation measures, where necessary.

The emission rates applied to the volume sources are summarised and presented in *Table 1.6*. The detailed emission inventory including source parameters, emission factors and methodology to estimated emission rates are presented in more detail in *Annex A3.*

(1) Australian Government (2012) National Pollution Inventory Emission Estimation Technique Manual [online] Available from: http://www.npi.gov.au/reporting/industry-reporting-materials/emission-estimation-technique-manuals [Accessed 01 March 2017]

Table 1.6 ***Applied Emission Rates***

Project Component	Source Type	Source Description	Pollutant Type	Emission Rate (g/s)
Coal Mine	Volume	Fugitive emission from 100,000tpa coal production	PM	5.03
Coal Stockpiling Area	Volume	Fugitive emission from stockpiling 100,000tpa of coal	PM	1.60

Land Use and Terrain

The land use and terrain around the Project will affect dispersion. Airflow over the ground is disturbed by protuberances into the air, for example buildings, trees and vegetation. The surface roughness length is a representation of the disruption of airflow close to the ground due to these obstructions. In this case, the land use type is primarily characterised by forest. The albedo, bowen ratio and surface roughness used in AERMOD to characterise the above-mentioned environment is presented below in *Table 1.7.*

Table 1.7 ***Land Use Characteristics***

Land Use Type	Albedo	Bowen Ratio	Surface Roughness
Deciduous forest	0.215	0.875	0.9

Hills, mountains and valleys can affect dispersion by directing the plume. The terrain pre-processor AERMAP using the Shuttle Radar Topographic Mission (SRTM) 90 x 90m imagery was run to provide information on the a) base elevation of each receptor and source defined in the model; and b) the terrain height that has the greatest influence on dispersion for each individual receptor, otherwise known as the hill height scale. Both the base elevation and hill height scale were incorporated into AERMOD.

Receptor Grid

A 10km by 10km grid with a 150m resolution was applied across the study area to capture impacts from the coal mine and stockpiling areas. Furthermore, specific receptor points were included in the model to reflect the locations of the representative sensitive receptors.

Meteorological Data

The meteorological data used in the model must be reflective of the local conditions. There is very little meteorological data available for Myanmar, and that which was identified was not considered robust due to missing and incomplete data. Therefore five years of meteorological data were modelled using a 12km x 12km grid resolution using the Weather Research and

Forecasting Model (WRF) [1]. The WRF model is a next-generation mesoscale numerical weather prediction system designed for both atmospheric research and operational forecasting needs. The model is extensively validated using actual observations to ensure the best possible accuracy and precision.

Buildings

When air flow passes over buildings, a phenomenon known as building downwash occurs where the air is entrained in the lee of the building and drawn down to ground level. This effect can bring the plume from the stack down to ground level quicker than would otherwise be the case, and therefore increase the ground level concentration relative to a case where there are no buildings. Building effects are typically a consideration where the buildings are greater than one third the height of the stacks.

No detailed information regarding the dimensions of buildings was available therefore no buildings were included within the model setup.

(1) Skamarock, W. C., J. B. Klemp, J. Dudhia, D. O. Gill, D. M. Barker, M. G Duda, X.-Y. Huang, W. Wang, and J. G. Powers, 2008: A Description of the Advanced Research WRF Version 3. NCAR Tech. Note NCAR/TN-475+STR, 113 pp.

Annex C3

Emission Factors and AERMOD Emission Inventory

1 EMISISON FACTORS AND AERMOD EMISSION INVENTORY

This Annex details the emission factors used to estimate emission rates for the project, and includes the detailed emission inventory for each source type identified.

The final section of this annex includes summary tables detailing the AERMOD inputs for the cement plant, limestone quarry, mudstone quarry and coal mine.

2 EMISSION FACTORS

2.1 OVERVIEW

Emission factors from AP-42 and Npi were used to determine emission rates for a number of processes leading to fugitive dust emissions at the cement plant, limestone quarry, mudstone quarry and coal mine.

The primary sources of information include:

- National Pollution Inventory (NPi) Emission Estimation Technique Manual for Mining, Version 3.1[1];
- United States Environmental Protection Agency (USEPA) Air Pollutant Emission factors (AP-42) for Aggregate Handling And Storage Piles [2] ; and
- United States Environmental Protection Agency (USEPA) Air Pollutant Emission factors (AP-42) for Portland Cement Manufacturing [3].

2.1.1 *Emission factors for Portland Cement manufacturing*

The emission factors used to generate emission rates for operations at the cement plant are set out in *Table 2.1.*

(1) Australian Government (2012) National Pollution Inventory Emission Estimation Technique Manual for Mining, Version 3.1 [Online] Available at : http://www.npi.gov.au/system/files/resources/7e04163a-12ba-6864-d19a-f57d960aae58/files/mining.pdf [Accessed 11th March 2017]

(2) Unites States Environmental Protection Agency (USEPA) Air Pollutant Emission Factors (AP-42) Chapter 13.2.4 Aggregate Handling and Storage Piles [Online] Available at: https://www3.epa.gov/ttn/chief/ap42/ch13/final/c13s0204.pdf [Accessed 11th March 2017]

(3) Unites States Environmental Protection Agency (USEPA) Air Pollutant Emission Factors (AP-42) Chapter 11.6 Portland Cement Manufacturing [Online] Available at: https://www3.epa.gov/ttn/chief/ap42/ch11/final/c11s06.pdf [Accessed 11th March 2017]

Table 2.1 Emission Factors for Portland Cement Manufacturing

Process	Emission Factor	Unit
Particulate Matter (PM) from Kilns and Clinker Coolers		
Preheater/precalciner process kiln with fabric filter	0.100	kg/ton of clinker
Clinker cooler with ESP	0.0480	kg/ton of clinker
Particulate Matter (PM) from Manufacturing Raw Material and Product Processing and Handling		
Raw mill with fabric filter	6.20×10^{-3}	kg/ton of material process
Raw mill feed belt with fabric filter	1.60×10^{-3}	kg/ton of material process
Raw mill weigh hopper with fabric filter	0.0100	kg/ton of material process
Raw mill air separator with fabric filter	0.0160	kg/ton of material process
Finish grinding mill with fabric filter	4.20×10^{-3}	kg/ton of material process
Finish grinding mill feed belt with fabric filter	1.20×10^{-3}	kg/ton of material process
Finish grinding mill weigh hopper with fabric filter	4.70×10^{-3}	kg/ton of material process
Finish grinding mill air separator with fabric filter	0.0140	kg/ton of material process
Primary limestone crushing with fabric filter	5.00×10^{-4}	kg/ton of material process
Primary limestone screening with fabric filter	1.10×10^{-4}	kg/ton of material process
Limestone transfer with fabric filter	1.50×10^{-5}	kg/ton of material process
Secondary limestone screening and crushing with fabric filter	1.60×10^{-4}	kg/ton of material process
Source: USEPA AP-42 Emission Factor database – Chapter 11.6 Portland Cement Manufacturing		

2.1.2 *Emission Factors for Aggregate Handling and Storage Piles*

Overview

The approach set out in AP-42 and Npi was used to estimate the emissions of particulate matter from aggregate handling and storage piles at the cement plant, limestone quarry and mudstone quarry. Formulae are given to calculate emissions based upon source characteristics and other considerations such as local meteorological conditions.

Calculation of Emissions from Aggregate Handling and Storage Piles

Emission equations have been used to calculate emissions from material handling for the following processes:

- loading crushers;
- clearing and excavating; and
- loading and unloading haul trucks;

The emission factor equation used to estimate the emissions is as follows:

- E = 0.0016 x [((u/2.2)^1.3)/((m/2)^1.4)] (kg/ton of material) *(Equation 1)*
  - Where:
    - E = emission factor
    - u = mean wind speed
    - m = material moisture content

2.1.3 *Emission Factors for Mining*

Overview

The approach set out in Npi was used to estimate the emissions of particulate matter from mining processes at the coal mine, limestone quarry and mudstone quarry. Formulae are given to calculate emissions based upon source characteristics and other considerations such as local meteorological conditions.

Calculation of Emissions from Mining Operations

Emission equations have been used to calculate emissions from the following processes at the coal mine, mudstone quarry and limestone quarry:

- bulldozing;
- drilling;
- blasting;

- vehicle movements over unpaved surfaces;
- wind erosion form active stockpiles;
- excavators/shovels/front-end loaders; and
- wind erosion from active stockpiles.

The emission factor equation used to estimate the emissions from each of the above mentioned processes is as follows:

Bulldozers on Coal

- EF TSP = 35.6*s^1.2(%)/M^1.4(%) *(Equation 2)*
  - Where:
    - EF = emission Factor
    - S = silt content (%)
    - M= moisture content (%)

Bulldozers on Material other than Coal

- EF TSP = 2.6*s^1.2(%)/M^1.3(%) (*Equation 3)*
  - Where:
    - EF = Emission Factor
    - S = silt content (%)
    - M= moisture content (%)

Drilling

- TSP = 0.59 kg/hole (*Equation 4)*

Blasting

- EF TSP (kg/blast) = 0.00022 x A^1.5 (m2) (*Equation 5)*
  - Where:
    - EF = emission factor
    - A = area blasted (m^2)

Wheel Generated Dust from Unpaved Roads

- EF TSP (kgVKT) = (0.4536/1.6039)*4.9*(S(%)/12)^0.7)*(W(t)/3)^0.45 (*Equation 6)*

- Where:
  - EF = emission factor
  - S = silt content (%)
  - W(t) = vehicle mass

Wind Erosion from Active Stockpiles

- EF TSP = 1.9 x (S(%)/1.5)*365*(365-p/235)*(F(%)/15) (*Equation 7)*
  - Where:
    - EF = emission factor
    - S = silt content (%)
    - p = number of days rainfall >0.25mm
    - F = % of time wind speed >5.4m/s

3 EMISSION INVENTORY FOR EXISTING CEMENT PLANT (1500TPD)

The information used to calculate the emission rates for input into the AERMOD model are presented below in *Table 3.1.* The emission inventory and is presented in *Table 3.2, Table 3.3* and *Table 3.4.*

The emissions inventory has been developed based on the maximum amount of clinker produced in one full operational year.

Table 3.1 Existing Cement Plant Information (1500tpd)

Parameter	Quantity	Unit	Note
Output			
Clinker per day	1500	ton/day	Data provided by Shwe Tanug Cement
Clinker produced	493500	ton/year	Data provided by Shwe Tanug Cement
Operating hours	7896	hours	Data provided by Shwe Tanug Cement
Input			
Coal	113505	ton/year	Data provided by Shwe Tanug Cement
Limestone	709628	ton/year	Data provided by Shwe Tanug Cement
Mudstone	84464	ton/year	Data provided by Shwe Tanug Cement
Laterite	21883	ton/year	Data provided by Shwe Tanug Cement
Dolomite	24686	ton/year	Data provided by Shwe Tanug Cement
Other relevant data			
Moisture content of limestone	3	%	Data provided by Shwe Tanug Cement
Mean wind speed	3.36	m/s	Weather Research and Forecasting Model (WRF) data

Table 3.2 *Fugitive Dust Emissions Inventory for Existing Cement Plant (1500tpd)*

Project Process	Representative USEPA/NPI Process (see *Section 1*)	TSP Emission Factor	Unit	Emission Rate (g/s)
Loading Crusher	Material Transfer	1.16×10^{-3}	kg/ton of material process	0.0262
Primary Limestone crusher	Primary limestone crushing with fabric filter	5.00×10^{-4}	kg/ton of material process	0.0113
Secondary limestone crusher	Secondary limestone screening and crushing with fabric filter	1.60×10^{-4}	kg/ton of material process	3.60×10^{-3}
Conveyor transfer point	*Assumed covered*	*n/a*	*n/a*	*n/a*
Limestone Storage	Limestone transfer with fabric filter	1.50×10^{-5}	kg/ton of material process	3.38×10^{-4}
Limestone Stacker	Limestone transfer with fabric filter	1.50×10^{-5}	kg/ton of material process	3.38×10^{-4}
Limestone Re-claimer	Limestone transfer with fabric filter	1.50×10^{-5}	kg/ton of material process	3.38×10^{-4}
Auxiliary Material Crusher	Primary limestone crushing with fabric filter	5.00×10^{-4}	kg/ton of material process	1.69×10^{-3}
Raw Mill	Raw mill with fabric filter	6.20×10^{-3}	kg/ton of material process	0.160
	Raw mill feed belt with fabric filter	1.60×10^{-3}	kg/ton of material process	0.041
	Raw mill weigh hopper with fabric filter	0.0100	kg/ton of material process	0.259
Clinker Silo	*Assumed covered*	*n/a*	*n/a*	*n/a*
Cement Silo	*Assumed covered*	*n/a*	*n/a*	*n/a*
Coal Crusher	Primary limestone crushing with fabric filter	5.00×10^{-4}		1.80×10^{-3}
Coal Handling	*Assumed covered*	*n/a*	*n/a*	*n/a*
Coal Storage	*Assumed covered*	*n/a*	*n/a*	*n/a*
Coal Mill	Raw mill with fabric filter	6.20×10^{-3}	kg/ton of material process	0.0223
Cement Mill	Finish grinding mill with fabric filter	4.20×10^{-3}	kg/ton of material process	0.0690
	Finish grinding mill feed belt with fabric filter	1.20×10^{-3}	kg/ton of material process	0.0197
	Finish grinding mill weigh hopper with fabric filter	4.70×10^{-3}	kg/ton of material process	0.0772
	Finish grinding mill air separator with fabric filter	0.0140	kg/ton of material process	0.230
Packer	*Assumed covered*	*n/a*	*n/a*	*n/a*
Total fugitive TSP emission rate from facility				**0.92**

Table 3.3 *Preheater Stack Emission Inventory for Existing Cement Plant (1500tpd)*

Stack Parameter	Data		Unit	Note
Stack Location	20°52'5.00"N	96°23'30.77"E	Latitude/Longitude	Location of stack identified using aerial imagery
Stack height	87		m	Data provided by Shwe Tanug Cement
Stack diameter	2.80		m	Data provided by Shwe Tanug Cement
Emission velocity	16.3		m/s	Data provided by Shwe Tanug Cement
Volume flow rate	100		(Am^3/s)	Calculated based on emission velocity and stack diameter
Volume flow rate	67.8		(Nm^3/s)	Volume flow rate corrected for temperature only as actual oxygen and moisture content of exhaust gas not known(1)

Stack Parameter	Data	Unit	Note
Exit temperature	404	kelvin	Data provided by Shwe Tanug Cement
Reference temperature	273	kelvin	IFC EHS (2007)(2)
Oxygen (actual)	*n/a*	%	No data provided
Oxygen (normalised)	10	%	IFC EHS (2007)(2)
Moisture (actual)	*n/a*	%	No data provided
Moisture (normalised)	0	%	IFC EHS (2007)(2)
Expected hours of operation per year	7680	hours	Data provided by Shwe Tanug Cement
Emission Concentrations			
NO_x	600	mg/Nm³	Myanmar emission limit guideline(2)(3)
SO_2	13	mg/Nm³	Data provided by Shwe Tanug Cement
PM	100	mg/Nm³	Myanmar emission limit guideline(2)(3)
Emission Rates			
NO_x	40.7	g/s	Calculated based on emission concentration and normalised volume flow rate specified.
SO_2	0.881	g/s	
PM	6.78	g/s	

(1) Environmental Permitting (England and Wales) Regulations 2010 Regulation 60(1) – Pollution Inventory Reporting – Combustion Activities Guidance Note, Version 4 January 2013

(2) International Finance Corporation (IFC) Environmental, Health and Safety Guidelines for Cement and Lime Manufacturing, 2007.

(3) Myanmar national Environmental Quality (Emission) Guidelines, 2015.

Table 3.4 Grate Cooler Stack Emission Inventory for Existing Cement Plant (1500tpd)

Stack Parameter	Data	Unit	Note
Stack Location	20°52'1.34"N 96°23'32.58"E	Latitude/Longitude	Location of stack identified using aerial imagery
Stack height	30	m	Data provided by Shwe Tanug Cement
Stack diameter	2.20	m	Data provided by Shwe Tanug Cement
Emission velocity	14.1	m/s	Data provided by Shwe Tanug Cement
Volume flow rate	53.6	(Am³/s)	Calculated based on emission velocity and stack diameter
Volume flow rate	31.2	(Nm³/s)	Volume flow rate corrected for temperature only as actual oxygen and moisture content of exhaust gas not known(1)
Exit temperature	469	kelvin	Data provided by Shwe Tanug Cement
Reference temperature	273	kelvin	IFC EHS (2007)(2)
Oxygen (actual)	*n/a*	%	No data provided
Oxygen (normalised)	10	%	IFC EHS (2007)(2)
Moisture (actual)	*n/a*	%	No data provided
Moisture (normalised)	0	%	IFC EHS (2007)(2)
Expected hours of operation per year	7680	hours	Data provided by Shwe Tanug Cement
Emission Concentrations			

Stack Parameter	Data	Unit	Note
PM	50	mg/Nm^3	Myanmar emission limit guideline[(2)(3)]
Emission Rates			
PM	1.56	g/s	Calculated based on emission concentration and normalised volume flow rate specified.

(1) Environmental Permitting (England and Wales) Regulations 2010 Regulation 60(1) – Pollution Inventory Reporting – Combustion Activities Guidance Note, Version 4 January 2013

(2) International Finance Corporation (IFC) Environmental, Health and Safety Guidelines for Cement and Lime Manufacturing, 2007.

(3) Myanmar national Environmental Quality (Emission) Guidelines, 2015.

4 *EMISSION INVENTORY FOR PROPOSED CEMENT PLANT (4000TPD)*

The information used to calculate the emission rates for input into the AERMOD model are presented below in *Table 4.1.* The emission inventory is presented in *Table 4.2*, *Table 4.3* and *Table 4.4.*

The emissions inventory has been developed based on the maximum amount of clinker produced in one full operational year.

Table 4.1 Proposed Cement Plant Information (4000tpd)

Parameter	Quantity	Unit	Note
Output			
Clinker per day	4000	ton/day	Myanmar Shwe Tanug 4000TPD Technical Introductions, 2016
Clinker per year	1240000	ton/year	Myanmar Shwe Tanug 4000TPD Technical Introductions, 2016
Cement produced per year	1488000	ton/year	Myanmar Shwe Tanug 4000TPD Technical Introductions, 2016
Operating hours	7896	hours	Myanmar Shwe Tanug 4000TPD Technical Introductions, 2016
Input			
Coal	220007	ton/year	Myanmar Shwe Tanug 4000TPD Technical Introductions, 2016
Limestone	1566492	ton/year	Myanmar Shwe Tanug 4000TPD Technical Introductions, 2016
Mudstone	262260	ton/year	Myanmar Shwe Tanug 4000TPD Technical Introductions, 2016
Laterite	73780	ton/year	Myanmar Shwe Tanug 4000TPD Technical Introductions, 2016
Raw Meal	1902532	ton/year	Myanmar Shwe Tanug 4000TPD Technical Introductions, 2016
Gypsum	37216	ton/year	Myanmar Shwe Tanug 4000TPD Technical Introductions, 2016
Mix material	74431	ton/year	Myanmar Shwe Tanug 4000TPD Technical Introductions, 2016
Other relevant data			
Moisture content of limestone	3.00	%	Data provided by Shwe Taung Cement
Mean wind speed	3.36	m/s	Weather Research and Forecasting Model (WRF) data

Table 4.2 *Fugitive Dust Emission Inventory for the Proposed Cement Plant (4000tpd)*

Project Process	Representative USEPA/NPI Process (see *Section 1*)	TSP Emission Factor	Unit	Emission Rate (g/s)
Loading Crusher	Material Transfer	1.16×10^{-3}	kg/ton of material process	0.0578
Primary Limestone crusher	Primary limestone crushing with fabric filter	5.00×10^{-4}	kg/ton of material process	0.0248
Secondary limestone crusher	Secondary limestone screening and crushing with fabric filter	1.60×10^{-4}	kg/ton of material process	7.95×10^{-3}
Conveyor transfer point	*Assumed covered*	*n/a*	*n/a*	*n/a*
Limestone Storage	Limestone transfer with fabric filter	1.50×10^{-5}	kg/ton of material process	7.45×10^{-4}
Limestone Stacker	Limestone transfer with fabric filter	1.50×10^{-5}	kg/ton of material process	7.45×10^{-4}
Limestone Re-claimer	Limestone transfer with fabric filter	1.50×10^{-5}	kg/ton of material process	7.45×10^{-4}
Auxiliary Material Crusher	Primary limestone crushing with fabric filter	5.00×10^{-4}	kg/ton of material process	5.33×10^{-3}
Raw Mill	Raw mill with fabric filter	6.20×10^{-3}	kg/ton of material process	0.374
	Raw mill feed belt with fabric filter	1.60×10^{-3}	kg/ton of material process	0.097
	Raw mill weigh hopper with fabric filter	0.0100	kg/ton of material process	0.603
Clinker Silo	*Assumed covered*	*n/a*	*n/a*	*n/a*
Cement Silo	*Assumed covered*	*n/a*	*n/a*	*n/a*
Coal Crusher	Primary limestone crushing with fabric filter	5.00×10^{-4}		3.49×10^{-3}
Coal Handling	*Assumed covered*	*n/a*	*n/a*	*n/a*
Coal Storage	*Assumed covered*	*n/a*	*n/a*	*n/a*
Coal Mill	Raw mill with fabric filter	6.20×10^{-3}	kg/ton of material process	0.0433
Cement Mill	Finish grinding mill with fabric filter	4.20×10^{-3}	kg/ton of material process	0.198
	Finish grinding mill feed belt with fabric filter	1.20×10^{-3}	kg/ton of material process	0.0566
	Finish grinding mill weigh hopper with fabric filter	4.70×10^{-3}	kg/ton of material process	0.222
	Finish grinding mill air separator with fabric filter	0.0140	kg/ton of material process	0.661
Packer	*Assumed covered*	*n/a*	*n/a*	*n/a*
Total fugitive TSP emission rate from facility				2.36

Table 4.3 *Preheater Stack Emission Inventory for the Proposed Cement Plant (4000tpd)*

Stack Parameter	Data	Unit	Note
Stack Location	20° 52.065'N 96° 23.433'E	Latitude/Longitude	Location of stack identified using aerial imagery
Stack height	87	m	Data provided by Shwe Tanug Cement
Stack diameter	3.60	m	Data provided by Shwe Tanug Cement
Emission velocity	16.5	m/s	Data provided by Shwe Tanug Cement
Volume flow rate	168	(Am^3/s)	Calculated based on emission velocity and stack diameter
Volume flow rate	117	(Nm^3/s)	Volume flow rate corrected for temperature only as actual oxygen and moisture content of exhaust gas not known(1)

Stack Parameter	Data	Unit	Note
Exit temperature	393	kelvin	Data provided by Shwe Tanug Cement
Reference temperature	273	kelvin	IFC EHS (2007)(2)
Oxygen (actual)	*n/a*	%	No data provided
Oxygen (normalised)	10	%	IFC EHS (2007)(2)
Moisture (actual)	*n/a*	%	No data provided
Moisture (normalised)	0	%	IFC EHS (2007)(2)
Expected hours of operation per year	7680	hours	Data provided by Shwe Tanug Cement
Emission Concentrations			
NO_x	600	mg/Nm^3	Myanmar emission limit guideline(2)(3)
SO_2	400	mg/Nm^3	Data provided by Shwe Tanug Cement
PM	30	mg/Nm^3	Myanmar emission limit guideline(2)(3)
Emission Rates			
NO_x	70	g/s	Calculated based on emission concentration and normalised volume flow rate specified.
SO_2	46.6	g/s	
PM	3.50	g/s	

(1) Environmental Permitting (England and Wales) Regulations 2010 Regulation 60(1) – Pollution Inventory Reporting – Combustion Activities Guidance Note, Version 4 January 2013

(2) International Finance Corporation (IFC) Environmental, Health and Safety Guidelines for Cement and Lime Manufacturing, 2007.

(3) Myanmar national Environmental Quality (Emission) Guidelines, 2015.

Table 4.4 Grate Cooler Stack Emission Inventory the for Proposed Cement Plant (4000tpd)

Stack Parameter	Data	Unit	Note
Stack Location	20° 52.013'N 96° 23.472'E	Latitude/Longitude	Location of stack identified using aerial imagery
Stack height	30	m	Data provided by Shwe Tanug Cement
Stack diameter	3.35	m	Data provided by Shwe Tanug Cement
Emission velocity	16.0	m/s	Data provided by Shwe Tanug Cement
Volume flow rate	141	(Am^3/s)	Calculated based on emission velocity and stack diameter
Volume flow rate	72.4	(Nm^3/s)	Volume flow rate corrected for temperature only as actual oxygen and moisture content of exhaust gas not known(1)
Exit temperature	469	kelvin	Data provided by Shwe Tanug Cement
Reference temperature	273	kelvin	IFC EHS (2007)(2)
Oxygen (actual)	*n/a*	%	No data provided
Oxygen (normalised)	10	%	IFC EHS (2007)(2)
Moisture (actual)	*n/a*	%	No data provided
Moisture (normalised)	0	%	IFC EHS (2007)(2)
Expected hours of operation per year	7680	hours	Data provided by Shwe Tanug Cement
Emission Concentrations			

Stack Parameter	Data	Unit	Note
PM	50	mg/Nm^3	Myanmar emission limit guideline[(2)(3)]
Emission Rates			
PM	3.62	g/s	Calculated based on emission concentration and normalised volume flow rate specified.

(1) Environmental Permitting (England and Wales) Regulations 2010 Regulation 60(1) – Pollution Inventory Reporting – Combustion Activities Guidance Note, Version 4 January 2013

(2) International Finance Corporation (IFC) Environmental, Health and Safety Guidelines for Cement and Lime Manufacturing, 2007.

(3) Myanmar national Environmental Quality (Emission) Guidelines, 2015.

5 LIMESTONE QUARRY EMISSION INVENTORY

The information used to calculate emission rates for input into the AERMOD model are presented below in *Table 5.1.* The emission inventory is presented in *Table 5.2.*

The emissions inventory has been developed based on the 5,500tpd information.

Table 5.1 Limestone Quarry Information

In-Pit Information	Units	1500tpd(1)	5500tpd(2)
Total rock	ton/yr	684000	2584000
Total Ore for stockpiling	ton/yr	624000	2357333
Total Waste Rock Production	ton/yr	60000	226667
Crusher Feed	ton/yr	576000	2176000
Number of Blasting Holes	no.	80	302
Number of Blasts	per yr	84	317
Typical Area Blasted	m^2	600	600
Depth of blast hole	m	6	6
Moisture of Material	%	3(3)	
Mean Wind Speed	m/s	3.36(4)	
Silt Content	%	3.9(5)	
Area			
Pit Area	m^2	123147	465222
Length of pit	m	351(6)	682(6)
Waste dump area	m^2	12140	45862
Stockpile area	m^2	24281	91728
Vehicle			
Vehicle mass	ton	17	17
Number of trucks	no.	10	38
Total length of product road	m	5100	5100
Haul truck journeys per day	journeys/day	12	12
Total truck journeys per day	journeys/day	120	453
Average speed	km/hr	25	25

(1) Information for limestone quarry for existing production line was provided by Shwe Tanug Cement.

(1) The new production line will require an additional 1.6 million tons of limestone per year. The information for the 1500tpd production line indicates 576,000 tons of limestone per year goes through the crusher system. The total production with the 5,500tpd production line operational will therefore be 2,176,000 tons of limestone per year. The data for the new production line is therefore multiplied by a factor of 3.78 to estimate the required information for the 5,500tpd production line.

(2) Moisture of limestone provided by Shwe Tanug Cement.

(3) Mean wind speed calculated from Weather Research and Forecasting Model (WRF) data.

(4) USEPA AP-42: Chapter 13.2.4 - Aggregate handling and storage piles (mean silt content for general limestone)

(5) Length of pit is the square root of the area. This has been used to define the volume source in AERMOD.

Table 5.2 Limestone Quarry Emission Inventory for 5500tpd Production Line

Project Process	Representative USEPA/NPI Process (see *Section 1*)	TSP Emission Factor	Unit	Emission Rate (g/s)
Clearing/excavating	Material Transfer	3.23×10^{-4}	kg/ton of material process	0.0265
Bulldozing	Bulldozer on Material other than Coal	3.19	kg/hr	0.887
Drilling	Drilling	178	kg/yr	5.65×10^{-3}
Blasting	Blasting	3.2	kg/blast	0.0325
Loading and unloading haul trucks (ore)	Material Transfer	1.16×10^{-3}	kg/ton of material process	0.0870
Loading and unloading haul trucks (ore)	Material Transfer	1.16×10^{-3}	kg/ton of material process	0.0870
Loading and unloading haul trucks (ore)	Material Transfer	1.16×10^{-3}	kg/ton of material process	0.0804
Loading and unloading haul trucks (ore)	Material Transfer	1.16×10^{-3}	kg/ton of material process	0.0804
Vehicle movements over unpaved surfaces	Wheel generated dust from unpaved roads	1.38	kg/VKT	0.517(1)
Conveying	*Assume covered – no emission*			
Wind erosion from limestone stockpiles	Wind erosion from active coal stockpiles	1305	kg/ha/yr	0.0643
Loading and unloading haul trucks (waste)	Material Transfer	3.23×10^{-4}	kg/ton of material process	2.32×10^{-3}
Loading and unloading haul trucks (waste)	Material Transfer	3.23×10^{-4}	kg/ton of material process	2.32×10^{-3}
Wind erosion from waste rock stockpiles	Wind erosion from active coal stockpiles	1305	kg/ha/yr	0.190
Total fugitive TSP emission rate from limestone quarry				2.06

(1) Based on total truck journeys per day assuming each truck travels the length of the pit area (682m) each journey as a worst case assumption.

6 MUDSTONE QUARRY EMISSION INVENTORY

The information used to calculate emission rates for input into the AERMOD model are presented below in *Table 6.1*. The emission inventory is presented in *Table 6.2*.

The emissions inventory has been developed based on the 5,500tpd information.

Table 6.1 Mudstone Quarry Information

In-Pit Information	Units	1500tpd(1)	5500tpd(2)
Total rock	ton/yr	168000	430260
Total Ore for stockpiling	ton/yr	84000	215130
Total Waste Rock Production	ton/yr	84000	215130
Crusher Feed	ton/yr	84000	215130
Number of Blasting Holes	no.	80	205
Number of Blasts	per yr	23	59
Typical Area Blasted	m^2	600	600
Depth of blast hole	m	6	6
Moisture of Material	%	10(3)	
Mean Wind Speed	m/s	3.36(4)	
Silt Content	%	7.5(5)	
Area			
Pit Area	m^2	378500	969366
Length of pit	m	615(6)	985(6)
Waste dump area	m^2	4800	12293
Stockpile area	m^2	6070	15546
Vehicle			
Vehicle mass	ton	17	17
Number of trucks	no.	5	13
Total length of product road	m	2500	2500
Haul truck journeys per day	journeys/day	20	20
Total truck journeys per day	journeys/day	100	260
Average speed	km/hr	25	25

(1) Information for mudstone quarry servicing the 1500tpd cement plant was provided by Shwe Tanug Cement.

(2) The new production line will require an additional 262,260 tons of mudstone per year. The information for the 1500tpd production line indicates 168,000 tons of mudstone per year is required. The total production with the 5,500tpd production line operational will therefore be 430,260 tons of mudstone per year. The data for the new production line is therefore multiplied by a factor of 2.56 to estimate the required information for the 5,500tpd production line.

(3) Moisture of limestone provided by Shwe Tanug Cement.

(4) Mean wind speed calculated from Weather Research and Forecasting Model (WRF) data.

(5) USEPA AP42 - Chapter 13.2.4 - Aggregate handling and storage piles (mean silt content of overburden at western surface coal mining

(6) Length of pit is the square root of the area. This has been used to define the volume source in AERMOD.

Table 6.2 Mudstone Quarry Emission Inventory for 5500tpd Production Line

Project Process	**Representative USEPA/NPI Process (see *Section 1*)**	**TSP Emission Factor**	**Unit**	**Emission Rate (g/s)**
Clearing/excavating	Material Transfer	3.23×10^{-4}	kg/ton of material process	4.40×10^{-3}
Bulldozing	Bulldozer on Material other than Coal	1.46	kg/hr	0.406
Drilling	Drilling	121	kg/yr	3.83×10^{-3}
Blasting	Blasting	3.2	kg/blast	6.04×10^{-3}
Loading and unloading haul trucks (ore)	Material Transfer	2.16×10^{-4}	kg/ton of material process	1.47×10^{-3}
Loading and unloading haul trucks (ore)	Material Transfer	2.16×10^{-4}	kg/ton of material process	1.47×10^{-3}
Wind erosion from mudstonestockpiles	Wind erosion from active coal stockpiles	2788	kg/ha/yr	0.137
Loading and unloading haul trucks (waste)	Material Transfer	3.23×10^{-4}	kg/ton of material process	2.20×10^{-3}
Loading and unloading haul trucks (waste)	Material Transfer	3.23×10^{-4}	kg/ton of material process	2.20×10^{-3}
Wind erosion from waste rock stockpiles	Wind erosion from active coal stockpiles	2788	kg/ha/yr	0.109
Vehicle movements over unpaved surfaces	Wheel generated dust from unpaved roads	2.18	kg/VKT	0.377 (1)
Total fugitive TSP emission rate from mudstone quarry				1.05

(1) Based on total truck journeys per day assuming each truck travels the length of the pit area (985m) each journey as a worst case assumption.

7 *COAL MINE EMISSION INVENTORY*

The information used to calculate the emission rates for input into the AERMOD model are presented below in *Table 7.1.* The emission inventory is presented in *Table 7.2* and *Table 7.3.*

The emissions inventory has been developed based on the coal mine producing 100,000tpa of coal for stockpiling and transporting.

Table 7.1 Coal Mine Information

In-Pit Information	Units	100,000tpa[(1)]
Total rock	ton/yr	1900000
Total Ore for stockpiling	ton/yr	100000
Total Waste Rock Production	ton/yr	1800000
Moisture of Material	%	9[(2)]
Mean Wind Speed	m/s	3.36[(3)]
Silt Content	%	6[(4)]
Area		
Pit Area	m^2	1800000
Length of pit	m	1341[(5)]
Waste dump area	m^2	7000
Stockpile area	m^2	150000
Length of stockpile area	m	1342[(6)]
Vehicle on product road		
Vehicle mass	ton	17
Number of trucks	no.	10
Total length of product road at mine site	m	400
Haul truck journeys per day	journeys/day	42
Total truck journeys per day	journeys/day	420
Average speed	km/hr	25
Vehicle at stockpiling area		
Vehicle mass	ton	17
Number of trucks	no.	10
Total length of product road at mine site	m	387
Haul truck journeys per day	journeys/day	42
Total truck journeys per day	journeys/day	420
Average speed	km/hr	25

(1) Information for coal mine producing 100,000tpa provided by Shwe Tanug Cement.
(2) Moisture of limestone provided by Shwe Tanug Cement.
(3) Mean wind speed calculated from Weather Research and Forecasting Model (WRF) data.
(4) USEPA AP42 - Chapter 13.2.4 - Aggregate handling and storage piles (mean silt content of coal at western surface coal mining)
(5) Length of pit is the square root of the area. This has been used to define the volume source in AERMOD.
(6) Length of stockpile area is the square root of the total area. This has been used to define the volume source in AERMOD.

Table 7.2 ***Coal Mine Emission Inventory - 100,000tpd Production***

Project Process	Representative USEPA/NPI Process (see *Section 1*)	TSP Emission Factor	Unit	Emission Rate (g/s)
Clearing/excavating	Material Transfer	3.23E-04	kg/ton of material process	0.0195
Bulldozing	Bulldozer on coal	14.67	kg/hr	4.07
Loading and unloading haul trucks (ore)	Excavators/shovels/front-end loaders (on coal)	0.0415	kg/ton of material process	0.132
Loading and unloading haul trucks (waste)	Material Transfer	3.23E-04	kg/ton of material process	0.0184
Loading and unloading haul trucks (waste)	Material Transfer	3.23E-04	kg/ton of material process	0.0184
Wind erosion from waste rock stockpiles	Wind erosion from active coal stockpiles	2075	kg/ha/yr	0.0460
Haul trucks movements over unpaved surfaces	Wheel generated dust from unpaved roads	1.91	kg/VKT	0.360(1)
Dump truck movements over unpaved surfaces	Wheel generated dust from unpaved roads	1.91	kg/VKT	0.360(1)
Total fugitive TSP emission rate from coal mining area				5.03

(1) Based on total truck journeys per day assuming each truck travels the length of the product road (400m) each journey as a worst case assumption.

Table 7.3 ***Coal Stockpiling Area Emission Inventory - 100,000tpd Production***

Project Process	Representative USEPA/NPI Process (see *Section 1*)	TSP Emission Factor	Unit	Emission Rate (g/s)
Loading and unloading haul trucks (ore)	Excavators/shovels/front-end loaders (on coal)	0.0415	kg/ton of material process	0.132
Loading and unloading haul trucks (ore)	Excavators/shovels/front-end loaders (on coal)	0.0415	kg/ton of material process	0.132
Wind erosion from coal stockpiles	Wind erosion from active coal stockpiles	2075	kg/ha/yr	0.987
Vehicle movements over unpaved surfaces	Wheel generated dust from unpaved roads	1.91	kg/VKT	0.349(1)
Total fugitive TSP emission rate from coal stockpiling area				1.60

(1) Based on total truck journeys per day assuming each truck travels the length of the stockpile area (1342m) each journey as a worst case assumption.

8 SUMMARY OF AERMOD INPUTS FOR CEMENT PLANT, LIMESTONE QUARRY, MUDSTONE QUARRY AND COAL MINE

8.1 CEMENT PLANT

The AERMOD model inputs for the cement plant are summarised in *Table 8.1* and *Table 8.2* below.

Table 8.1 Volume Source Information

Parameter	Data used in AERMOD	Unit
Source Type	Volume	Source type
Location	20°52'1.75"N 96°23'27.22"E	Lat/Long
Release height	2.5	m
Area of volume source	331776	m^2
Length of side	576	m
Emissions rate	3.28	g/s TSP

Table 8.2 Point Source Information

Parameter	1500tpd		4000tpd		Unit
Stack type	Preheater Stack	Grate Cooler Stack	Preheater Stack	Grate Cooler Stack	
Stack location	20°52'5.00"N 96°23'30.77"E	20°52'1.34"N 96°23'32.58"E	20° 52.065'N 96° 23.433'E	20° 52.013'N 96° 23.472'E	Lat/Long
Stack height	87.0	30.0	87.0	30.0	m
Stack diameter	2.80	2.20	3.60	3.35	m
Emission velocity	16.3	14.1	16.5	16.0	m/s
Actual Volume flow rate from stack	100	53.6	168	141	Am^3/s
Exit temperature	404	469	393.2	469	k
Expected/maximum hours of operation per year	8760	8760	8760	8760	hours
Emission Rate					
NO_x	40.7	*n/a*	70.0	*n/a*	g/s
SO_2	0.881	*n/a*	46.6	*n/a*	g/s
PM	6.78	1.56	3.50	3.62	g/s

8.2 LIMESTONE QUARRY

The AERMOD model inputs for the limestone quarry are summarised in *Table 8.3.*

Table 8.3 Volume Source Information

Parameter	Data used in AERMOD	Unit
Source Type	Volume	Source type
Location	20°52'33.64"N 96°24'25.32"E	Lat/Long
Release height	2.5	m
Area of volume source	465124	m^2
Length of side	682	m
Emissions rate	2.06	g/s TSP

8.3 *MUDSTONE QUARRY*

The AERMOD model inputs for the mudstone quarry are summarised in *Table 8.4 and* ***Error! Reference source not found.***.

Table 8.4 Volume Source Information for Proposed Pit

Parameter	Data used in AERMOD	Unit
Source Type	Volume	Source type
Location	20°52'4.45"N 96°22'40.28"E	Lat/Long
Release height	2.5	m
Area of volume source	970225	m^2
Length of side	985	m
Emissions rate	1.05	g/s TSP

8.4 *COAL MINE*

The AERMOD model inputs for the coal mine and associated stockpiling area are summarised in *Table 8.5* and *Table 8.6.*

Table 8.5 Volume Source Information for Coal Mine

Parameter	Data used in AERMOD(1)	Unit
Source Type	Volume	Source type
Location	23°26'39.26"N 94°16'58.80"E	Lat/Long
Release height	2.5	m
Area of volume source	448900	m^2
Length of side	670	m
Emissions rate	2.51 (5.03 total)	g/s TSP

(1) Two volume sources modelled due to model restriction.

Table 8.6 Volume Source Information for Stockpiling Area

Parameter	Data used in AERMOD	Unit
Source Type	Volume	Source type
Location	23°27'1.80"N 94°20'10.47"E	Lat/Long
Release height	2.5	m
Area of volume source	150000	m^2
Length of side	387	m
Emissions rate	1.6	g/s TSP

Annex D

Operational Noise Impact Assessment – Technical Inputs

Operation Noise Impact Assessment

A) Calculation of Façade Noise Levels at N1

PME	SWL, dB(A)	Distance between noise sources and NSR	Correction		CNL of individual PME, dB(A)	Overall CNL, dB(A)	Daytime Background Noise Level, dB(A)	Night-time Background Noise Level, dB(A)
			Cdist (3)	Cfacade				
Existing Production Equipment								
Turbo-Generators Room	93	1979	-73.9	3	22			
Pulverised Coal Preparation System	93	2234	-75.0	3	21			
Master Power Distribution Station	93	2191	-74.8	3	21			
Raw Material Blending Station	93	2064	-74.3	3	22			
Raw Mill Grinding and Treatment of Waste Gas at Kiln I	93	2064	-74.3	3	22			
Raw Mill Homogenising Silo	93	2043	-74.2	3	22			
Kiln Inlet	93	2021	-74.1	3	22			
Kiln Middle	93	1979	-73.9	3	22			
Kiln Head and Clinker Conveying	93	1872	-73.4	3	23			
Clinker Silo	93	1936	-73.7	3	22			
Mixed Materials Store and Conveying	93	2149	-74.6	3	21			
Cement Blending Station	93	1245	-69.9	3	26			
Cement Grinding	93	1245	-69.9	3	26			
Cement Silo and Bulking	93	1830	-73.2	3	23			
Cement Packing	93	2085	-74.4	3	22			
1#SP Waste Heat Boiler	93	2011	-74.1	3	22			
2#AQC Waste Heat Boiler	93	2096	-74.4	3	22			
Water Purifying Room	93	2043	-74.2	3	22			
Coal Crushing and Conveying	93	1968	-73.9	3	22			
Anxiliary Material Crushing	93	2181	-74.8	3	21			
Anxiliary Material Prehomogenising Shed	93	2277	-75.1	3	21			
Limestone Conveying	93	2181	-74.8	3	21			
Limestone Crushing	93	2181	-74.8	3	21			
Limestone Prehomogenising Shed	93	2277	-75.1	3	21			
Additional Production Equipment								
Turbo-Generators Room	93	2043	-74.2	3	22			
Chemical Water Treatment Room	93	2064	-74.3	3	22			
Pulverised Coal Preparation System	93	2106	-74.5	3	22			
Circulation Water Pump House	93	2149	-74.6	3	21			
Master Power Distribution Station	93	2085	-74.4	3	22			
Raw Material Blending Station	93	2245	-75.0	3	21			
Raw Mill Grinding and Treatment of Waste Gas at Kiln I	93	2128	-74.6	3	21			
Raw Mill Homogenising Silo	93	2053	-74.2	3	22			
Kiln Inlet	93	2064	-74.3	3	22			
Kiln Middle	93	2032	-74.2	3	22			
Kiln Head and Clinker Conveying	93	2085	-74.4	3	22			
Clinker Silo	93	1947	-73.8	3	22			
Mixed Materials Store and Conveying	93	1904	-73.6	3	22			
Cement Blending Station	93	1883	-73.5	3	23			
Cement Grinding	93	1851	-73.3	3	23			
Cement Silo and Bulking	93	1809	-73.1	3	23			
Cement Packing	93	1755	-72.9	3	23			
Circulating Water Cooling Tower	93	2021	-74.1	3	22			
1#AQC Waste Heat Boiler	93	2021	-74.1	3	22			
1#SP Waste Heat Boiler	93	2085	-74.4	3	22			
2#AQC Waste Heat Boiler	93	1979	-73.9	3	22			
2#SP Waste Heat Boiler	93	2096	-74.4	3	22			
Water Purifying Room	93	2043	-74.2	3	22			
Coal Crushing and Conveying	93	2277	-75.1	3	21			
Limestone Crushing	93	2691	-76.6	3	19			
Limestone Conveying	93	2277	-75.1	3	21			
Limestone Prehomogenising Shed	93	2362	-75.5	3	21	39	**49**	**44**

B) Calculation of Façade Noise Levels at N4

PME	SWL, dB(A)	Distance between Notional Source to NSR	Correction		CNL of individual PME, dB(A)	Overall CNL, dB(A)	Daytime Criterion, dB(A)	Night-time Criterion, dB(A)
			Cdist (3)	Cfacade				
Existing Production Equipment								
Turbo-Generators Room	93	1234	-69.8	3	26			
Pulverised Coal Preparation System	93	1511	-71.6	3	24			
Master Power Distribution Station	93	1457	-71.3	3	25			
Raw Material Blending Station	93	1330	-70.5	3	26			
Raw Mill Grinding and Treatment of Waste Gas at Kiln I	93	1330	-70.5	3	26			
Raw Mill Homogenising Silo	93	1309	-70.3	3	26			
Kiln Inlet	93	1287	-70.2	3	26			
Kiln Middle	93	1245	-69.9	3	26			
Kiln Head and Clinker Conveying	93	1128	-69.0	3	27			
Clinker Silo	93	1202	-69.6	3	26			
Mixed Materials Store and Conveying	93	1447	-71.2	3	25			
Cement Blending Station	93	1160	-69.3	3	27			
Cement Grinding	93	1160	-69.3	3	27			
Cement Silo and Bulking	93	1117	-69.0	3	27			
Cement Packing	93	1351	-70.6	3	25			
1#SP Waste Heat Boiler	93	1266	-70.0	3	26			
2#AQC Waste Heat Boiler	93	1362	-70.7	3	25			
Water Purifying Room	93	1309	-70.3	3	26			
Coal Crushing and Conveying	93	1234	-69.8	3	26			
Anxiliary Material Crushing	93	1457	-71.3	3	25			
Anxiliary Material Prehomogenising Shed	93	1543	-71.8	3	24			
Limestone Conveying	93	1457	-71.3	3	25			
Limestone Crushing	93	1457	-71.3	3	25			
Limestone Prehomogenising Shed	93	1543	-71.8	3	24			
Additional Production Equipment								
Turbo-Generators Room	93	1319	-70.4	3	26			
Chemical Water Treatment Room	93	1340	-70.5	3	25			
Pulverised Coal Preparation System	93	1383	-70.8	3	25			
Circulation Water Pump House	93	1436	-71.1	3	25			
Master Power Distribution Station	93	1362	-70.7	3	25			
Raw Material Blending Station	93	1511	-71.6	3	24			
Raw Mill Grinding and Treatment of Waste Gas at Kiln I	93	1404	-70.9	3	25			
Raw Mill Homogenising Silo	93	1319	-70.4	3	26			
Kiln Inlet	93	1340	-70.5	3	25			
Kiln Middle	93	1298	-70.3	3	26			
Kiln Head and Clinker Conveying	93	1255	-70.0	3	26			
Clinker Silo	93	1223	-69.8	3	26			
Mixed Materials Store and Conveying	93	1181	-69.4	3	27			
Cement Blending Station	93	1149	-69.2	3	27			
Cement Grinding	93	1117	-69.0	3	27			
Cement Silo and Bulking	93	1085	-68.7	3	27			
Cement Packing	93	1021	-68.2	3	28			
Circulating Water Cooling Tower	93	1277	-70.1	3	26			
1#AQC Waste Heat Boiler	93	1287	-70.2	3	26			
1#SP Waste Heat Boiler	93	1351	-70.6	3	25			
2#AQC Waste Heat Boiler	93	1245	-69.9	3	26			
2#SP Waste Heat Boiler	93	1362	-70.7	3	25			
Water Purifying Room	93	1309	-70.3	3	26			
Coal Crushing and Conveying	93	1553	-71.8	3	24			
Limestone Crushing	93	2053	-74.2	3	22			
Limestone Conveying	93	1574	-71.9	3	24			
Limestone Prehomogenising Shed	93	1628	-72.2	3	24	43	**49**	**44**

Remarks:
(1) PME will be operated all day
(2) Corrected Noise Level (CNL), dB(A) = SWL + distance correction + façade correction.
(3) Distance correction = - (20 log D + 8)

Annex E

Biodiversity Impact Assessment – Technical Inputs

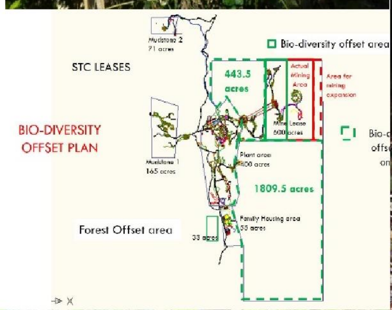
Annex E1

Survey Reports

Mammal survey at Paluzawa Coal Mine and Pyinyaung Limestone Mine

Dr. Christian Matauschek and Aung Lin

February 2017



Client	Client Representative
ERM	

Project	Project Reference Number
Mammal survey at Paluzawa Coal Mine and Pyinyaung Limestone Mine	--

Authors	Date
Christian Matauschek, PhD (Consultant biologist) Aung Lin, MSc. (Field biologist)	25-02-17
	Approved By

Revision	Description	Prepared by		Examined by	Date
	Survey report				

Key Words	Classification
Mammal survey, camera trapping, transect	☐ Open ■ Internal ☐ Proprietary

Distribution	Medium	Copy
	Soft copy	1

Content

Abbreviations

IUCN	International Union for Conservation of Nature and Natural Resources
ST	Shwe Taung
WS	Wildlife Sanctuary

Paluzawa Coal Mine

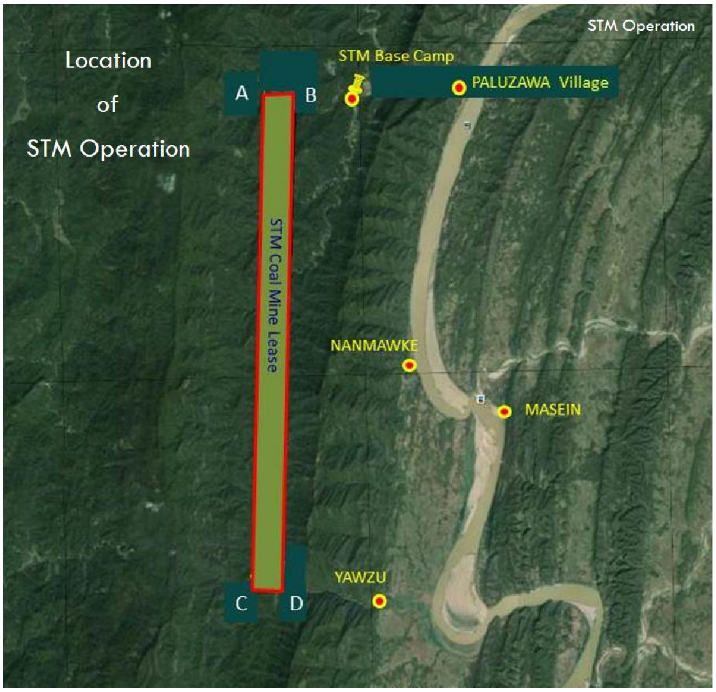
Site description

The project site is located close to Chaung Sone village (Paluzawa area), Ywar Thar village Tract, Kalaywa Township, 22 miles north of Kalaywa Town and 18 miles south of Maw Lite Town. The whole area lies west of Kalaywa -Maw Lite Road and about 4 miles west of the Chindwin River.

The base camp compound includes the a office, messing hall, clinics, oil depot, work shop, store, housings for employees, guest house, family line, nursery plot, and heavy machinery park. The coal mining area and three extraction (excavation) sites are in the west; the designated mining area is 3378.2 acres. The company has also a base camp at Paluzawa village 2 miles east on the Kalaywa-Maw Lite Road. The main fuel depot and coal stock yard are at this base camp. The coal from the stock yard is transported by truck east to Chindwin River and load on the river barge. The coal is mainly for use at a cement plant owned by the company at Pyi Nyaung, Thazi Township, Mandalay Region.

The study area is a hilly area with low mountain ranges and valleys. The area is within Mahtuu Reserved Forest area. Due to certain variation in elevation the forests are a mixture of mixed deciduous forest and moist evergreen forest. The forest is mostly secondary and partially degraded, but the vegetation as is still in relatively good condition. The mountain range and most of the streams are directed from north to south.

The coal mining lease of Shwe Taung company stretches from north to south. It is divided in several production sites (Phase 1-7) (Fig.1). Only Phase 1 to 4 are operated at the moment. The southern part of the lease is still not affected by mining activities.



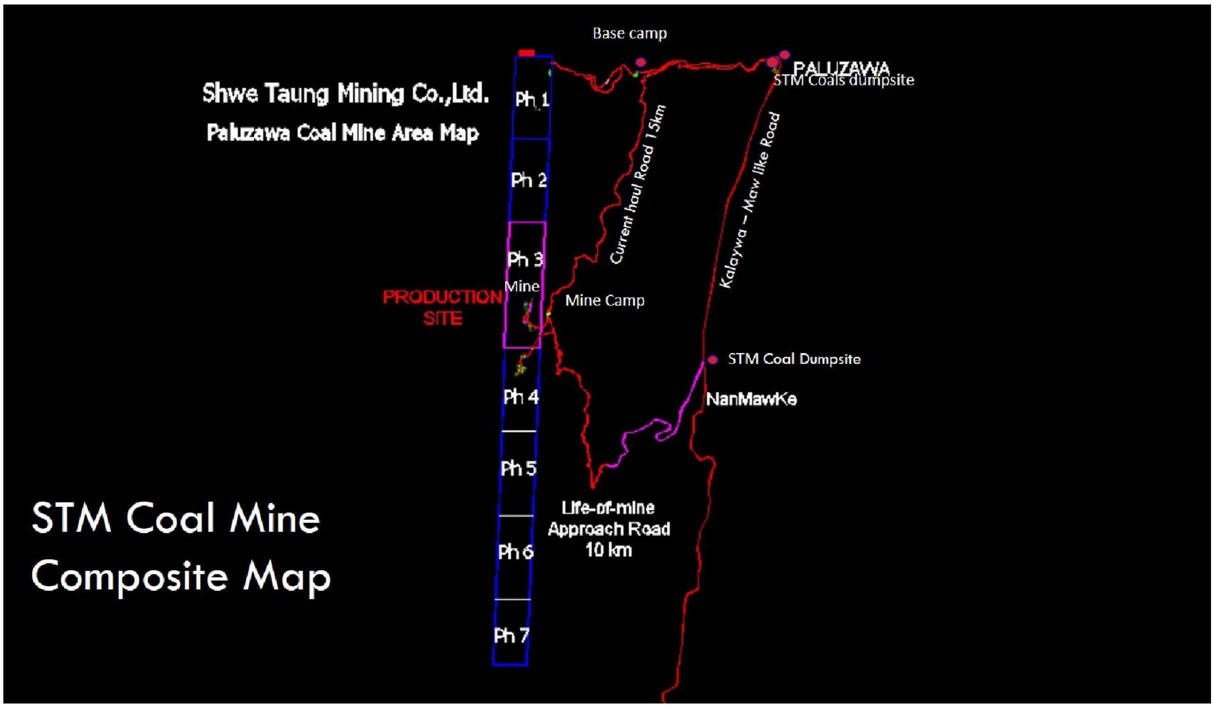


Fig 1: Location and site map of Paluzawa coal mine

Methodology

The survey methodology and resulting recommendations were planned and conducted under IFC Performance Standard (PS) 6.

Interviews

Interviews with local residents and hunters were used to obtain important information on presence or absence of mammal species. Both structured and unstructured interview were used to conduct these interviews. The interviews were focused on the target species like gibbon, langur, gaur or pangolin, but included also other mammals. The questions were designed to obtain data about each species: their population; their local status in terms of the past, present, and future; their ecological behavior and ecological niche; their breeding season; and the types of threats, both direct, and indirect, that each species faces. Questions were also asked about the wildlife trade, human animal conflict and habitat loss. Where possible, dates were identified. Questions were also asked about methods employed to kill or capture the animals, and what trade routes were used. For species identification the drawings in “A Field Guide to the Mammals of South-East Asia” (Francis 2008) and additional photos and drawings of primates were used. Locations of interviews are shown in supplementary map 2 and results are listed in Table 1.

Tab 1.: Overview interviews around Paluzawa coal mine

Date	Location	No. Participants	Special Remarks
26.01.17	Logging camp close to Chinese mining site	3	2 muntjac skins
04.02.	Sunflower farmers, south of the St lease	5	-
05.02.	Tin Win Tun, coal mining company	3	Reliable gaur and sambar evidence
05.02.	Bamboo collector`s camp	3	Reliable pangolin evidence
05.02.	Local hunter	1	Dhole teeth, gaur and gibbon evidence
05.02.	Hunter`s camp close to Chinese site	2	Pangolin evidence, wildlife trade
06.02.	Hunter`s camp close to Phase 1	3	Porcupine spines and intestine

Transect walks

The area has almost no proper trails beside the roads, which are connecting the operation sites with the base camp. The road ends at the operation site Phase 4. The southern half of the lease was not assessed by roads or trails yet and only poorly surveyed by the exploration team of the mine. In most parts we completely relied on the experience of an old hunter who used to hunt in that area in previous times. The surveyed distance covered app. 31 km (Tab.2). Efficient night surveys were difficult to realize. Given the difficult steep terrain with no trails in place, resulted in security concerns and the necessarily noisy movements in the dense understory vegetation made wildlife sightings rather unlikely.

Tab.2: Survey activities at Paluwaza coal mine

Date	Description	Purpose	Remarks
25.01	Walk from Phase 1 to Phase 2 and the Chinese mining site, and around Phase 4	Deployment of camera traps	
26.01.	Walk from Phase 3 to Phase 2, walk along the stream between Phase 4 and Phase 3	Deployment of camera traps	Cat tracks
04.02.	Walk from Phase 4 through the southern half of the ST lease	Exploration of the unexplored southern part of the lease	
05.02.	Survey of the landscape northwest of Phase 1, night survey around Phase 1	Exploration of the broader landscape, interviews	
06.02.	Survey of the stream, valley and mountains west of the ST lease starting from Phase 1	Exploration of the proposed offset area next to the lease	Cat tracks, Yellow-throated marten and giant squirrel sighting; Great hornbill sighting

07.02.	Survey around the bamboo collector`s camp	Langur survey	Gibbons calls

Camera trapping

For more than twenty years camera trapping presents a popular method to determine the presence of a species in a certain study area (Rovero et al. 2010; Pitett & Bennett 2014). They have been shown to be particularly useful for determining species richness in challenging rainforest ecosystems (Tobler et al. 2008; Srbek-Araujo & Chiarello 2005). Camera trap stations can be easy deployed on a cost efficient base, due to simple materials and low complexity. This non-invasive survey method opened possibilities for researchers to study terrestrial wildlife across large and remote areas, without much effort in space and time (Long et al. 2008). This is a main advantage when compared to the tracking-techniques, described above and other more elaborate research methods.

Fig 2: Deployment of camera traps

Camera trapping for the assessment of inventories can serve multiple purposes: it can provide reliable records of species presence (Tobler et al. 2008) in a certain study area, to show species diversity at a specific site, allow the comparison of species composition, occurrence and abundance at different sites (Rovero et al. 2010; Melo et al. 2012), or at different times of seasons in the year (Tobler et al. 2008) and study activity patterns of captured species (Gómez et al. 2005). They assist furthermore in refinement of distribution maps for individual species and can be used to assess anthropogenic or environmental impacts on mammalian communities (Tobler et al. 2008; Gomez et al. 2005). Additionally, camera-trapping is an efficient method to support long-term monitoring (O`Brien et al. 2003, Ahumada et al. 2011).

Camera trap location have been selected carefully in preliminary site surveys. See supplementary map 1 for camera trap locations (Tab. 3).

Tab. 3: Camera trap locations

Camera trap location no.	Camera Trap Label	Coordinates	Remarks	
Phase 1/Phase 2				
C1	ERM UV C27	N23° 26.865' E94° 16.707'	Fruiting tree	Yellow-throated marten, Porcupine, Domestic cattle, Humans
C2	ERM UV C29	N23° 26.430' E94° 16.464'	Mountain ridge	-
C3	ERM SG C25	N23° 26.369' E94° 16.480'	Ridge, near fruiting tree	-
C4	ERM SG C07	N23° 22.875' E94° 16.405'	Ridgeline, bamboo	Red muntjac, Leopard cat, Kalij pheasant
C5	ERM UV 15	N23° 22.794' E94° 16.366'	Bamboo	Porcupine, Red muntjac, Pallas` squirrel
C6	ERM UV C28	N23° 22.702' E94° 16.501'	Bamboo	Red jungle fowl
C7	ERM UO C05	N23° 22.709' E94° 16.533'	Fruiting tree	Porcupine, Red muntjac, Rhesus macaque, Rat, Kalij pheasant
Phase 3				
C8	-	N23° 24.662' E94° 16.668'	Dry bed of a small rocky stream, degraded bamboo forest, close to mining site	Yellow-throated marten, Leopard cat, Squirrel
C9	ERM UV 20	N23° 24.739' E94° 16.659'	bamboo	Red muntjac
Phase 2/Phase 3				
C10	ERM SG C08	N23° 24.776' E94° 16.665'	Fruiting tree, dense bamboo	Red muntjac
C11	ERM SG C23	N23° 24.941' E94° 16.643'	Dense bamboo forest	Wild boar, Northern tree-shrew
C12	ERM UO C01	N23° 24.959' E94° 16.672'	Dense bamboo forest, carnivore tracks	Wild boar, Squirrel
C13	ERM SG C06	N23° 25.057' E94° 16.734'	Ridge, degraded bamboo forest	Large indian civet, Domestic water buffalo, Scaly trush, Red jungle fowl
C14	ERM SG C22	N23° 24.920' E94° 16.723'	Ridge, dry stream, bamboo	Red muntjac, Greater necklaced laughingthrush
Phase 3/Phase 4				
C15	ERM SG C10	N23° 23.771' E94° 16.675'	Next to small stream, muntjac and carnivore tracks, secondary growth	Red muntjac, Red jungle fowl
C16	ERM UO C04	N23° 23.767' E94° 16.618'	Small stream, close to mining area, degraded forest, tracks of wild boar and muntjac	Fishing cat, Yellow-throated marten, red muntjac, Humans
C17	ERM UV 30	N23° 23.781' E94° 16.545'	Upstream small rocky stream, banana palm, small cat track, muntjac track	Red muntjac,Red-billed blue magpie

For the study we used 10 ScoutGuard, and 7 UO Vision camera traps. Both camera trap models using a passive heat in motion triggered sensor, which delivers high quality day and night images.

Additional equipment:

- Batteries (1 set per camera, 8 per set)
- SD memory cards (1 per camera)

The cameras in both camera trap studies were placed opportunistically at locations, which seemed promising in generating photographic images of terrestrial wildlife (App.1, Fig. 2). The area has only a very limited number of existing trails, which could be used for access to the site.

The cameras were set at an average height of 50 cm above the ground, to allow the recording of smaller mammals, as well (Kelly 2008; Jansen et al. 2014). The cameras have been be attached to trees, which had at least 15 cm BHD (Srbek-Araujo & Chiarello 2005), to allow a tight fit, and prevent dislocation, when individual animals are examining the camera trap unit at close distance.

Camera traps preferably were facing towards north or south, to have photographs without influence of backlight and to avoid ghost pictures, caused by false trigger by direct sunlight at sunrise and sunset (Jansen et al. 2014; Si et al. 2014). In order to avoid entanglement by woody vegetation (e.g. reflection of infrared flash), mainly locations with little or no woody vegetation in front of the camera have been selected (Tab.4).

Tab. 4: Settings of camera trap devices. These settings were used as standard for all cameras, to follow a homogenous camera trap setting

Camera Settings								
Set Mode	Image Size	Image Format	Set Mode Interval	Sensor Level	Night Vision Shutter	Time Stamp	Set Date	Coordinate Input
Camera	8 MP	Widescreen	1 Minute	Normal	Medium	On	Ind. Date	Off

All collected images were entered into Camera Base 1.6.1 (Tobler 2007), an MS Access based database designed for managing camera trap survey data. For every photograph taken, the camera trap device saves the camera trap location, date and time of individual capture event, moon phase and temperature as metadata in exif-Format. Afterwards, it is possible to readout the collected information and generate datasets for each individual captured species and capture event in Camera Base and save them for further data analysis.

The data will be filtered to exclude images of the same species at the same station within a period of one hour, in order to reduce entanglement, and ensure that capture events are independent (O´Brien et al. 2003; Tobler et al. 2008).

Presence/absence of species

The study provide basic data on presence/absence of terrestrial mammal species in the vicinity of the mining site. In total the camera trap days were 228. We registered 73 independent camera trap events for mammals and 14 for birds. In total 12 species of mammals and 5 species of birds were recorded (Tab. 5).

Tab. 5: Mammal species recorded on camera traps during the present study

Common name	Scientific name	RAI	IUCN status
Northern Treeshrew	*Tupaia belangeri*	1,32	LC
Rhesus Macaque	*Macaca mulatta*	0,44	LC
Leopard Cat	*Prionailurus bengalensis*	0,88	LC
Fishing Cat	*Prionailurus viverrinus*	0,44	VU
Yellow-throated marten	*Martes flavigula*	1,75	LC
Large Indian Civet	*Viverra zibetha*	0,44	LC
Common Palm Civet	*Paradoxurus hermaphroditus*	0,44	LC
Red muntjac	*Muntiacus muntjac*	5,7	LC
Wild boar	*Sus scrofa*	0,88	LC
Malayan Porcupine	*Hystrix brachyura*	9,6	LC
Rat	Muridae	7,2	-
Squirrel	*Callosciurus sp.*	2,19	-

Relative abundance

To measure the relative abundance of species in the study area the Relative Abundance Index (RAI) can be applied (Carbone et al. 2001; O`Brien et al. 2003). It is based on the number of pictures of a species of interest per 100 trap nights. Another abundance index is the percentage of photos of a target species in relation to all other animal photos.

Porcupine (9,6);Rat (7,2), Muntjac (5,7); Squirrel (2,19); Yellow-throated marten (1,75); Treeshrew (1,32); leopard cat, Wild boar (0,88); Fishing cat, Rhesus macaque, Large indian civet, Common palm civet (0,44) (Tab. 5). Please note, that relative abundance indices cannot provide conclusion about the real abundance of species. It can provide just a rather rough relative estimate in relation to the sampling effort.

Species accumulation curve

The success of the completeness of a species inventory is determined by Species Accumulation Curves (SAC), which saturate when all species of interest in the study area are detected (Tobler et al. 2008). The SAC represents the relationship of the number of species and the sampling effort (number of camera days), which depend on the duration of sampling time, which gets consequently determined by the size and structure (homo-/heterogeneity) of the area sampled (Colwell 2009). The curve is expected to approach an asymptote, which gives a judgement of sampling adequacy of targeted large- and medium-sized mammal species composition in the study area. With increasing trapping effort the species richness curve should level off, when the sampling effort (respective camera trap days) is large enough, showing the inventorying of targeted mammalian taxa is sufficient (Ugland et al. 2003). Given the limited amount of time the SAC in this study is not saturated yet. Potentially rare and elusive species might have been not assessed yet. Nevertheless, considering the relatively high disturbance by human activities and the considerable degree of habitat degradation, we found a surprisingly high number of species in a short study period.

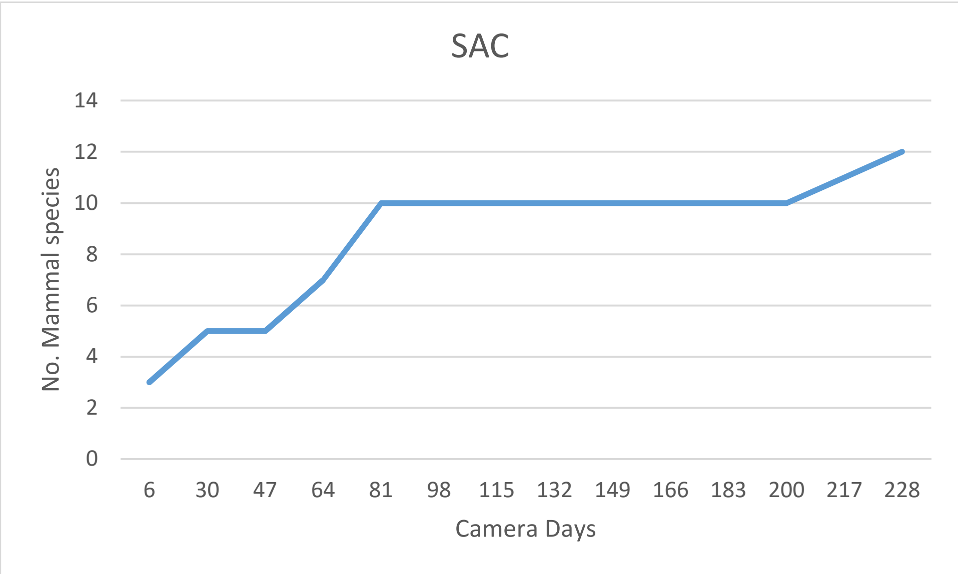


Fig. 3: Species accumulation curve for the present study

Target species

According to IFC PS 6 the main focus of this study was on threatened species which are classified under IUCN redlist criteria. Species accounts and taxonomy following Wilson & Mittermeier (2009-2012). A previous study done in November 2015 identified 25 species of mammals.

In total 12 species were confirmed by camera trapping. Two more species were recorded by direct sighting or acoustic evidence, two by skin/teeth, one by a video of a mining worker. Seven species were identified in interviews with local people (for species records see suppl. Maps 3 and 4). Only species which have been identified clearly or by more than one independent people are considered as confirmed (Tab. 6).

Critically Endangered

Chinese pangolin (*Manis pentadactyla*) CR

One of the target species is the Chinese Pangolin. All species of pangolins suffered a severe decline in recent years. The scales and their meat are highly demanded in Chinese traditional medicine. We got a video evidence of a of a pangolin found at one of the Shwe Taung mining operation sites, close to the Chinese mining operation site. One of the miners took a video with his smartphone. The pangolin was released to the forest. Another pangolin was sold one day before our interview to a wildlife trader from Kale (1 vis = 620,000 MMK). It was caught just outside the ST mining lease by logging workers. Bamboo collectors had a sighting two weeks before our interview close to the ST lease. The presence of the Critically Endangered Chinese Pangolin in the area can be confirmed.

Endangered

Phayre`s langur (*Trachypithecus phayrei phayrei*) EN

The presence of this species was confirmed by all interviews, and a previous survey had a direct sighting (ERM internal report). During the years of logging for timber many domestic elephants where brought to the area. The mahouts were in their majority Kayen people, where the consumption of primate meat is common. Especially the intestines of langurs. During that period langurs have undergone a substantial decline in the region. This was confirmed in several independent interviews.

Langurs have been confirmed during previous survey in 2015. Most of the interviews we have undertaken in and around the area confirmed their presence but in general low numbers.

A bamboo collector claimed to have regular encounters with a langur group of about 7-10 individuals. A firewood collector and hunter described a group of 6-7 individuals which he regular sees around the Chinese mining site.

Western hoolock gibbon (*Hoolock hoolock*) EN

Two species of hoolock gibbon are recognized: the western hoolock gibbon (*Hoolock hoolock*), which is considered to be globally Endangered, and the eastern hoolock gibbon (*Hoolock leuconedys*), which is considered globally Vulnerable. The vast majority of the global populations of both western and eastern hoolock gibbons remain within Myanmar. Myanmar accounts for 100% of the global population of the eastern hoolock gibbon and at least 90% of the global population of the western hoolock gibbon. Previous studies suggests that within Myanmar there are from 310,000 to 370,000 eastern hoolock gibbons, 82,000 to 110,000 western hoolock gibbons

On the last survey day we had an acoustic record of Hoolock gibbons. One gibbon group was singing around 10 am.

There was also one interview evidence for the presence of gibbons. A 70 year old hunter saw two gibbons app. 7 month before the interview. He described a drastic decline of the local gibbon population in recent years due to the increasing hunting pressure by Chin hunters from Kale area.

Dhole (*Cuon alpinus*) EN

One of the interviewed hunters reported, that he caught a dhole inside the Shwe Taung area. The animal was trapped with a snare about eight month before our survey. The canines of the dhole were found at the local hunter`s house. He allowed us to take one as proof.

Vulnerable

Bengal slow loris (*Nycticebus bengalensis*) VU

Confirmed by all interviews, but seems to be very rare. Two month before our interview one individual was killed by the dog of a hunter while it was moving on the ground.

Asiatic black bear (*Ursus thibetanus*) VU

Bears suffer under heavy hunting pressure in most areas of south-east Asia. Given the high number of snare hunters and human activities in this specific landscape indicate only little numbers of bears. Nevertheless the last credible sighting of an Asiatic black bear inside the ST mining lease was only one year ago by mining worker. Other reliable sightings by local hunters seem to be not very recent, sometimes more than eight or ten years ago.

Fishing Cat (*Prionailurus viverrinus*) VU

An exceptional record is the camera trap record at a heavily degraded rocky stream between Phase 3 and 4 in very close distance to one of the mining operation sites. The cat on the picture is distinguished from leopard cat by its smaller spots, which form distinctive lines and the relative shorter tail (max 50% of head-body length) and its bulky appearance. The local leopard cats show much larger and darker spots, scattered in a more irregular pattern across the body. Rather large cat tracks were also found along another stream in the valley west of the lease.

Fishing cats are currently classified as Vulnerable. Very little is known about this species and records are generally scarce. Home ranges can be as large as 22 km² (males, females up to 6 km²). To contribute towards a conservation of such species, a broader approach on the landscape level is needed.

Fig 4: Cat tracks found along streams and riverbeds

Gaur (*Bos gaurus*) VU

One of the management staff of the mine saw one individual crossing the road close to Phase 3. 7 individuals were seen at Tin Win Tun site for month before the interview. One old hunter saw 3 individuals one month before the survey close to ST area.

Although we had no direct evidence (Photo, sighting) we consider the presence of the species inside ST area and in surrounding forests as confirmed. The species is highly distinctive due to its size, color, behavior or horn shape, that a confusion with domestic cattle or buffalo is very unlikely.

Sambar deer (*Rusa unicolor*) VU

Sambar deer seem to be very rare in the area. There was only one interview evidence at the mining site of another company (Tin Win Tun). One of the interviewed workers saw two individuals just four days prior to the interview.

Near Threatened

Assamese Macaque (*Macaca assamensis*) NT

In one of our interviews Assamese macaque (*Macaca assamensis*) were identified beside the common and regularly identified Rhesus macaques (*Macaca mulatta*). Rhesus macaques were recorded inside ST area on one of the camera traps.

Assamese macaques are classified as Near Threatened.

Chinese serow (*Capricornis milneedwardsi*) NT

No direct evidence, just indirect evidence by interviews. The species seems to be quite rare. Only one interview revealed some evidence for the presence of the species inside the ST lease.

Black Giant Squirrel (*Ratufa bicolor*) NT

Direct sighting of one individual very close to the mining lease. This species is widely distributed, but highly dependent to high canopy. Populations are declining due to loss of tall forest.

Other species

Other common species were Red Muntjac (*Muntiacus muntjak*) and Eurasian wild boar (*Sus scrofa*). Tracks of those species could be found frequently along streams, mountain ridges and inside degraded bamboo forests inside ST lease as well as in surrounding areas. These two species are also among the most targeted species of local hunters. The Malayan porcupine () was also recorded frequently on our camera traps. It is hunted with dogs and snares, not only for their meat, but also for their intestines, which are used in traditional medicine for stomach problems.

Among small carnivores we recorded Leopard cat (*Prionailurus bengalensis*) on two occasions, Large indian civet (*Viverra zibetha*) and yellow-throated marten (*Martes flavigula*). The latter still seems quite common in the area. Two individuals could be observed foraging along a small stream close to the Phase 1 mining site. One common palm civet (*Paradoxurus hermaphroditus*) was found dead at one of the small tea shops along the road inside ST area. According to the shop owners the animal was killed by a truck. The skin was dried and stuffed.

Fig 5: Stuffed skin of a common palm civet

We found tracks of small cats on several occasions throughout the ST lease. It is difficult to determine the species only according to the footprints, but due to the small size and the record of Leopard cat in the camera traps, we assume that most of the recorded tracks can be assigned to this species. The footprints of Fishing cat found along one of the streams were substantially larger and were also found inside the water (see above).

During the interviews there was no evidence of the presence of large cats like tigers, leopards or clouded leopards, although the clouded leopard is known to persist also in disturbed habitats, often overlooked due to its elusive and secretive life.

The carcass of a Northern treeshrew (*Tupaia belangeri*) was found inside a stream. It was obviously killed by humans and probably burned to remove the fur. Why it was left in the stream is not known.

Fig 6: Carcass of a northern treeshrew found in a stream

Two species records, which have been recorded during interview surveys in a previous study, are likely to be the result of some misidentification. The record of moon rat (*Echinosorex gymnurus*) would be highly surprising as the distribution area of this species is far off the survey site with its northern limits in Malaysia and southern Thailand, reaching Myanmar only in its most southern part. Also the presence of red goral (*Capricornis rubidus)* must be doubted. This species has been recorded in Myanmar only from few locations in the far north of Kachin state. During the interviews it may have been confused with red muntjac by local people and misidentified them in the pictures shown to them.

Recorded bird species, which are not included in the previous bird survey are listed in Tab. 7.

Tab. 6: Mammal species recorded during the present study at Paluwaza coal mine

Common name	Scientific name	Evidence	Inside ST area	Adjacent ST area	IUCN status
Order Scandentia					
Northern Treeshrew	*Tupaia belangeri*	Camera trap, carcass	+	+	LC
Order Pholidota					
Chinese Pangolin	*Manis pentadactyla*	Interview, video	+	+	CR
Order Primates					
Bengal Slow Loris	*Nycticebus bengalensis*	Interview	+	+	VU
Phayre`s Langur	*Trachypithecus p. phayrei*	Interview	-	+	EN
Rhesus Macaque	*Macaca mulatta*	Camera trap, interview	+	+	LC
Assamese Macaque	*Macaca assamensis*	Interview	-	+	NT
Western Hoolock Gibbon	*Hoolock hoolock*	Acoustic record, interview	-	+	EN
Order Carnivora					
Leopard Cat	*Prionailurus bengalensis*	Camera trap	+	-	LC
Fishing Cat	*Prionailurus viverrinus*	Camera trap, tracks	+	+	VU
Asiatic Black Bear	*Ursus thibentanus*	Interview	+	-	VU
Yellow-throated marten	*Martes flavigula*	Direct sighting, camera trap	+	+	LC
Large Indian Civet	*Viverra zibetha*	Camera trap	+	-	LC
Common Palm Civet	*Paradoxurus hermaphroditus*	Skin, camera trap	+	-	LC
Dhole	*Cuon alpinus*	Canine, interview	+	-	EN
Order Artiodactyla					
Gaur	*Bos gaurus*	Interview	+	+	VU
Chinese Serow	*Capricornis milneedwardsi*	Interview	+	-	NT

Sambar	*Rusa unicolor*	Interview	-	+	VU
Red muntjac	*Muntiacus muntjac*	Camera trap, sighting, skins	+	+	LC
Wild boar	*Sus scrofa*	Camera trap	+	+	LC
Order Rodentia					
Malayan Porcupine	*Hystrix brachyura*	Camera trap, spines/intestines	+	+	LC
Black Giant Squirrel	*Ratufa bicolor*	Sighting	-	+	NT

Tab 7. Additional bird species recorded during the mammal survey at ST coal mining site

Common name	Scientific name	Evidence	IUCN status
Kalij Pheasant	*Lophura leucomelanos*	Camera trap	LC
Great Hornbill	*Buceros bicornis*	Direct sighting	NT
Scaly Thrush	*Zoothera dauma*	Camera trap	LC
Red-headed Trogon	*Harpactes erythrocephalus*	Direct sighting	LC

Identified threats

Indirect effects of the mining activities bear more threats to wildlife than the mining operation itself. The newly constructed roads provide easy access for all kinds of people exploiting the natural resources of the area. All along the roads inside and outside the various mining leases you can find campsites with hunters and loggers.

The area was logged for timber between 2011 and 2014. The current logging activities are uncontrolled harvesting of firewood, destroying and degrading the remaining forest almost along all roads. Firewood is consumed not only in private households, it is also used to supply the worker`s camps with fuel and to provide construction material for the underground mines of adjacent mining operators.

Alongside with the logging goes the hunting of wildlife for food and international wildlife trade. Hunting methods include trapping with snares, as well as hunting with dogs and powder guns. Bushmeat is consumed by local people and workers. Most commonly hunted species for meat are wild boar and muntjac.

Fig 7: Skins of two muntjacs at a hunter`s camp

During the years of logging for timber many domestic elephants where brought to the area. The mahouts were in their majority Kayen people, where the consumption of primate meat is common. Especially the intestines of langurs. During that period langurs have undergone a substantial decline in the region. This was confirmed in several independent interviews.

Wildlife trade seems to be a major issues in the area. Traders and hunters follow the roads which are developed by the mining companies. Traders in Kale are buying pangolin scales, gaur horns, antlers of sambar deer, as well as tortoises.

Main threats

- Hunting and wildlife trade
- Logging for firewood
- Bamboo collection
- Road construction
- Degradation of streams and rivers
- Pollution with waste water
- Waste

Recommendations for reduction and mitigation of threats and biodiversity offset

To contribute towards conservation of mammal populations means to think in landscape dimensions. Therefore it is necessary to incorporate also the other four mining companies in all biodiversity conservation efforts. Regular meetings and consistent rules, regulations and mitigation methods should be in place for all operating companies.

A wildlife monitoring system should be in place. Collection of data on wildlife sightings, hunting, road kills etc can provide useful information on wildlife populations and can function as indicator of management success. A conservation officer or wildlife biologist should be hired to conduct monitoring, awareness and enforcement of rules and regulations. This person could also be involved in the awareness activities in schools, which are already supported by the mine, but so far focused only on general education. Awareness activities should also include environmental and wildlife related topics.

The conservation officer could be in charge to link the activities of the different operators and coordinate efforts towards a sustainable biodiversity conservation. Ideally a representative of the township forest department should be involved in all activities. DSA and travel costs should be covered by the mining operators. A conservation fund, jointly developed by all operators could provide funding for such activities.

The road between Paluzawa and Kalewa which is currently under construction is a joint project between all five mining companies. If it is possible to construct a road in a joint project between the five mining companies it should also be possible to contribute towards a joint conservation effort in the region. A financial mechanism with contributions depending on the size of the respective lease, similar like in the road construction project, could be applied.

As mentioned above the mining operations are the least problem in terms of mammal conservation. The indirect effects coming along the mining roads, such as hunters, loggers, bamboo collectors as well as unsustainable and habitat degrading activities of mining workers are much more harmful and destructive. So far no real mitigation measures by the mining operators are addressing these indirect negative effects.

Mining workers involved in illegal activities, such as wildlife trade, need to be warned, and eventually fined. Encroachment along the mining roads needs to be controlled.

The management of aquatic habitat, such as streams and rivers needs to be redeveloped. Gravel extraction, dumping of excavated material from road construction into river beds, construction of dams and pollution by wastewater from worker`s camps are destroying important habitats. As we discovered fishing cats in the area this gets even more important. These cats are dependent on riverine habitats. To maintain a population of this rare species and to avoid the decline or loss of another population of fishing cats sustainable and less destructive operational procedures needs to be developed and implemented.

Summary of recommended activities:

- Cease hunting
- Cease illegal logging
- Control of encroachment along the roads
- Control of workers and employees (fines for illegal activities, like wildlife trade or hunting)

- Conservation officer
- Include the township forest department in conservation activities
- Include wildlife conservation in awareness activities
- Redevelop water management and management of streams and rivers
- Establish monitoring of wildlife (collection of information on sightings, road kills etc)
- Establishment of a Conservation fund (consider contribution of all five mining companies of the region)
- Large-scale offset funded and managed in a joint effort of all five mining companies

The requirements for biodiversity offsets as recommended by IFC provide criteria and a basis for the planning of effective biodiversity offsets:

“For the protection and conservation of biodiversity, the mitigation hierarchy includes biodiversity offsets, which may be considered only after appropriate avoidance, minimization, and restoration measures have been applied.

• Measurable conservation outcomes reasonably expected to result in no net loss and preferably a net gain of biodiversity. Net gain is required in critical habitats

• Must be demonstrated “on-the-ground” and on an appropriate geographic scale

• The design must adhere to the “like-for-like or better” principle (“trading-up” in certain circumstances)

For critical habitats:

• Project doesn’t lead to net reduction in the global and/or national/regional population of any Critically Endangered or Endangered species over time (mainly IUCN Red List)

• Mitigations will be designed to achieve net gains of those biodiversity values for which critical habitat was designated

• Biodiversity offsets may sometimes be necessary to meet critical habitat requirements

• The project’s mitigation strategy will be described in a Biodiversity Action Plan

• A biodiversity monitoring and evaluation program must be developed”

According to an existing offset plan (fig. 8) a biodiversity offset area covering 10,250 acres (4100 ha) is projected right next to the ST mining lease to the west. During our survey of the proposed offset area, we encountered still good forest, maybe the best during our whole survey. Although we found tracks of humans and domestic dogs, and banana plantation inside the valley, we encountered Yellow-throated marten, Black giant squirrel, Crested serpent eagle, and Great hornbill. Along and inside the stream we found tracks of cats (one of them potentially of fishing cat).

Before defining an offset area we recommend further surveys in the area and the consideration of a large-scale offset area, established in a joint effort by all mining companies operating in the area. The area still might provide sufficient habitat, even for large mammals such as gaur or sambar. According to local hunters there is relatively high gaur and sambar activity, especially during rainy season, in Tafanchaung valley, which is located at the confluence of three streams. The area has a saltlick and is quite difficult to reach. It can be reached from the ST base camp following the nearby stream. According to the mining employees there is so far no mining lease or human settlement. This needs to be verified and maybe considered for future biodiversity offset planning (Fig 9).

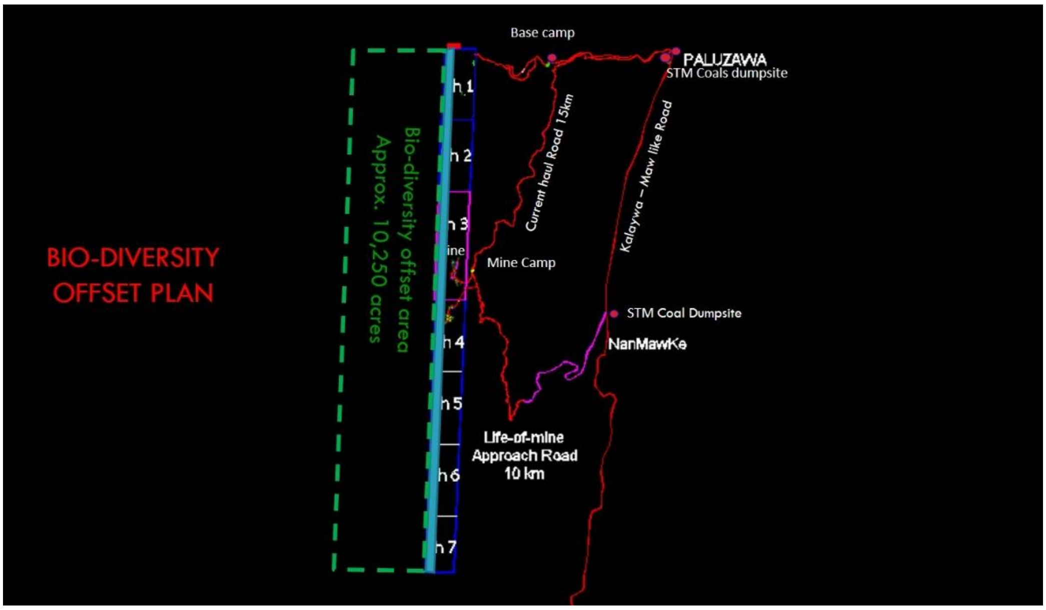


Fig 8: Biodiversity offset plan for Paluzawa coal mine

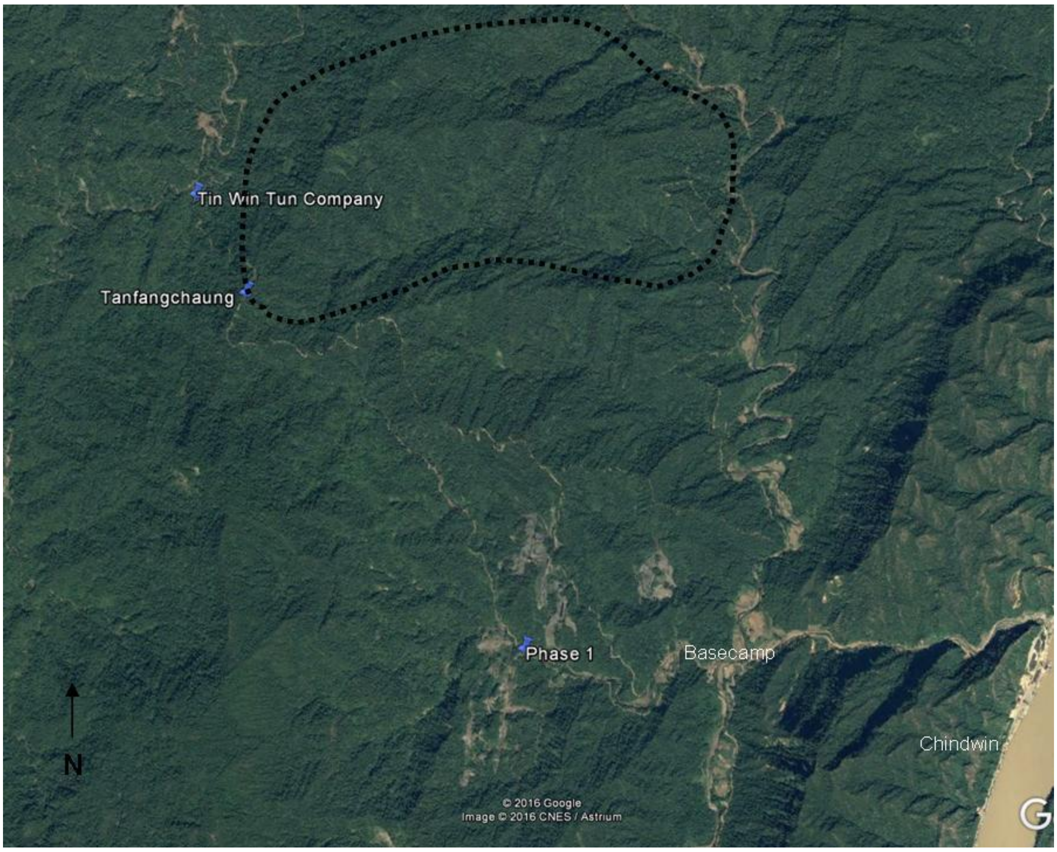


Fig 9: Potential offset area (black line) in Tanfangchaung valley

Pyinyaung Limestone Mine

Site description

The project area is situated on the valley surrounded by the mountains range and near the Thazi – Kalaw high-way road and 3 miles 6 furlong far from Pyin Nyaung Village, 2 miles far from Ku Byin Village, 25 miles from east of Tharzi Township, 30 miles from west of Kalaw, 124 miles from east of Mandalay and 330 miles from Yangon. The APACHE Cement Plant and Employee Housing Areas are 400 acres, limestone quarry site area is 600 acres in front of the cement plant and mud stone quarry site area is 165 acres behind of the cement plant.

The area is composed of four separate parts: the factory area 161.87 hectare (400 acre), limestone mining area 242.8 hectare (600 acre), mudstone mining area 66.77 hectare (165 acre) and mudstone mining and weir 28.7 hectare (71 acre). The total project area is 500.19 hectare (1236 acre). The project operation system also include two separate processes: cement production and limestone and mudstone mining. Limestone and mudstone are raw material for cement production.

It is located in the Kupyin Reserve forest was founded since the colonial period. The total forest area including extension was 11800 hectare (29158 acre). It was subdivided into 56 blocks for timber extraction. The timber extraction was started since in colonial period. Kupyin Reserve Forest lies within the eco-region of Irrawaddy Moist Deciduous Forest and quite close to the Northern Indochina Subtropical Forest.

Fig 10: Location and site map of Pyinyaung cement mine

Methodology

Transect walks

Overall goal was not just to survey the small area directly affected by the limestone quarry mine, but rather have a look on the broader landscape in terms of habitat connectivity and potential biodiversity offset. We walked from Pyinyaung village to the ridgeline, reaching it from southwest. We descended from the mining site towards the cement factory and covered lower parts between the cement fact and Pyinyaung village. North of the ST area we examined the connectivity of habitats between the mountain with the cement mine and the neighboring mountain, which is separated by a small and during dry season shallow stream. The area north towards the Panlaung-Pyadalin WS was assessed by motorbike reaching the guard post of the WS rangers (Tab. 8; Suppl. Map 5)).

Tab. 8: Overview interviews around Pyinyaung cement mine

Date	Location	No. Participants	Special Remarks
27.01.17	Village north of mine, village head	2	
27.01.17	Village north of mine, local hunter	1	
29.01.17	Logger and bamboo collectors close to the mountain ridge inside ST area	3	Macaques (Assamese, rhesus), pangolin evidence (1 year old)
29.01.17	Ranger post of the P-P WS	3	
31.01.17	Farm north of the ST area	2	

Interviews

Interviews with local residents and hunters were used to obtain important information on presence or absence of mammal species. Both structured and unstructured interview were used to conduct these interviews. The interviews were focused on the target species like gibbon, langur, gaur or pangolin, but included also other mammals. The questions were designed to obtain data about each species: their population; their local status in terms of the past, present, and future; their ecological behavior and ecological niche; their breeding season; and the types of threats, both direct, and indirect, that each species faces. Questions were also asked about the wildlife trade, human animal conflict and habitat loss. Where possible, dates were identified. Questions were also asked about methods employed to kill or capture the animals, and what trade routes were used.

Fig 11: Interview with local people

Interviews were held along the walking trails, at the limestone mine, at the small village north of the ST area, small farms between ST and the Panlaung-Pyadalin WS and at the guard post of the WS (Tab. 9).

Tab. 9: Overview interviews around Paluzawa coal mine

Date	Location	No. Participants	Special Remarks
26.01.17	Logging camp close to Chinese mining site	3	2 muntjac skins
04.02.	Sunflower farmers, south of the St lease	5	-
05.02.	Tin Win Tun, coal mining company	3	Reliable gaur and sambar evidence
05.02.	Bamboo collector`s camp	3	Reliable pangolin evidence
05.02.	Local hunter	1	Dhole teeth, gaur and gibbon evidence
05.02.	Hunter`s camp close to Chinese site	2	Pangolin evidence, wildlife trade
06.02.	Hunter`s camp close to Phase 1	3	Porcupine spines and intestine

Target species

The area inside and around the mine is highly degraded and heavily disturbed by human activities. The probability for direct encounters with wildlife were rather low. During our walking surveys we encountered two species of squirrels. Wild boar and muntjac could be confirmed by tracks. For all other species we had to rely on interview evidence (Tab 10).

Critically Endangered

Chinese pangolin (*Manis pentadactyla*) CR

One of the target species is the Chinese Pangolin. Pangolin suffered a severe decline in recent years. The scales and their meat are highly demanded in Chinese traditional medicine.

One sighting last year in the degraded forest on the foothill of the limestone mining site. Another hunter killed one about one year ago in the plantations close to the mining site.

Endangered

Shan State langur (*Trachypithecus phayrei shanicus*) EN

The Shan State langur is the eastern subspecies of the endangered Phayre`s langur. It is only known from very few protected areas in Myanmar. As the Mount Popa population seems to be a distinct taxon, the conservation status of this subspecies seems to be even worse. It should occur in the P-P Wildlife Sanctuary, which southern boundary is located only 4 km north of the cement mine.

Interviews indicate the presence of the species possibly inside ST area, but more likely on the adjacent mountain, where it is frequently seen by a local farmer and by a hunter from the nearby village, who described a group size of 5-7 individuals.

Vulnerable

Bengal slow loris (*Nycticebus bengalensis*) VU

Slow loris were confirmed by all interviews, but seems to be quite rare and are not often seen.

Hog badger (*Arctonyx collaris)* VU

One interviewed person identified the hog badger. He could not specify location or time. We include the hog badger in the species list although it was not confirmed by other interviews or evidence. Because of its secretive behavior and often nocturnal activity it is likely to be overlooked by most people.

Near Threatened

Assamese Macaque (*Macaca assamensis*) NT

Assamese macaque were clearly identified in one interviews. According to the interviewed person they form smaller groups (10-15 individuals) than the more common Rhesus macaques.

Rhesus macaques are regularly seen in large groups (more than 80 individuals) by three people who are collecting wood and working on shifting cultivation. Last sighting of Assamese macaque was only one day before our interview.

Chinese serow (*Capricornis milneedwardsi*) NT

We found no direct evidence for the presence of serow. The habitat seems, despite being heavily degraded still suitable for serow. Several interviews provide indirect evidence, with all interviewed persons highlighted that this species became rather rare in recent years.

Black Giant Squirrel (*Ratufa bicolor*) NT

Direct sighting of one individual directly next to the limestone mining site. This species is widely distributed, but highly dependent to high canopy. Populations are declining due to loss of tall forest.

Other species

The Eastern hoolock gibbon (*Hoolock leuconedys*), which is classified as Vulnerable could not be confirmed. One of the interviewed hunters said he heard gibbon calls last time several years ago. All others didn`t know the species. It is likely that gibbons already disappeared from the areas several years ago.

Beside the jungle cat (*Felis chaus*), which was identified by two independent persons, one clearly identified and described the Asian golden cat (*Catopuma temminckii*), but couldn`t specify when he saw the golden cat. We consider it therefore as unconfirmed. It is classified as Near Threatened. Bears or large cats seems to have disappeared already more than 10 years ago. Small carnivores like Yellow-throated marten (*Martes flavigula*), three species of civets (Small indian civet (*Viverricula indica*), Small-toothed palm civet (*Arctogalidia trivirgata*), Common palm civet (*Paradoxurus hermaphroditus*) were regulary identified by interviewed people, Large-toothed ferret badger (*Melogale personata*) and hog badger (*Arctonyx collaris*) one time each.

The presence of red goral (*Capricornis rubidus*), which was indicated by a previous interview survey in this area must be doubted. This species has been recorded in Myanmar only from few locations in the far north of Kachin state. During the interviews it may have been confused with red muntjac by local people and misidentified them in the pictures shown to them.

Tab. 10: Mammal species recorded during the present study at Apache cement site

Common name	Scientific name	Evidence	Inside ST area	Adjacent ST area	IUCN status
Order Pholidota					
Chinese Pangolin	*Manis pentadactyla*	Interview	+	+	CR
Order Primates					
Bengal Slow Loris	*Nycticebus bengalensis*	Interview	+	+	VU
Shan Langur	*Trachypithecus. phayrei shanicus*	Interview	-	+	EN
Rhesus Macaque	*Macaca mulatta*	interview	+	+	LC
Assamese Macaque	*Macaca assamensis*	Interview	+	-	NT
Eastern Hoolock Gibbon	*Hoolock leuconedys*	-	-	-	VU
Order Carnivora					
Leopard Cat	*Prionailurus bengalensis*	Interview	+	+	LC
Jungle Cat	*Felis chaus*	Interview	-	+	LC
Common Palm Civet	*Paradoxurus hermaphroditus*	Interview	+	+	LC
Small-toothed palm civet	*Arctogalidia trivirgata*	Interview	+	+	LC
Large-toothed ferret badger	*Melogale personata*	Interview	+	+	LC
Yellow-throated marten	*Martes flavigula*	Interview	+	+	LC
Hog badger	*Arctonyx collaris*	Interview	-	+	VU
Order Artiodactyla					
Chinese Serow	*Capricornis milneedwardsi*	Interview	+	-	NT
Red muntjac	*Muntiacus muntjac*	interview	+	+	LC
Wild boar	*Sus scrofa*	Interview, tracks	+	+	LC
Order Rodentia					
Black Giant Squirrel	*Ratufa bicolor*	Sighting	+	-	NT

Identified threats

The habitat is already heavily degraded, with almost no larger trees left. The lower parts are used for firewood extraction, agriculture and cattle grazing. Several roads provide access to most of the area leaving only very limited space for wildlife. Wild boar and muntjac seems to be still present in the area. Also pangolin could still be present.

Logging and bamboo collection is also taking place on the stepper parts of the mountain almost to the top of the ridge. Most of the wood is used fuel for the production of limestone powder. Between Pyinyaung village and the mining site there are over 100 limestone powder production sites, all of them dependent on firewood from nearby forests. It is very unlikely that this can be stopped or reduced in the near future (Fig 12).

Fig 12: Large amounts of fuelwood are needed for limestone powder production

Hunting seems to be a minor threat as most interviewed people said, that wildlife has dramatically declined over the past years and hunting became more and more inefficient.

A major threat for mammals is the fragmentation of habitats and isolation of populations in the remaining forest patches.

Main threat include:

- Degradation of habitat
- Logging
- Fragmentation of habitats

Recommendations for reduction and mitigation of threats and biodiversity offset

There is already a proposed biodiversity offset plan. The plan includes 2253 acre (912 ha) of offset areas, all of them located directly next to mine lease (6oo acres/243 ha) (Fig. 13). All of these areas are already heavily degraded, especially the southern part (1809.5 acres). This area is affected by firewood extraction for the limestone powder production around Pyinyaung village, agriculture and bamboo collection. Especially the high demand for fuelwood for limestone powder production seems to be not easy to solve.

In terms of an effective protection of remaining mammal populations the maintenance of habitat connectivity has to be considered. Genetic isolation of small populations in degraded and highly fragmented habitats needs to be avoided to prevent the loss of sub-populations or even the loss of whole populations. Therefore we suggest a substantial biodiversity offset towards the north to keep the mining area connected with the nearby Panlaung-Pyadalin Cave Wildlife Sanctuary. Other taxonomic groups like invertebrates or herpetofauna, or plants needs to be considered. It has to be clarified that the limestone formation north of the lease and inside the WS provide habitat for the same species affected by the mining activities at the limestone formation inside the ST lease (Suppl. Map 6).

App. 3-4 miles north of the lease is Panlaung-Pyadalin Cave Wildlife Sanctuary (Fig. 14). The WS has only limited staff. There are only two ranger posts for the whole area. During our interview the rangers pointed out that they don`t feel capable to prevent the WS sanctuary from further degradation. They suffer from a substantial lack of staff and equipment such as motorbikes or a boat, as the WS can be easily accessed by boat via an adjacent reservoir. In the past the WS provided habitat for endangered species such as banteng, dhole or Shan state langur. About the current status of wildlife populations inside the WS is only little known. A biodiversity study has not been conducted. To support a biodiversity assessment of the WS could also provide an opportunity for mining operators to contribute towards the conservation of biodiversity in the region.

Recommended activities to ensure habitat connectivity:

- Examine the possibilities of a biodiversity offset area connecting the remaining habitat around the mining site with with Panlaung-Pyadalin WS
- Consider financial support for Panlaung-Pyadalin WS (additional rangers, motorbikes, boat)
- Support a biodiversity study in Panlaung-Pyadalin WS

Further activities to address threats to wildlife inside the mining lease:

- Stop logging activities inside the companie`s lease
- Stop hunting activities inside the companie`s lease
- Include wildlife and wildlife trade in awareness activities
- Increase habitat restoration activities (maintenance of tree and plant diversity)

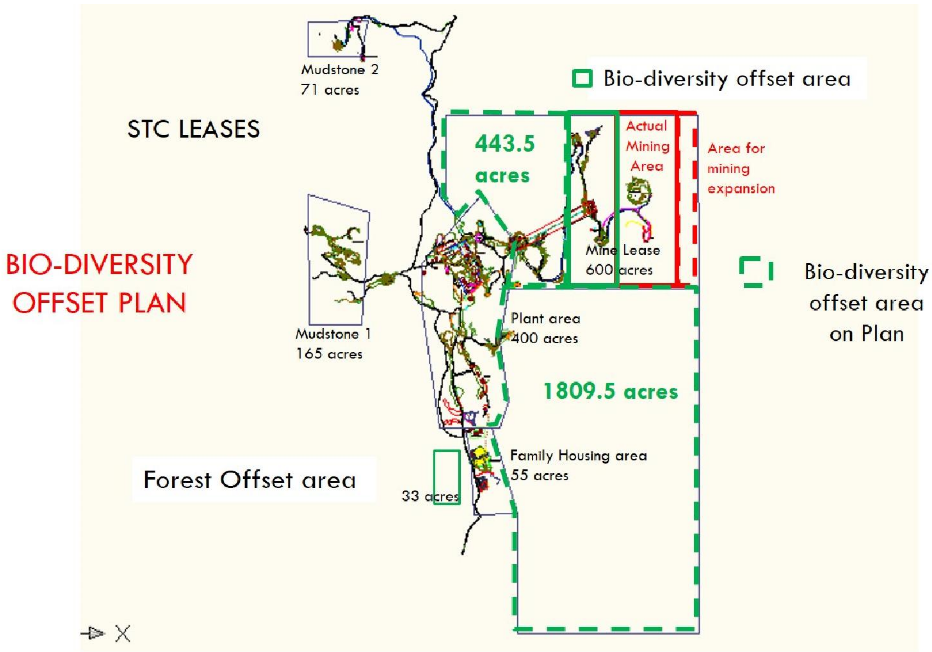


Fig 13: Existing biodiversity offset plan for Pyinyaung mine

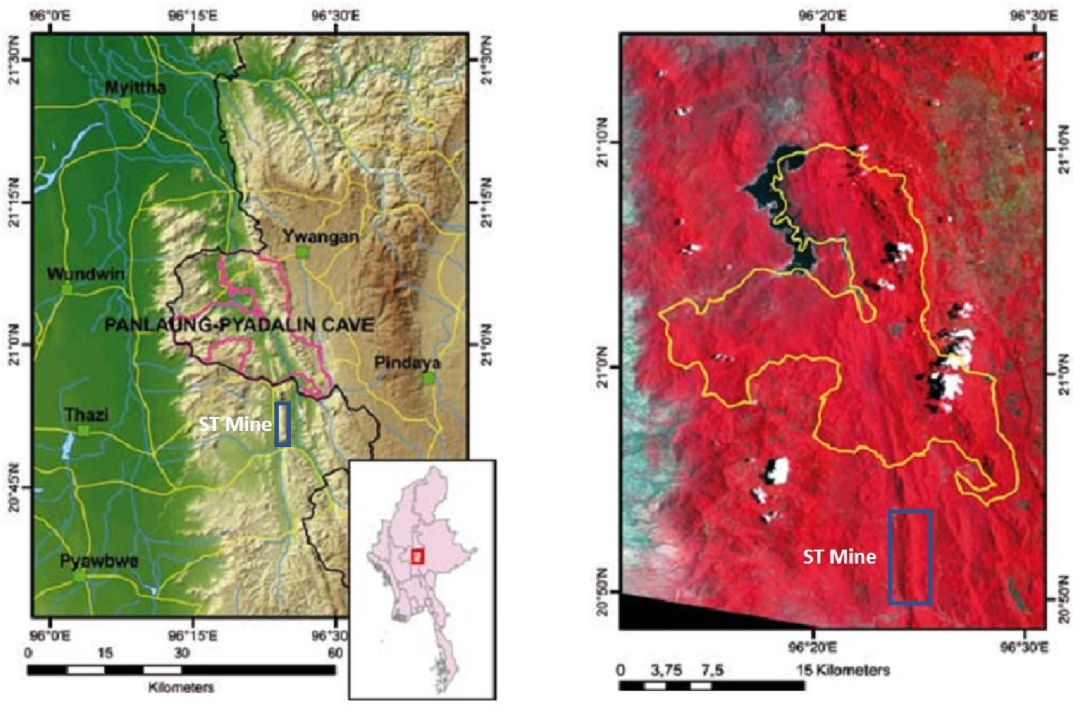


Fig 14: Location of Panlaung-Pyadalin Cave Wildlife Sanctuary in relation to the Shwe Taung Mine (Istituto Oikos & BANCA)

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Supplement 1: Selected camera trap pictures

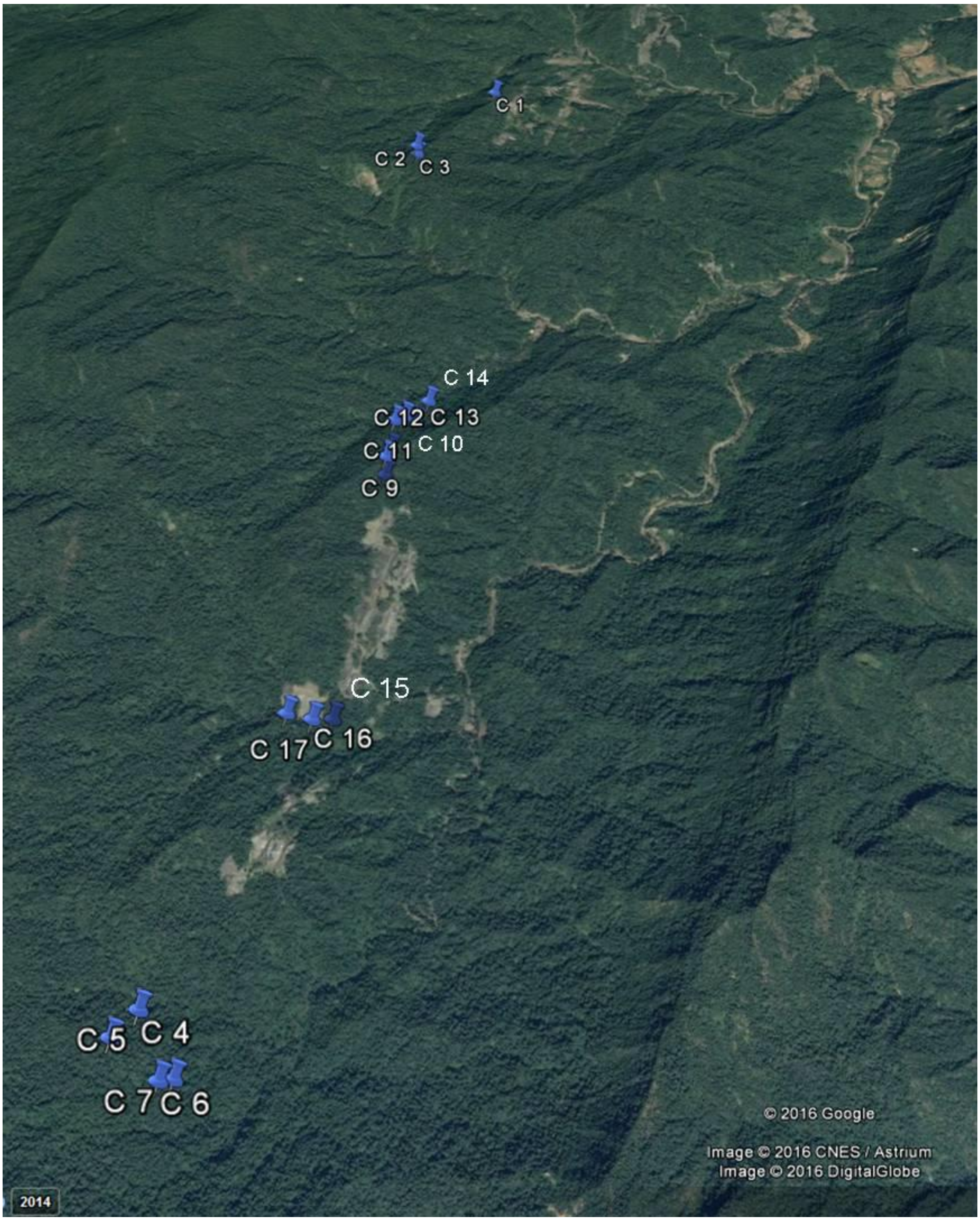
Red muntjac (left), Malayan porcupine (right)

Rhesus macaque (left), Eurasian wild boar (right)

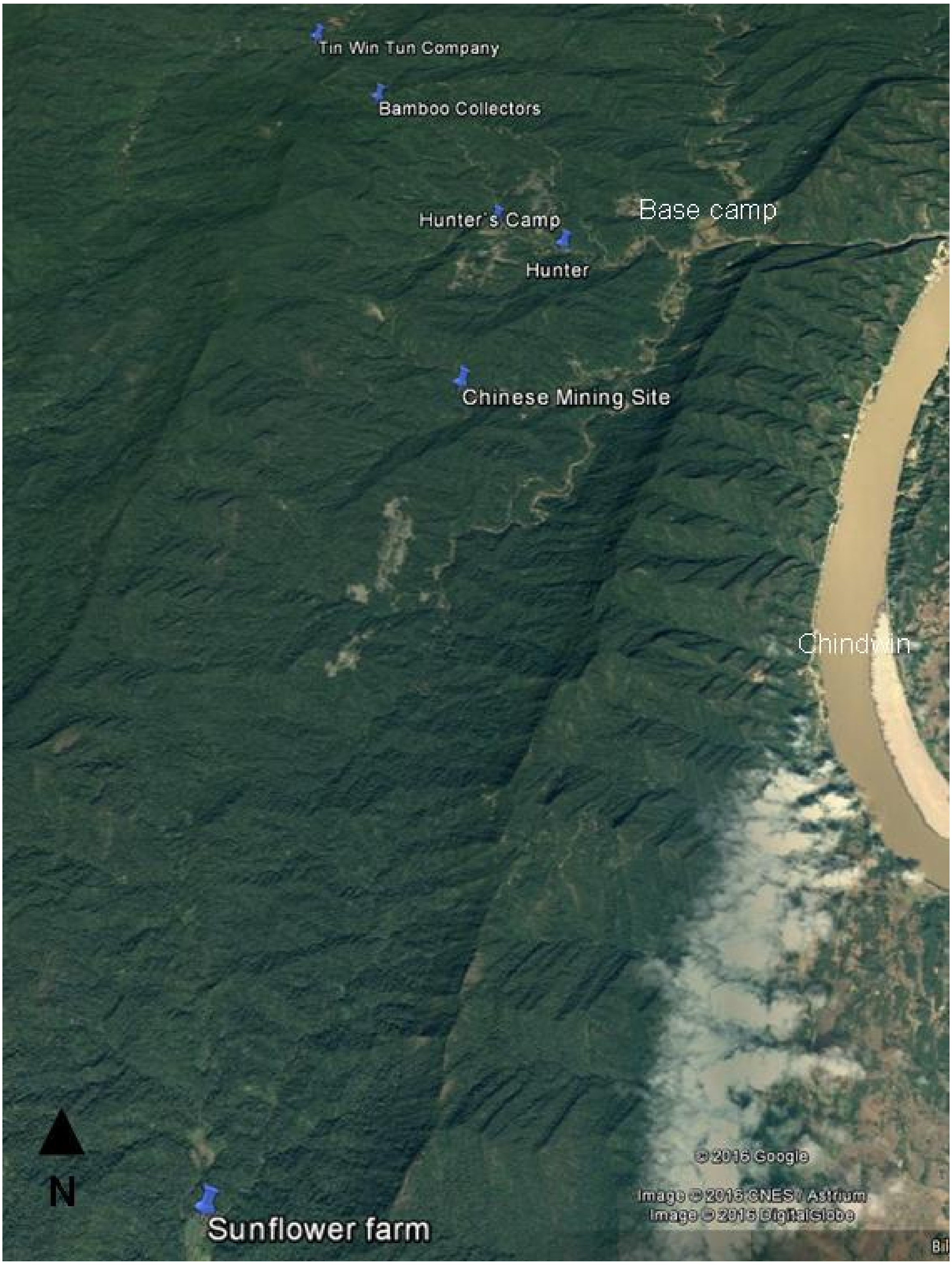
Large indian civet (left), Leopard cat (right)

Fishing cat (left), Yellow-throated marten (right)

Supplement 2: Maps

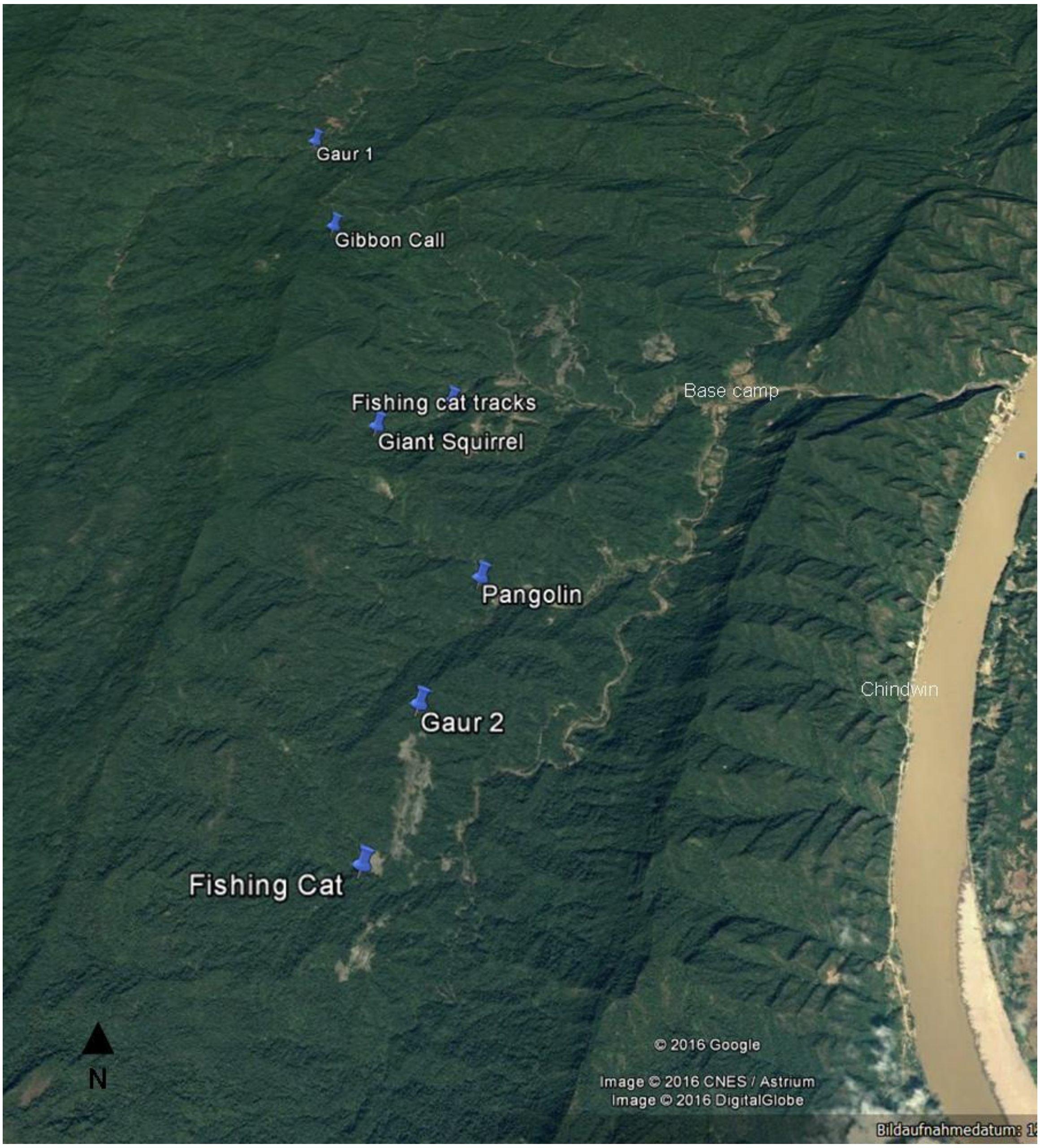


Map 1: Camera trap locations at Paluzawa coal mine

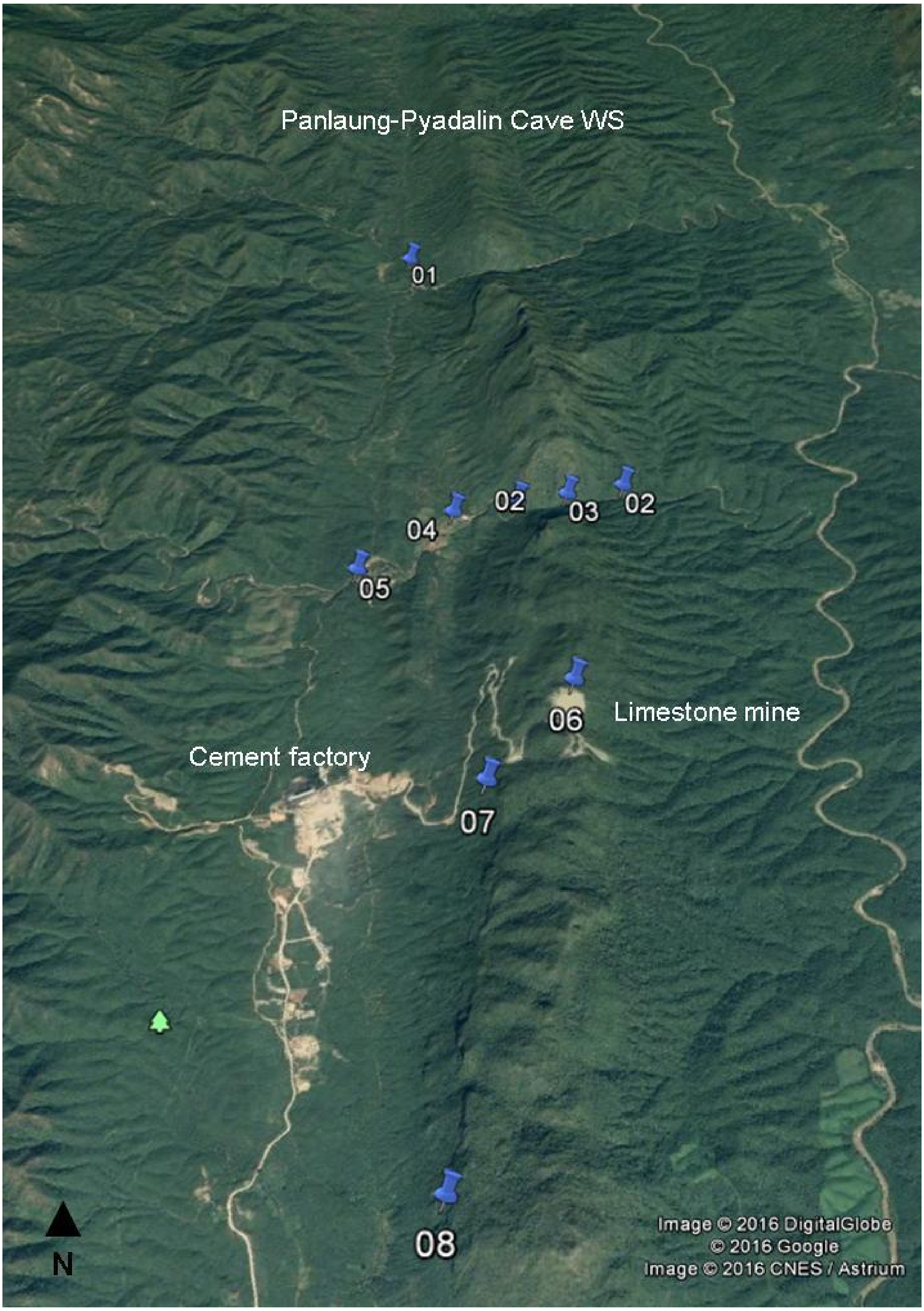


Map 2: Interview locations at Paluzawa coal mine

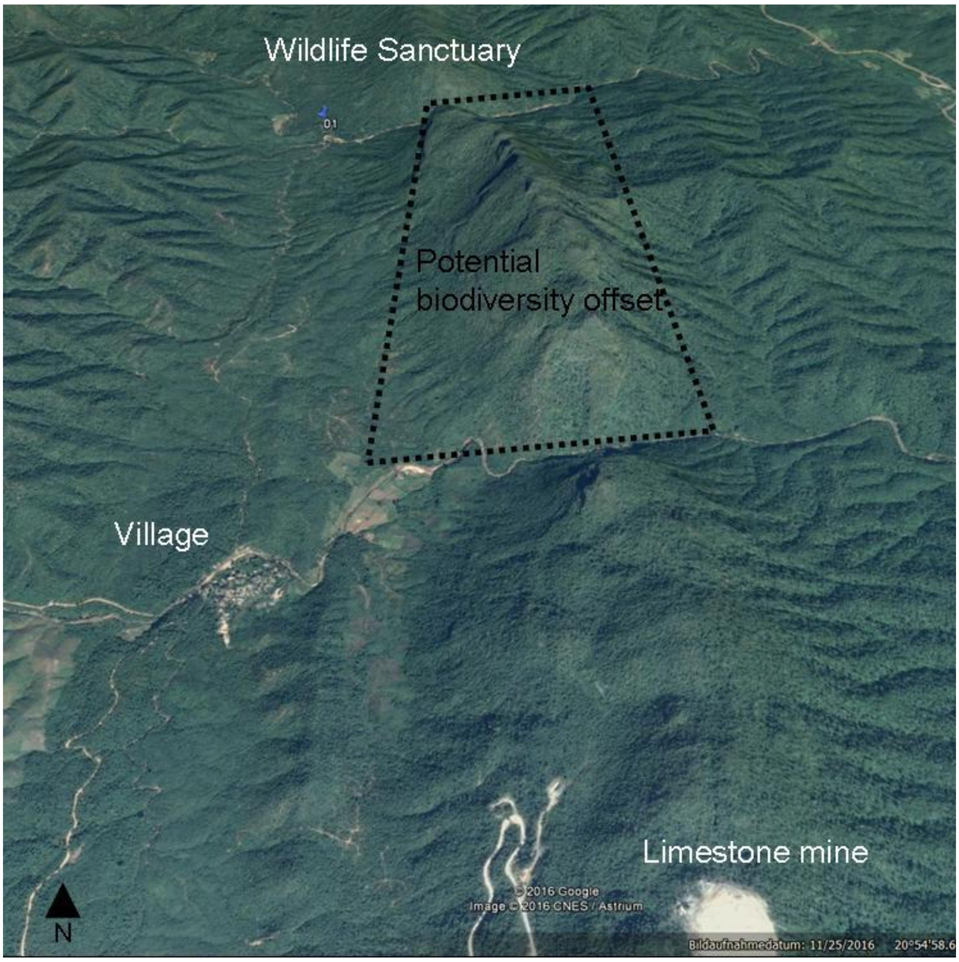
Map 3: Wildlife tracks and sightings (black dotted line: app. Boundaries of ST lease)



Map 4: Reliable records of IUCN listed species



Map 5: Survey locations at Pyinyaung cement mine (01: Wildldife Sanctuary ranger post, 02/03: stream north of the mining site; 04: Farm House; 05: Village; 06: Giant Squirrel sighting; 07-08: Surveyed area inside ST lease



Map 6: Potential offset area to ensure connectivity of habitats between the mining site and the nearby Wildlife Sanctuary.

Biodiversity assessment on the limestone ranges near the Shwe Taung Cement (=Apache Cement) concession between Pyinyaung and Kubyin, Mandalay Province

(based on land snails as indicator group)

Jaap J. Vermeulen PhD

Katja Anker MSc

Date: March 22, 2017.

A survey for

ERM (Environmental Resources Management**)**
Bangkok Office
Thailand

On behalf of

Shwe Taung Development (APACHE CEMENT)
Myanmar

Contents

1 – Major conclusions

Below, we call the limestone range in which the APACHE-concession is situated the *Pyinyaung limestone range*. For easy description we have divided the range in sectors A to F, see **Fig. 3a.**

Fig. 3b is A sketch map in which all available information (from sampling, field observation, Google Earth image interpretation, and from discussions with local people) is synthesized .

1.1 – Land snail fauna

1.1.1 – Presence of site-endemic species

- We did not find any potentially site-endemic species in the APACHE-concession area (sector D), that would trigger the IUCN Red List Criteria CR or EX as a result of the quarrying.
- We think it is less likely that true site-endemic species will occur in the APACHE-concession area. This is because we have not found caves, wells, or other environments suitable for site-endemic species in the APACHE-concession area.

Explanation. In more or less continuous limestone ranges, site-endemic species are often adapted to extreme environments, such as caves or limestone wells. These environments have a limited spatial extent, and the site-endemic species cannot spread beyond their boundaries.

1.1.2 – Presence of local-endemic species

- Ten snail species are potentially local-endemic to the Pyinyaung limestone range, see **fig. 5** for species names and distribution over the range. Their presence demonstrates the need to implement offsetting measures if biodiversity loss caused by quarrying is to be avoided.
- Six species which are potentially local-endemic to the Pyinyaung limestone range occur within the boundaries of the Apache concession, see **fig. 5**: *Diplommatina crispata* new subsp., *Khasiella pingoungensis*, *Bradybaena schanorum*, *Chloritis anserina*, *Pseudonenia shanica*, *Anauchen* new sp.
- *Anauchen* new sp., presently only known from the APACHE-concession, is likely to bre distributed beyond the concession boundaries as well. Therefore, the species is best regarded as a local-endemic. Nevertheless, its range may be so limited, that the activities on the Apache site reduce its range to an extent that it would trigger the IUCN Red List Criterion EN.
- Considering the distribution of the local-endemic species, the part of the Pyinyaung limestone range North of the concession (sectors A, B, C, and part of D) is most suitable for offsetting, see **fig. 3b**. This is because several local-endemic species occur exclusively in the APACHE-concession and/or further North: *Dicharax* sp., *Sinoennea* new sp., *Anauchen* new sp. None have been found restricted to the South part of the range (sectors E and F).
- However, our collecting the southernmost end of the range was insufficient; more local-endemic which occur restricted to the South part of the Pyinyaung limestone range species may occur in the least disturbed parts of it, see **fig. 3b**.

1.1.3 – Species new to science

- Four species and subspecies potentially local-endemic to the Pyinyaung limestone Range are probably new to science: *Diplommatina crispata* new subsp., *Plectotropis* new sp., *Sinoennea* new sp., *Anauchen* new sp.
- Two of these are found within the APACHE-concession: *Diplommatina crispata* new subsp., and *Anauchen* new sp. (see fig. 5).

1.1.4 - Uniqueness of the fauna of the Pyinyaung limestone range

Above, we demonstate the uniqueness of the Pyinyaung limestone range though the presence of potentially local-endemic species. Below, we show that the fauna as a whole is different from the fauna of some collecting sites in its surroundings.

- Comparison of the snail faunas of the Pyinyaung limestone range and the limestones East of Kalaw shows fundamental differences, with a DSC[1] of 0.39 only (see **fig. 6**). This shows that:
- Strong gradients exist in the fauna composition in the region. It is likely that each limestone area, like the Pyinyaung limestone range, has a fauna different from that of surrounding limestone ranges.
- A consequence is that the fauna of each limestone area in the region, including the Pyinyaung limestone range, includes a number of unique elements: local-endemic species.

1.1.5 – A North-South gradient in the fauna composition of the Pyinyaung limestone range

- The overall composition of the snail fauna of the northern end of the Pyinyaung limestone range (sectors C and D) differs from the fauna of the southern end (sectors E and F, established in spite of insufficient collecting of the southern sectors): DSC=0.73.
- This means that the cumulative effect of all economic activity along the Pyinyaung limestone range may lead to biodiversity loss, even if the part of the limestone range to the North of the concession is protected by the APACHE offsetting program.
- Again, this statement may gain weight once the southernmost part of the range is more thoroughly checked for local-endemic species.

1.1.6 – Fauna composition versus altitude in the North part of the Pyinyaung limestone (sectors C and D).

- The snail fauna on:
    - the North-facing slopes bordering the gorges South of the sectors B and C and on
    - the West slopes and the crest of the sectors C and D of the limestone range
- are different (DSC=0.75, see **fig. 6**). This difference is proportionally reflected in the distribution of the local-endemic species: 7 out of 10 occur in both, whereas 2 (*Dioryx pingoungensis* and *Sinoennea* sp.) prefer the lowlands and 1 (Anauchen sp.) is restricted to high grounds.
- We only incompletely sampled the crest of sector C. However, we observed that these parts have a general environment similar to that of the crest of sector D (including the APACHE-quarry), but are less degraded by ongoing logging and bushfires. We therefore assume that the crest of sector C has a fauna similar to that of the crest of sector D, but possibly more varied.
- This makes sector C (and probably sector B and A as well) attractive areas for offset purposes:
    - the fauna of large parts is similar to that of sector D, including the APACHE-concession;
    - the levels of environmental degradation are lower;
    - and the different faunas of the North-facing slopes, not represented in sector D or further South in the limestone range, are a bonus.

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[1] Dice Similarity Coefficient = Dsc = 2|x ∩ y|/|x|+|y|, in which x and y are the number of species found in two localities. Values between 0 and 1; high values denote similarity.
In this particular case the low value is partly caused by asymmetry of the two sets (79 species collected in the Pyinyaung limestone range, versus 33 East of Kalaw; see **fig. 6**. Nevertheless, no fewer than 11 species have been found East of Kalaw which we did not find on the Pyinyaung limestone range.
The other DSC values on this page are based on approximately symmetrical datasets

1.1.7 – Indicators of disturbance

Where the vegetation, indifferent of the bedrock type, has been degraded to almost pure stands of bamboo, or where bushfires have destroyed the topsoil, only few snail species survive. We have not sampled such sites separately because the effects of environmental degradation are not the primary goal of the survey.

We found no more than one species that indicate disturbance:

- *Achatina fulica* (Achatinidae), an agricultural pest species introduced from Africa, on fallow land near sampling site 11.

Near-absence of intensively farmed agricultural land in the vicinity of the limestone range may explain the small number of disturbance-indicators and introduced species.

Many regard *Paropeas (Allopeas) gracile* and *P. (A.) clavulinus* as introduced. A while ago, shells of these species were found in 40.000 years old archeological deposits, which casts some doubt on their status.

1.2 – Other organisms observed

1.2.1 – Reptiles

We photographed three lizard species. Lee Grismer identified two as *Calotes emma* (2 individuals), and *C. versicolor*. Both are common and widespread.

1.2.2 - Mammals

We observed an unidentified monkey species near sampling site 17. We were not able to make photographs.

1.2.3 – Plants

Contrary to the true tropics, the flora includes large numbers of non-woody species, some of which will prove to be limestone restricted, and a smaller fraction to be local-endemic. A comprehensive Flora to identify Myanmar plants is not yet written; identification of local-endemics and site-endemics will have to be done as proposed in the quotation. This survey was at the height of the dry season, and little was flowering, but nevertheless we found:

- Possibly *Ornithoboea* (Gesneriaceae) or related genus on sampling site 6. A few young plants, not flowering, on rocks. *Ornithoboea* is a small genus with several endangered local-endemic species
- *Amorphophallus*, or similar genus (Araceae) on various sampling sites. A large genus including numerous local-endemic species. We found tubers, taken out with soil samples. The tubers will be sent to a specialist, but results cannot be expected shortly.

1.3 – Offsetting areas and groundwater management

At present, the groundwater table sinks at 2.5 cm/year (information from APACHE). Further degradation of the vegetation, and removal of the karstified surface of the limestone range, may impede replenishment of the groundwater reservoir. Offset areas may slow this process down, or even stop it.

Explanation: Little rainwater runs off the slopes of limestone hills. Most seeps into rock fissures, and directly feeds the groundwater reservoir. Indicators of underground water movement in the limestone range are resurgent wells near sampling sites 11 (with cold water; see **fig. 2a, 3b**) and 17 (with hot water). Both are on the on the North edge of a stream bed cutting through the limestone range; the position of stream beds and wells are determined by fault lines crossing the limestone range.

1.4 – Small-scale (economic) activities involving resources from the limestone range

1.4.1 – Teak logging

On sampling site 8, see **fig. 2**, sector D immediately North of the concession, we observed locals logging medium-sized regrowth teak trees. The logging is illegal (APACHE). On the lower slopes, all usable trees are gone, on the upper slopes logging is in progress. The logs are sawn into planks on the spot, and the planks are dragged out by hand. Google Earth shows that similar logging is ongoing along all the sectors of the limestone range, particularly along its West flank, much less along the East flank. We generally mapped areas where logging trails are visible as 'not suitable for offsetting' in **fig 3b**. Although the damage per tree extracted is minimal (no loss of organic matter more than the sawn timber taken out, and very narrow skidding tracks), the exploitation is on such a scale that it results in degradation of the vegetation. This is also because the loggers often set fire to the undergrowth.

Particularly from site 8, not only villagers take produce, but also people coming in from other areas (APACHE). Elsewhere, recent logging is restricted to the lower, non-limestone slopes of the range, although a first cut of teak trees seems to have been taken everywhere.

1.4.2 – Bamboo cutting

Stems are taken out in large numbers from the most degraded parts of the vegetation, where the bamboo grows thickest. The harvest feeds a thriving local industry, producing fences, matting etc. We cannot find much harm in this exploitation.

1.4.3 – Limestone and firewood for lime production

Lime kilns are found to the East of Pyinyaung village (between sector D and E) and on the limestone plateau of sector F. We find these have extensive impact on the surroundings:

- Limestone is taken from small quarries around the foot of the hills. When extraction from a quarry becomes too labor-intensive or too dangerous, a new quarry is started elsewhere at the foot of the hill. Associated bushfires cause further damage.
- A kiln is fired for four days for a load of lime, using a large quantity of wood in large logs. Scented smoke from some kilns indicates the use of species of some Dipterocarpaceae.

1.4.4 – Bushfires

Bushfires are started by all taking produce for the limestone hills and others, during the dry season, 'to chase the snakes away'. The fires are left uncontrolled, and slowly smolder and occasionally flare up for days, destroying the leaf litter and organic soil layer, but leaving the bamboo and trees unaffected.

This practice is damaging to the environment: it destroys the soil fauna and the seed bank from which the woodland regenerates. It favours bamboo, the dominant species in one of the last stages of degradation, and it leaves mineral laterite soils without any organic top layer and therefore with slim chances to recover.

1.5 – Further arguments for the sectors A to C, and part of sector D as offsetting sites

See **fig. 3a and b**. Next to cement plants quarrying parts of sector D and E, points from where incursions into the limestone range take place are:

- Agricultural land to the North of sector A (not visited, source: Google Earth).
- Kubyin village to the West of the gorge between sector C and D (small-scale timber extraction from the lower slopes).

- Pyinyaung village (limestone for lime production, wood to fire the lime kilns, teak, bamboo). From here, not only villagers take produce, but also people coming in from other areas.
- Various paths and tracks into the South half of sector D (limestone, teak, firewood, bamboo).
- Sector E, particularly the central limestone plateau (limestone for lime production, wood to fire the limes kilns.

Once recognized in the field, traces of these activities can be seen on Google Earth.
The parts where the vegetation is least disturbed appear most suitable for offsetting purpose. The population pressure around these remote parts is lowest; there is little industrial activity, and therefore fewer stakeholders to negotiate with. The least disturbed parts are:

- Sector A, South part (not visited, source: Google Earth).
- Sector B (not visited, source: (Google Earth).
- Sector C. Access to part of the range is difficult (a track to the West of the range can only be negotiated with a truck, with difficulty, during the dry season) and the population pressure is low (Kubyin village at its South end, with 60 families, and a small settlement of a few houses at its North end). On the NW- flank of sector C (sampling locality 10) we found the least immature (= nowhere near mature) teak woodlands in the area, where we spotted 12 different species of epiphytic orchids growing in abundance.
- Sector D, North end, as well as large parts to the South of the APACHE concession.

More disturbed, but still acceptable as a second choice for offsetting purposes are:

- Sector D, parts to the North of the Apache concession. This is progressively degraded by extraction of teak.
- Parts of sector E.

1.6 – Management of offsetting areas

(The following is without knowledge of stakeholders and their relations) The main economic activity in the least disturbed areas is teak extraction. Teak forests can regenerate after logging. If APACHE would use the goodwill created locally by its extensive social programs to involve all stakeholders, the following could be done to avoid slow degradation of potential offset areas:

- Create a buffer zone around the offset area, including the lower non-limestone slopes of the range.
- Grant exclusive logging rights in parts of the buffer zone to the inhabitants of the nearby villages, provided that they re-plant young trees for every tree taken.
- Expand the plant nursery in the APACHE concession, to provide young teak trees free of charge.
- Convince the local people not to burn the undergrowth

1.7 – Final notes

1.7.1 - Suitable high-Ca limestone areas with low biodiversity value on the Shan Plateau

Fig. 1 (based on Google Earth images, not checked with geological maps) gives an impression of the extent of outcropping limestone in part of the Shan Province. Underground limestone, covered with a thin layer of laterite soil, occurs in large parts of the Shan Plateau (observed along the road from Heho to Kalaw). At first impression, the biodiversity value of these limestone areas seems much lower than that of the (sparsely) forested limestone ranges in the Shan foothills, including the APACHE concession. Further expansion of limestone-based industry into the Shan Plateau would be preferable from biodiversity point of view.

1.7.2 – Safety in the lime kilns

People in the limestone kilns often work on bare feet, and without protection against the alkaline lime dust. A particularly distressing sight was a small girl, sitting in the lime dust and helping her mother sieving the lime powder. We wonder if APACHE could extend their social program to inform the kiln workers about health risks and provide minimal protective clothing.

2 – The survey

2.1 – Introduction

The survey is conducted for ERM (Environmental Resources Management**)**, Thailand office (David Nicholson), on behalf of Shwe Taung Development (APACHE CEMENT). APACHE needs to assess the impact on the local biodiversity of their limestone quarry between Pyinyaung and Kubyin, Mandalay Province, Myanmar, following the conditions pertaining to biodiversity conservation laid down in IFC PS6 (2012).

To explore the various options for mitigation and/or offsetting the impact of the development, they wish to gather information on the local biodiversity, particularly where it concerns the presence of species endemic to the quarry area and/or its immediate surroundings.

The quarry will destroy a small (3.4 km^2) and sharply delimited section of a set of parallel limestone ranges of close to 300 km long and, in places, up to 50 km wide (**fig. 1**). Thus, the positioning of the quarry is in line with the recommendation in Vermeulen & Whitten 1999:

An exploitation site should be located in the largest limestone area. … The site should never extend over the entire area, but always leave a substantial part alone.

This is because species tend to occupy suitable environment to the limits. For many limestone-restricted species, this means that they will expand their range up to the boundaries of the limestone hill on which they live. Therefore, quarrying a part of a large limestone hill (and leaving the rest untouched) is less likely to lead to extinction of species than quarrying a small hill in its entirety.

Species, which occur restricted to a specific environment of limited extent on or in a limestone hill (for instance, a well in a cave) do not benefit from this recommendation.

To avoid net loss of biodiversity because of the APACHE development, *impact mitigation* would be relevant in case species are discovered with such a limited area of distribution that they occur restricted (on a world-wide scale!) to the quarry area. If no such species are found, *impact offsetting* is likely to be more effective.

The client has pre-selected 2 potential offset sites: the limestone range to the north of the concession, and the limestone range to the south of the concession, see **fig. 3**.

We compare the biodiversity richness of the concession and the offset sites, to determine if the offset sites can compensate for biodiversity losses at the concession. We also check for potential site-endemic species, which would, in the course of the development, make necessary mitigating measures. More specifically:

- Are there species that are likely to occur restricted to the APACHE concession, or to the area immediately around the concession?
- Are there species in and around the APACHE concession that, if reviewed for the IUCN Red List, would possibly be classified as CR, or EN (IUCN Species Survival Commission, 2012)?
- Is the fauna composition of the concession and the offset sites similar, or do we observe a gradient?
- Do we find indicators of environmental disturbance in the fauna?

Not directly related to the above is the client's next question:

- Are there any species that are new to science?

2.2 – Scope and area covered by the survey

We use land snails (Mollusca: Gastropoda) as indicator group; see chapter 3.

We sample each sampling site following a fixed procedure. This will ensure that all sampling sites receive an equal amount of attention, and that the samples of each site are representative for the site.

We sample in the following order:

- Sampling sites in the concession.
- Sampling sites in the potential offset areas north of the concession.
- Sampling sites in the potential offset areas south of the concession.
- Sampling sites elsewhere.

Sampling elsewhere is necessary for reference purposes. Many species with a scientific name are known from one or two localities only; their actual distribution range is unknown. Therefore, we adapt our strategy to the incomplete documentation of the fauna, by sampling easily accessible sites on public land or sites of potential interest in the wide surroundings as far as time allows. The absence on such sites of assumedly local-endemic or a site-endemic species found in the concession or the potential offset areas may not prove the assumption, but at least supports it.

2.3 – Limitations

The local snail fauna is part of a fauna province covering most of India, Myanmar, as well as parts of Laos and Thailand. It includes some 1500 known species, described in numerous, mainly pre-1900 publications. Only few groups of land snails have been revised in recent years, with clear and detailed illustrations of the species.

Moreover, Myanmar is situated on the very East flank of former British India, bordering Laos where the French wielded the colonial scepter, or tried to. For taxonomy, this is relevant: both colonial powers independently set to describe the fauna of their dominions, without any attempt to come to a synthesis. This led to two very different taxonomies, a British and a French one, on species level, and even on generic level. The most basic consequence is that any species may have two scientific names, and that their synonymy has so far gone undetected.

Thailand, also bordering Myanmar, but never subjected by any colonial power, is comparatively terra incognita. Only the last two decades, Dr. S. Panha undertook systematic exploration of the Thai fauna. He still struggles with the existence of two disparate taxonomies and a general lack of synsthesis, for which reason he concentrates on a few families that have been largely overlooked by earlier explorers (for instance Vertiginidae).

The existence of two taxonomies has consequences for our attempts to accord a range size category (see below) to the species we find. For instance, we may think a species identified with British literature is endemic to the Shan States, but if we do not check the French literature, we may remain unaware of the fact that it is widespread, under a different name, in Laos and northern Vietnam.

We use the British literature as a primary resource, and we attempt a synthesis between the British and French literature only for species that we suspect to be interesting for our purpose.

Arthropods, particularly those that permanently live in caves, often display distribution patterns on a slightly smaller scale than snails. Because of their high levels of site endemism, with species often known only from a single site globally, consultation of a leading entomologist (Louis Deharveng and team) to determine if the sites harbor such species is highly recommended.

2.4 – Other observations

Aware of the urgent need of the client to identify potential local-endemic and site-endemic species that would trigger the IUCN Red List categories CR and EN because of the development, we, as far as time allows, make photographs of all potentially interesting species of plants and animals, and distribute these to specialists for identification. We also note:

- Potential archaeological sites.
- Caves, investigated by us or not.

We advise on sites that may be worthy of a visit by other specialists.

3 – Land snails as indicator group

Most biodiversity inventories concentrate on the vertebrate fauna (amphibians, reptiles, birds, fishes, mammals), and/or on selected plant groups. They have little value for comparative studies about biodiversity and its distribution:

- The numbers of species are too small for statistic value.
- The number of site-endemics and local-endemics is small.

However, vertebrates are important, because they appeal to people in general, and the infrequent cases of site endemism help to make a strong case for protection.

Ninety percent of all biodiversity, including that of tropical limestone hills, consists of invertebrates (insects, mollusks, spiders, crustaceans, worms etc.). The immense number of invertebrate species and the wide range of techniques necessary to catch these animals makes comprehensive or even representative sampling impossible. However, we have identified groups of organisms that can serve as ***indicator groups*** in limestone areas.

During previous surveys, teams sampled organisms of various indicator groups in limestone areas, specifically land snails and arthropods. This is because the species of these two groups may show similar patterns of distribution, but on a different scale. They give two datasets that complement each other, and synthesis yields a representative image of the biodiversity:

- Land snail species are often local-endemics or regional-endemics. Site-endemic species do occur, but not in large numbers. Distribution patterns of land snail species primarily yield differences in the fauna composition of larger units: groups of hills, or regions with limestone hills, and secondarily about biodiversity values of single hills.
- Arthropods count more site-endemic species among their numbers. These primarily provide information on the biodiversity value of single hills, or elements of single hills such as caves, and secondarily about larger units.

Technically, land snails as an indicator group have an advantage over arthropods:

- Snails are easy to sample.

- The samples are easy to process.
- Snail taxonomy is less overwhelming in terms of numbers of species that arthropod taxonomy. The field of study is such that the specialist will only rarely need to consult other specialists, which often takes a lot of time.
- Snails occur in sufficiently large numbers of species in limestone areas to render statistics derived from species lists significant.

Next to being an indicator of biodiversity richness, snails can also show human impact on a site:

- A depauperate fauna including only few species where many may reasonably be expected.
- Presence of only widespread species.
- Presence of introduced species.
- Skewing of the fauna on the site: the presence of very large numbers of individuals of species that elsewhere occur in small numbers only.

4. Endemic species and how we recognize them

Species with a very limited area of distribution are called *endemic species*. In this report, we categorize each species by the size of its area of distribution. We distinguish the following categories, adapted from Vermeulen & Whitten (1999: 14):

- A ***site-endemic*** species has a range of up to about 100 km^2, but may have a range not exceeding 100 m^2 in extreme cases (e.g. a fish species found in a single cave well). *Here, we regard a* ***species occurring restricted to a part of a sector (see fig. 3a) of the Pyinyaung limestone range, a site-endemic species.***
- A ***local-endemic*** species has a range covering 100 to 10.000 km^2. *Here, we regard a* ***species occurring restricted to the limestone range bordering the Shan Plateau local-endemic species (see map 3a, sectors A to F)***.
- A ***regional-endemic*** species has a range covering 10.000 to 100.000 km^2. *Here, we adapt this to categorize* ***species restricted to the central part of Myanmar, East of the Irawaddy River, and including the adjacent mountain ranges of Laos, and Thailand.***
- A ***widespread*** species has a range covering more than1000.000 km^2. *Here, the term is used for* ***species that occur beyond the range outlined above, usually in large parts of India and Indochina, and sometimes in southern China***.
- An ***introduced*** species (introduced by humans) does not add to the biodiversity value of a hill, but is often indicative of environmental disturbance.

When sampling the fauna of a hill, we concentrate on the presence of site-endemic and local-endemic species. These are most vulnerable to human impact. A bushfire swiping through the vegetation of a limestone hill, or a quarry, can wipe out the site-endemic fauna of the hill.

We attach special biodiversity value to site-endemic and local-endemic species which have no near relatives in the region, or no extant close relatives at all (they represent an old evolutionary lineage all by themselves). Examples are a snail species in Vietnam, of which the nearest extant relatives live in Europe. Another example is the Gingko tree, the last extant species of a group of plants that was widespread in the geological past.

There is hardly any absolute proof that a species is a true site-endemic or local-endemic. Even if all surrounding land is searched extensively and without success, a population of an assumedly site-endemic or local-endemic species may eventually turn up miles away. We use the following indicators to classify a species as a potential site-endemic or local-endemic species:

- The species is restricted to an environment that has unusual or extreme properties, which forces organisms to adapt to it to survive.
- The species is restricted to a discrete and isolated unit of an environment as above.
- The species belongs to a taxonomic group that includes numerous site endemic species.
- The species is recorded in literature as a site endemic.
- The species is new to science and not recorded anywhere, neither in literature, nor in collections (but only if the species belongs to a taxonomically well-known group).
- The species is found in only a single sample, of many samples taken in a wide area around that sample.
- The species is neither one of the well-known widespread species, nor an introduced species. Some widespread species may occur in small, isolated populations. If not recognized as a widespread species, such a population may be mistaken for a site-endemic species.

5 – Limestone biodiversity

The environment on limestone bedrock is often extreme: high levels of exposure to sun, rain and wind on exposed rock surfaces, contrasting with extremely sheltered, eternally dark caves with minimal fluctuations in temperature and humidity. Soils, if present, typically consist of the insoluble fraction of the limestone rock. They are thin, have little capacity to retain fertility or water, and often they are alkaline. In addition, ore bodies geologically associated with the limestone may cause high levels of poisonous metals.

Organisms colonizing these environments have two options: perishing, or adapting to the environment, and often to specific niches in the environment. Evolution, working indiscriminately and permanently on all life, leads then to the formation of new species well adapted to limestone environments.

Geologically speaking, limestone hills are the fossil remnants of marine reefs, built up by organisms growing vertically because they need light. Therefore, limestone bodies often have a much more limited horizontal extent than other sedimentary rock types. The capacity of a living reef to spread horizontally is limited by the depth of the surrounding water. If the water is too deep, light cannot reach the seabed, and reef-building organisms cannot settle. When, often after aeons of burial, the reefs are denuded by erosion, they usually stand as separate limestone hills in the landscape, with sediments of different nature in between.

Newly evolved species colonizing those limestone hills, once adapted to limestone environment and, as a result, no longer able to live elsewhere, are likely to find themselves trapped on a single or a few hills. They are isolated from their nearest relatives which, in the past, colonized more distant limestone hills, and which evolved into different new species.

As a result, limestone areas worldwide are extraordinarily rich in biodiversity, particularly in species with an extremely limited area of distribution: limestone areas are factories producing large numbers of species.

6 - Methods

6.1 - Where we collect

In order not to lose information that may be relevant later, we sample different surface environments separately (a forested slope, a sunny cliff, a deep cleft in the rock).

Underground environments (caves of all sizes down to small cracks in the rock, but also deep-soil deposits in rock crevices) may be home to often minute (0.7 – 2 mm) snail species hardly visible to the naked eye. We therefore take ‘blind’ samples in suitable places. We try to laboratory-process such samples in the field (microscope!) because, quite often, a second sampling is necessary when the first sampling reveals the presence of cave species, but does not yield sufficient material. Only when ‘blind’ samples indeed reveal cave-adapted species, we keep them separate from surface samples of the same spot.

Generally, we exclude aquatic snails from our survey, except for species of some families (Hydrobiidae s.l., for instance) which include large numbers of local-endemic and site-endemic species elsewhere. These aquatic snails are often found in small streams and (underground) wells in limestone areas. If we find such environments, we take ‘blind’ samples again, because the species are generally minute.

6.2 – Taking samples.

Quick and representative sampling is only possible if we target empty shells rather than living animals. Empty shells are in most cases sufficient for identification, except in some genera where the whole animal is needed for the purpose. In addition, slugs and semi-slugs (snails without a shell or with a small shell respectively) will be under-represented. This is compensated by the abundant presence of the very small species in our samples, which are very difficult to spot in the field.

The following procedure produces a representative sample of the snail fauna on a sampling site:

- Shells over 6 mm long are handpicked.
- We collect smaller species by taking ***soil-samples***, small amounts (a few handfuls) of soil from as many different microhabitats at a sampling site as possible.

Microhabitats and thanatocoenoses[2] we pay special attention to are:

- ‘Deathtraps’ below slightly overhanging limestone cliffs. Snails falling from the top of the cliff may bounce towards the rock face. Sheltered from rain, this is often very dry, so that the animals die, leaving well-preserved shells in loose sediment.
- Soil accumulated around the root systems of plants growing on cliff faces.
- Accumulations of organic soil in rock crevices.
- Leaf litter at the foot of limestone outcrops.
- Litter samples from sites where empty shells may accumulate (e.g. drift material over sediment-covered sinkholes, flood-marks of small streams).

Flood-marks of streams may also contain shells. We sample these, too, but we keep them as separate samples, because it is not certain that the shells found are actually living nearby: they may have washed in from elsewhere.

We continue gathering material on a sampling site until we have some 15-20 l of soil (two buckets full). Some handfuls will be poor in individuals and species (but may include species that do not occur in other handfuls); others will be very rich. All material together taken from a sampling site will yield a representative picture of the fauna of the locality under investigation.

[2] *death assemblage*. Groupings of remnants of organisms which may not have been associated during life, often originating from different habitats and brought together by rain, wind or predators.

When sampling a soil deposit, we remove any coarse leaf litter lying on top. Then we scrape together and bag the uppermost few centimeters of soil. Soil deposits in the above-mentioned 'deathtraps' and other thanatocoenoses are collected as a whole.

6.3 – Field-processing of samples

Field processing aims at separating an enriched fraction from the soil sample. Usually, this fraction is far less than half of the original sample in volume and down to a tenth of it in weight. This facilitates transfer to the home laboratory, and time-effective extraction of the fauna from the samples.

Field processing is done by flotation of the soil, pouring the soil in water and skimming off the floating fraction, including most of the shells. After drying, we separate the sample over a cascade of increasingly fine sieves. Each fraction will contain particles of approximately similar size, which ensures that no species are missed when extracting the shells under a microscope. We extract the coarse fractions during the survey as far as time permits. We pack the fine fractions for transfer to the home laboratory.

6.4 – Further processing in the home laboratory

Back in our home countries, the fine fractions are extracted under a dissecting microscope. The coarsest fractions can be picked with the naked eye, for the finer fractions, a dissecting microscope is needed.

Per locality, we separate the shells into species. We identify the species making use of literature and a reference collection.

7 – The area and its biodiversity

Fig. 1 shows the distribution of outcropping limestone in the wide surroundings of the concession, the west part of the Shan Plateau. Most conspicuous is the approximately 300 km long band with numerous outcrops from North to South. These limestones are bordering the Shan Plateau; the outcrops to the West are part of a series of hill ranges forming the plateau foothills.

The outcrops to the East are part of the Shan plateau itself. Here, the limestones are largely buried under a layer of red laterite soils. They are outcropping only locally, often as rounded hills, or where streams have cut through the laterite cover into the limestone bedrock, or where steep cliffs occur which are probably remnants of former landscapes.

The foothills to the West are largely covered with deciduous and some evergreen woodland. Traces of human impact abound but some of the woodland seems to be rather mature. The limestones to the East, on the plateau itself, are largely stripped of natural vegetation, apparently are not suitable for agriculture, and are only locally reforested with pine trees. Locally, they are also quarried, probably for burning lime. Most likely, their biodiversity value is very low.

Therefore, from a biodiversity point of view, the limestones on the plateau would be the best choice for any limestone-based industry, or at least a better choice than the forested limestones to the west, in the foothills

(*The above is based on analysis of Google Earth images, without checking other sources such as geological maps; the analysis will be checked during the field survey*).

8 – Snail sampling: results

Fig. 2 shows the sampling sites. We sampled 4 sites within the concession (all representative), 4 to the North of the concession (3 representative), 6 to the South of the concession (2 representative), and 3 to the East of the concession (2 representative). Altogether, we sampled 11 sites so thoroughly that the results give a good impression of the fauna of the site.

8.1 – list of sampling sites

8.1.1 – Sites along the road from Heho to the concession

Site 2017.01. Date 13/02/2017. Coordinates: 20°41'34.14"N 96°44'48.08"E. Alt.: 1280 m asl.
Shan Prov., along NH4 from Heho to Kalaw, hill range W of Innkhaung.
Limestone hillslope with much degraded, herbaceous vegetation and patches of shrub. Samples from near limestone boulders. Hand-picked shells and soil samples (*1/2 bucketful, sampling representative*).
General observations: In spite of degradation, probably caused by cattle (goats?), some apparently limestone restricted plant species are extant (Gesneriaceae).

Site 2017.2. Date 13/02/2017. Coordinates: 20°37'31.91"N 96°36'29.20"E. Alt.: 1350 m asl.
Shan Prov., along NH4 3.8 km NE of Kalaw.
Limestone cliff, degraded vegetation at foot largely burnt. Samples from sediment pockets at the foot of the cliff. Hand-picked shells and soil samples (*1 bucketful, sampling representative*).

Site 2017.03. Date 13/02/2017. Coordinates: 20°39'0.23"N 96°35'58.92"E. Alt.: 1370 m asl.
Shan Prov., along NH4 3.8 km NE of Kalaw.
Limestone cliff, with degraded vegetation including some shrubs at the foot. Samples from sediment pockets at the foot of the cliff. Hand-picked shells and soil samples (*1/2 bucketful, sampling incomplete*).

8.1.2 – Sites in concession area

Site 2017.04. Date 14/02/2017. Coordinates: 20°52'17.39"N 96°24'31.02"E. Alt.: 750 m asl.
Mandalay Prov., STC-APACHE concession, S side.
Small peak in limestone crest. Slopes rocky, with bamboo thickets, small trees and some climbers. Sampling from rock ledges and crevices. The sample includes yellow, shell-containing deposits in tubular cavities in a boulder pushed aside for road construction. Hand-picked shells and soil samples (*1 bucketful, sampling representative*).
General remarks: Hibernating tubers of *Amorphophallus* sp. (Araceae) present, possibly a limestone-restricted species. Also undergrowth climbing Caprifoliaceae with small purple flowers, possibly a potentially limestone restricted species

Site 2017.05. Date 14/02/2017. Coordinates: 20°52'36.04"N 96°24'30.81"E. Alt.: 720 m asl.
Mandalay Prov., STC-APACHE concession, N side.
Transverse depression in limestone ridge. Bottom with laterite cover and locally outcrops. Sampling from soil around and in between outcrops. Hand-picked shells and soil samples (*1 bucketful, sampling representative*).
General observations: all teak of usable size logged out long ago; only rotten stumps and some planks remaining. S-facing slope with bamboo thickets and small trees. (N-facing slope destroyed by quarrying).

Site 2017.06. Date 15/02/2017. Coordinates: 20°52'9.80"N 96°24'31.73"E. Alt.: 750 m asl.
Mandalay Prov., STC-APACHE concession, S side.

Depression in crest of limestone ridge, the N-facing slope with some evergreen vegetation and bamboo thickets. Sampling from among limestone boulders, at the foot of cliffs and from small cave. Hand-picked shells and soil samples (*1 bucketful, sampling representative*).
General observations: All usable teak trees logged out long ago. *Amischotolype*, or *Pollia* (Commelinaceae), an unidentified Acanthaceae ,and a Campanulaceae, all not flowering and potential limestone endemics, grow at the bottom of the depression, otherwise invaded by roadside weeds through the new quarry road. On a rockface we found young plants of, possibly, *Ornithoboea* (Gesneriaceae), another limestone endemic.

Site 2017.07. Date 15/02/2017. Coordinates: N 20°52'12.90"N 96°24'15.20"E. Alt.: 630 m asl.
Mandalay Prov., STC-APACHE concession, W side.
Dolomite bedrock. Rocky W-facing slope with predominant bamboo thickets and some small trees. Snail sampling at foot of rock outcrops. Hand-picked shells and soil samples (*1 bucketful, sampling representative*).
General observations: All medium-sized Teak trees were logged long ago; only rotting stumps and some planks remaining. Extensive traces of more recent undergrowth bushfire, destroying the soil, but apparently leaving the canopy unaffected.
2 plant species potentially limestone-restricted: an undergrowth climbing Caprifoliaceae with small purple flowers, and an herbaceous species of the same family.

8.1.3 – Sites to the North of the concession area

Site 2017.08. Date 16/02/2017. Coordinates: 20°52'55.69"N 96°24'27.91"E. Alt.: 730 m asl.
Mandalay Prov., Pyinyaung area, just N of STC-APACHE concession.
Dolomite outcropping in and around transverse depression in N-S ridge. Bamboo thickets with small trees; all large Teak logged out. Sampling at foot of rock outcrops and cliffs on N and E facing slopes. Hand-picked shells and soil samples (*2 bucketsful, sampling representative*).
General observations: Lower slopes, around explosives depots, mainly bamboo thickets, with only young teak trees left here and there. Upper slope with second-cut logging in progress; bamboo thickets predominant. Saprophytic orchid (*Gastrodia* sp., only underground tuber seen) on N-facing slope.

Site 2017.09. Date 18/02/2017. Coordinates: 20°55'52.52"N 96°23'54.59"E. Alt.: 270 m asl.
Shan Prov., Pyinyaung area, gorge trough limestone range 4.5 km N of Kubyin village.
Stream cutting E-W gorge through limestone ridge. N-facing slope with steep cliffs, overgrown with partly evergreen woodland. Sampling at the foot of outcrops and from crevices, above flood mark. Hand-picked shells and soil samples (*1 bucketful, sampling representative*).
General observations: S-facing slope rocky, with small deciduous trees with bamboo thickets in between. Some evergreen climbers near base only. Orchid (*Cymbidium* sp.) in tree.
Streambed with a rather species-rich herbaceous flora (a.o. Lamiaceae, Acanthaceae, Gentianaceae), probably with widespread species only.
Landscape picturesque, with steep rock faces. During the dry season, the streambed in the gorge connects people living East of the limestone range to the world: motorbikes frequently pass by, track also suitable for trucks.

Site 2017.10. Date 18/02/2017. Coordinates: 20°55'9.19"N 96°23'44.59"E. Alt.: 470 m asl.
Mandalay Prov., Pyinyaung area, W flank of limestone range c. 3.1 km N of Kubyin village.
Topographic base of limestone formation, approx. half-way up W-facing hillslope. Outcrops overgrown with bamboo thickets and small trees. Sampling at the foot of outcrops and from crevices. Hand-picked shells and soil samples (*1/4 bucketful, sampling incomplete*).
General observations: Below the limestone base a steep, W-facing, exposed, sunny slope on sandstone/conglomerate bedrock with open-canopy regrowth half-grown Teak woodland, and subordinate bamboo thickets. Traces of logging long ago present, second cut logging on lower slope.

Teak trees on higher slope with 12 species of orchids (*Ascocentrum* sp.; *Bulbophyllum* 2 sp.; *Cleisostoma subulatum* aff.; *Cleisostoma* sp.; *Dendrobium* 4 sp.; *Oberonia* sp.; (?) *Micropera* sp.; *Trichoglottis* sp.).

Site 2017.11. Date 19/02/2017. Coordinates: 20°53'56.34"N 96°24'22.05"E. Alt.: 300 m asl.
Mandalay Prov., Pyinyaung area, gorge through limestone range E of Kubyin village.
Stream cutting E-W gorge through limestone ridge. N-facing slope with steep cliffs, overgrown with partly evergreen woodland with some mature trees. Sampling at the foot of outcrops and from crevices. Hand-picked shells and soil samples (*2 bucketsful, sampling representative*).
General observations: S-facing slope rocky, with bamboo thickets and small deciduous trees, some evergreen vegetation near base only. Unidentified orchid in tree. A resurgent well, 1 m above the streambed, indicates permanent water circulation inside the hill, and possible presence of cave systems. Streambed with a rather species-rich herbaceous flora (a.o. Lamiaceae, Acanthaceae), probably with widespread species only.
Landscape more picturesque than site 9; extensive travertine deposits somewhat higher up the slope may indicate that the gorge was formed by a collapsing cave system. During the dry season, the streambed in the gorge connects people living East of the limestone range to the world: motorbikes and even trucks frequently pass by.

8.1.4 – Sites to the South of the concession area

Site 12. Date 19/02/2017. Coordinates: 20°40'53.84"N 96°26'38.25"E . Alt.: 630 m asl.
Mandalay Prov., Pyinyaung area, limestone plateau 2.6 km SE of Yeboo village.
Limestone plateau with numerous quarries and degraded vegetation (bamboo thickets). Collecting in bamboo thickets with only few trees left. Hand-picked shells and soil samples (*1/2 bucketful, sampling incomplete*).
General observations: The plateau is gutted by numerous small limestone quarries; the woody vegetation has largely disappeared into the lime kilns. The vegetation on the surrounding hills is less depleted, but could not be reached for representative sampling.

Site 2017.13. Date 19/02/2017. Coordinates: 20°45'49.21"N 96°25'19.98"E. Alt.: 650 m asl.
00 Prov., Mandalay Prov., Pyinyaung area, 6.9 km SSE of Pyinyaung.
Limestone plateau surrounded by hills. Vegetation degraded to bamboo thickets with only few trees left. Hand-picked shells and soil samples (*1/2 bucketful, sampling incomplete*).
General observations: a pattern of tracks crisscrosses the plateau to extract firewood and bamboo. A few small quarries are present at the topographic base of the limestone.

Site 2017.14. Date 19/02/2017. Coordinates: 20°49'29.33"N 96°24'56.22"E. Alt.: 330 m asl.
Mandalay Prov., Pyinyaung area, E entrance of gorge in limestone range E of Pyinyaung.
Slope overgrown with dense secondary growth. Bedrock sandstone/shale, with large limestone boulders rolled down from upper slope. Sampling from leaf litter on steep slope of a gulley. Hand-picked shells and soil samples (*1 bucketful, sampling representative*).

Site 2017.15. Date 19/02/2017. Coordinates: 20°49'31.40"N 96°24'32.50"E. Alt.: 300 m asl.
Mandalay Prov., Pyinyaung area, gorge in limestone range E of Pyinyaung.
Stream cutting E-W gorge through limestone ridge. N-facing slope, remnants of caves in roadside quarry, with some ochre-colored cave soil. Blind sample of the cave soil (*a few litres*).

Site 2017.16. Date 19/02/2017. Coordinates: 20°49'35.98"N 96°24'33.47"E. Alt.: 320 m asl.
Mandalay Prov., Pyinyaung area, gorge in limestone range E of Pyinyaung.
Stream cutting E-W gorge through limestone ridge. N-facing slope, remnants of caves high up in roadside quarry, with abundant red laterite soil spilling over into the quarry. Blind sample of laterite soil (*1/4 bucketful*).

Site 2017.17. Date 19/02/2017. Coordinates: 20°49'42.23"N 96°24'34.62"E. Alt.: 320 m asl.
Mandalay Prov., Pyinyaung area, gorge in limestone range E of Pyinyaung.
Stream cutting E-W gorge through limestone ridge. S-facing slope with thin deciduous woodland and many bamboo thickets. Limestone cliff near the base of the slope, with various shallow caves at the foot of the cliffs. Sampling at the foot of the cliff; hand-picked shells and soil samples (*1 bucketful; sampling representative*).
General observations: Caves present, used as a place of worship.

8.2 – The list of snail species

Fig. 4 lists all the species we have sampled or noted, per sampling site.

The first four columns give taxonomic information about the species.

1. Name of the family to which the species belongs.

2. The species name, consisting of two parts, "*Cyclophorus volvulus*": the first is the generic name, the second the specific name. Several species cannot be identified down to species level. These are listed with a generic name only, "*Kaliella*", with "sp." added, or "**new sp.**" if we have already established that the species is new to science. Where necessary to avoid confusion, we add an informal identifier in column 4.

3. Author of the species and the year of its original description.

4. Informal identifier/additional information. If relevant, the fourth column gives some key characters uniquely to identify a species.

Column 5 gives the range size category of the species, see chapter 4.

The other columns give the distribution of each species over the sampling sites, which are shown on the map in **fig. 2**, and listed in chapter 8.1.

8.3 – Presence of site-endemic and local-endemic species

8.3.1 – Site-endemic species

We did not find any potentially site-endemic species in the APACHE-concession area, nor elsewhere in the Pyingyaung limestone range. Therefore, we found no species that would require impact mitigation measures to survive the quarrying.

Generally speaking, it is unlikely that true site-endemic snail species are present in the APACHE concession.

Site-endemic species which occur restricted to a part of a continuous limestone range (such as the Pyinyaung limestone range) are usually found in extreme environments of limited spatial extent, such as caves, or waterbodies in or outside caves.

- We have not seen suitable caves of any size in the area. The caves that we have seen include a few remnant cavities E of Pyinyaung village. 'Blind' sediment samples (sampling sites 15

and 16) from these cavities did not contain potentially site-endemic species. Another cave E of Pyinyaung (sampling site 17) is used as a place of worship and carefully cleaned.
- We found two resurgent wells. The well in the gorge East of Kubyin village (near sampling site 9) did not contain potentially site-endemic species; the well in the gorge E of Pyinyaung village (near sampling site 17) is too hot to contain any snail fauna.

Explanation: Limestone-restricted species tend to occupy all suitable habitat available and accessible. For surface species this usually means that they occupy a patchwork of sites up to the circumference of the limestone hill. For above-ground aquatic species, as well as underground terrestrial or aquatic species, this means that they occupy a cave or water body, i.e. an area so small that it could entirely be destroyed by quarrying.

8.3.2 – Local-endemic species

Fig. 5 lists the 10 species which are potentially endemic to the Pyinyaung limestone range (Range Size Category 2). Some occur along the entire length of the range, from North to South (like *Bradybaena schanorum*), others are restricted to part of the range (like *Pseudonenia shanica*).

Some have a range so limited that they could be listed as site-endemic species (*Dicharax* sp., *Plectotropis* new sp., *Sinoennea* new sp., *Anauchen* new sp.). However, as argued above, site-endemic species in continuous limestone ranges are usually adapted to spatially limited areas with extreme environmental properties . All the species mentioned above are rock-, soil-, or vegetation dwellers, not limited in their movements by any obvious environmental constraint. Eventually, they are likely to be found elsewhere on the range, and therefore we list them as local-endemics.

Probably, *Anauchen* new sp., at present only known from the APACHE-concession, is distributed beyond the concession boundaries as well. Therefore, the species is best regarded as a local-endemic. Nevertheless, its range may be so limited, that the activities on the Apache site reduce its range to an extent that it would trigger the IUCN Red List Criterion EN.

Several local-endemic species occur exclusively in the North part of the Pyinyaung range (the APACHE-concession and further North: *Dicharax* sp., *Sinoennea* new sp., *Anauchen* new sp. We have not found local-endemic species restricted to the South part of the range (from Pyinyaung Southwards).

From this point of view, the part of the Pyinyaung limestone range North of the concession is more suitable for offsetting purposes.

However, it should be kept in mind that the southernmost end of the range (sampling sites 12 and 13) have not been representatively sampled. Local endemics may lurk in the South in places with less degraded environment not visited by us, see **fig. 3b**.

The presence of 10 snail species potentially endemic to the Pyinyaung limestone range shows that offsetting may be effective to reduce biodiversity loss caused by quarrying activities along the limestone range.

8.4 – Presence of species new to science

Sixteen species could not be identified down to species level with reasonable certainty. Eight of these are probably new to science.

Four of the local-endemic species are probably new to science, two of these are found in the concession: Diplommatina crispata new subsp., and Anauchen new sp.

The number of unidentifiable species is surprisingly low. This is because the existing literature adequately covers a representative part of the local fauna.

8.5 – Differences in the fauna composition

For the calculations in this chapter, Introduced species (RSC=5) have been omitted from the species list in **fig. 4.** We calculate similarity between sampling sites, or groups of sampling sites, making use of the DSC[3]. The results are given in the tables in **fig. 6**. The DSC is sensitive to sets of unequal size (we try as much as we can to standardize sampling procedures to ensure that a low number of species on a site reflects true faunal poverty and not incomplete collecting). Below, we add a note where the DSC is affected by asymmetrical collecting on the compared sampling sites.

8.5.1 - Uniqueness of the fauna of the Pyinyaung limestone range

To compare the faunas of the Pyinyaung limestone range and surrounding limestone areas we sampled three sites between Kalaw and Heho (sampling sites 1, 2, and 3). In spite of the asymmetric nature of our collecting effort (the environment on the three sites is heavily degraded, and our collecting on one site was cursory), it is evident that the fauna on these sites differs fundamentally from the fauna on the Pyinyaung limestone: DSC = 0.39 only, with 11 species on the three sites which we did not find on the Pyinyaung limestone range.

We are confident that strong gradients exist in the fauna composition of the limestone hills in the region. Each limestone area has a fauna different from that of surrounding limestone areas. As a consequence, the rates of endemism will be high...

…even though we have no knowledge of the fauna composition on the Southwards continuation of the Pyinyaung limestone range, or on the extensive limestone areas to the East (see **fig. 1**),

The Pyinyaung limestone range, too, has a fauna different from that of surrounding ranges, which includes a number of unique elements (local-endemic species).

8.5.2 – A North-South gradient in the fauna composition of the Pyinyaung limestone range

We compare the cumulative fauna of the sampling sites:

- in the concession (sampling sites 4+5+6+7),
- to the North of the concession (sampling sites 8+9+10+11),
- to the South of the concession (sampling sites 12 +13+14+16+17).

Differences in set size probably reflect true differences in species richness except for the southernmost end of the range, where sampling sites 12 and 13 are probably not representative for the local fauna because of the heavily degraded environment. We had no opportunity to find alternative sampling sites. Sampling site 16 yielded only a single shell, but this is compensated by the representative sampling of sites 14 and 17, nearby.

The sites are compared in pairs, which yields a DSC ranging from 0.73 to 0.77.

[3] Dice Similarity Coefficient = Dsc = $2|x \cap y|/|x|+|y|$, in which x and y are the number of species found in two localities. Values between 0 and 1; high values denote similarity.

A North-South gradient is present in the composition, with the DSC ranging from 0.73 to 0.77 between the compared pairs (see **fig. 6**): the fauna of the South end of the range is significantly different from the fauna of the North end of the range.

This means that the cumulative effect of all economic activity along the Pyinyaung limestone range may lead to biodiversity loss, even if the part of the limestone range to the North of the concession is protected by the APACHE offsetting program.

Again, this statement may gain weight once the southernmost part of the range is more thoroughly checked for local-endemic species.

8.5.3 – Fauna composition versus altitude in the North part of the Pyinyaung limestone range, including the concession.

We compare the cumulative fauna of the following sampling sites in the concession as well as to the North of the concession:

- Sampling sites below 400 m alt., on sheltered, North-facing slopes overgrown with partly evergreen woodland, bordering the gorges cutting through the limestone range near Kubyin and N of Kubyin (sampling sites 9+11).
- Sampling sites above 400 m alt., on sun-exposed or slightly sheltered West- or N-facing slopes overgrown with largely deciduous woodland with often a marked dominance of bamboo thickets on the flanks and the top area of the limestone range (sampling sites 4+5+6+7+8+10)…

The DSC=0.75, see **fig. 6**, shows that the faunas are different. This difference is proportionally reflected in the distribution of the local-endemic species: 7 out of 10 occur in both, whereas 2 (*Dioryx pingoungensis* and *Sinoennea* sp.) prefer the lowlands and 1 (*Anauchen* sp.) is restricted to high grounds.

Unfortunately our attempts to sample the high grounds of the limestone range well to the North of the concession succeeded only partly (sampling site 10, incomplete collecting), without opportunity to try a second time. The path up to sampling site 10, however, leads through woodland very similar to the woodland in and around the concession, but in general somewhat less disturbed, at least without any traces of logging in progress. Besides, the woodland supports a reasonably diverse orchid flora of 12 different species.

We provisionally conclude that the higher parts of the limestone range North of the concession are suitable for offsetting purposes, in the sense that they probably harbor a fauna similar to that of the concession, or richer in species. The two North-facing slopes bordering the gorges cutting through the range, with a different fauna, add to the biodiversity diversity and are a bonus.

10 – References

Google Earth Pro. Accessed in 2014-2016.

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Figures

Fig. 1 – Karst in the western Shan plateau

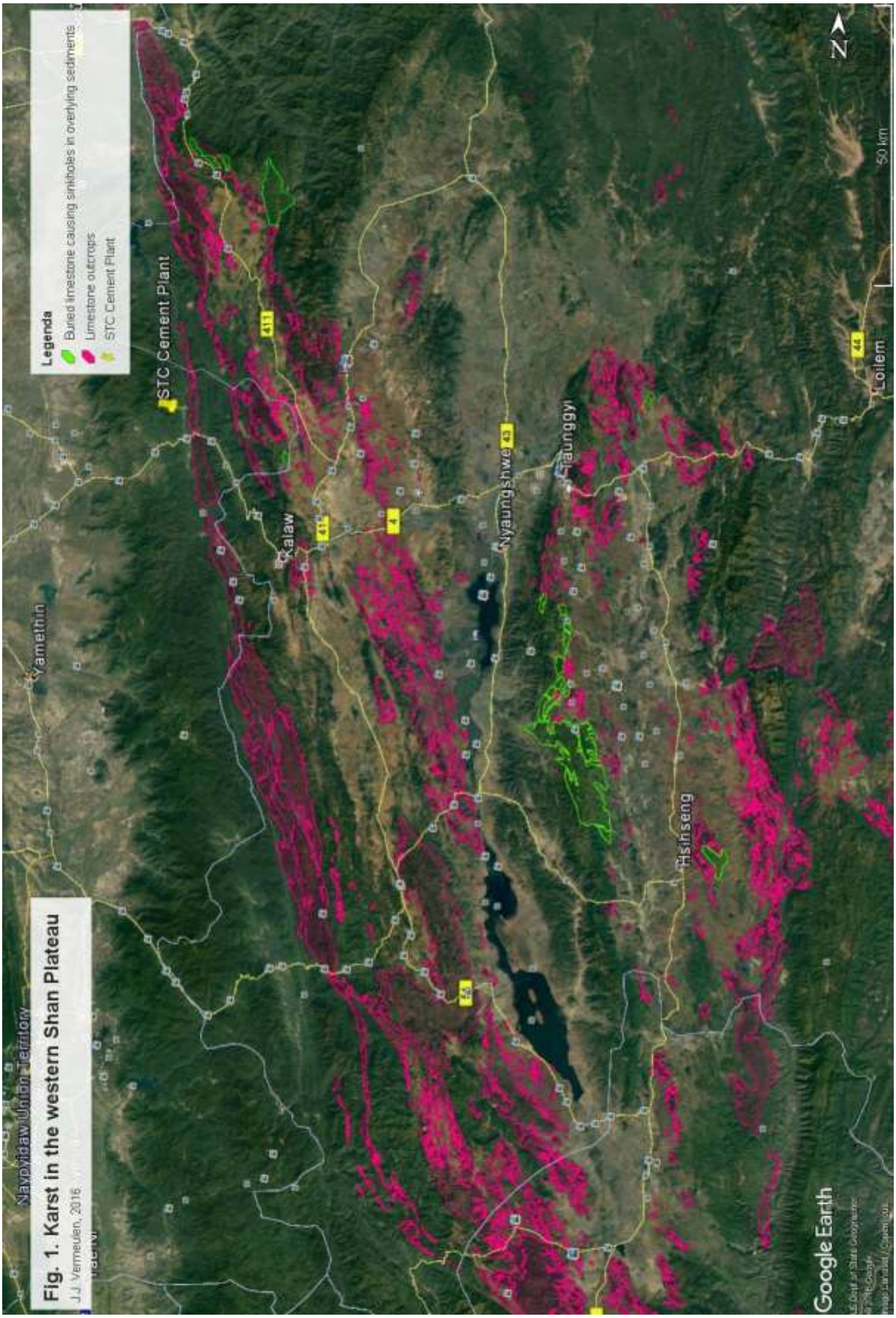


Fig. 2a – Sampling sites – Pyinyaung and further North

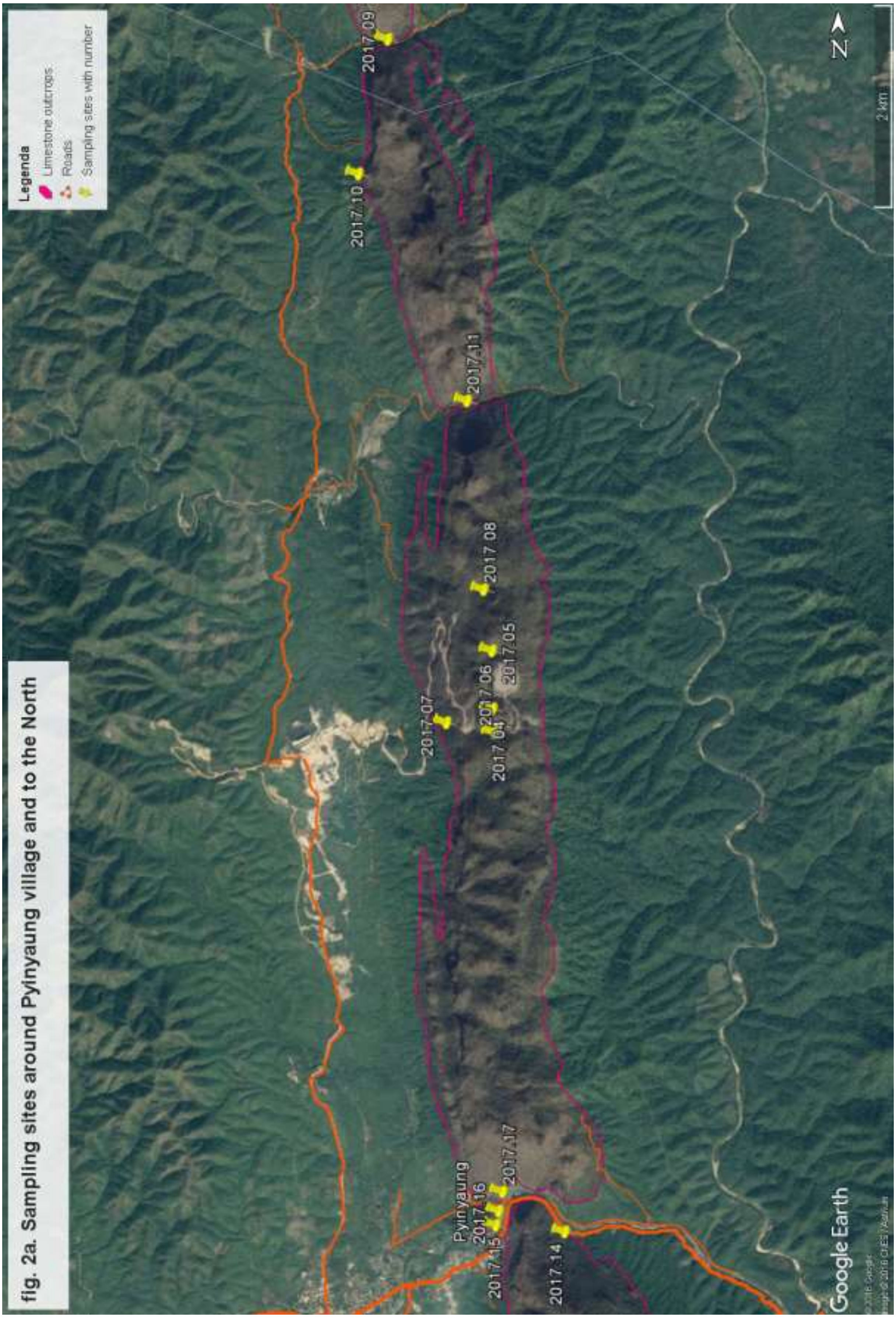


Fig. 2b – Sampling sites – South of Pyinyaung

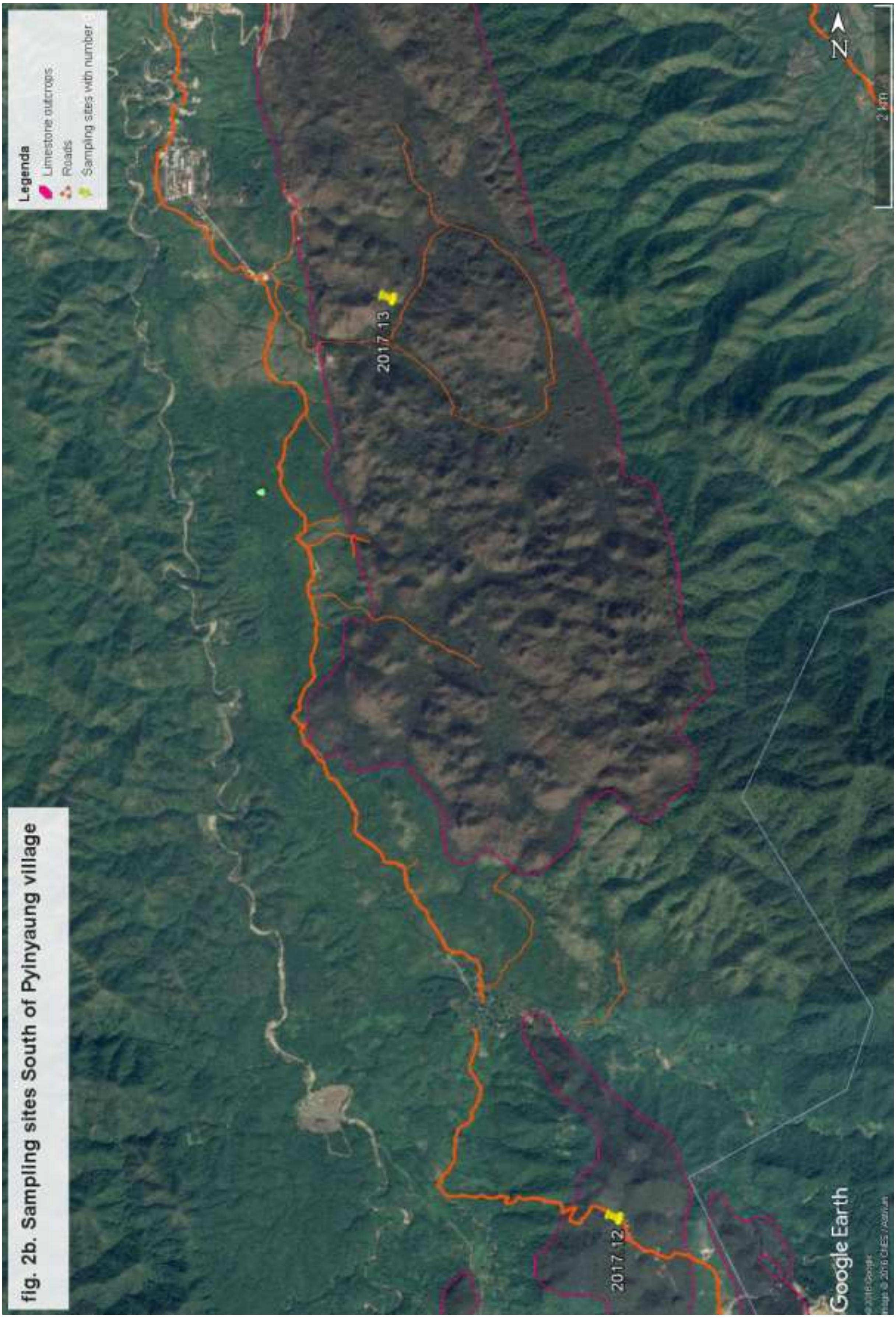


Fig. 2c – Sampling sites – East of Kalaw

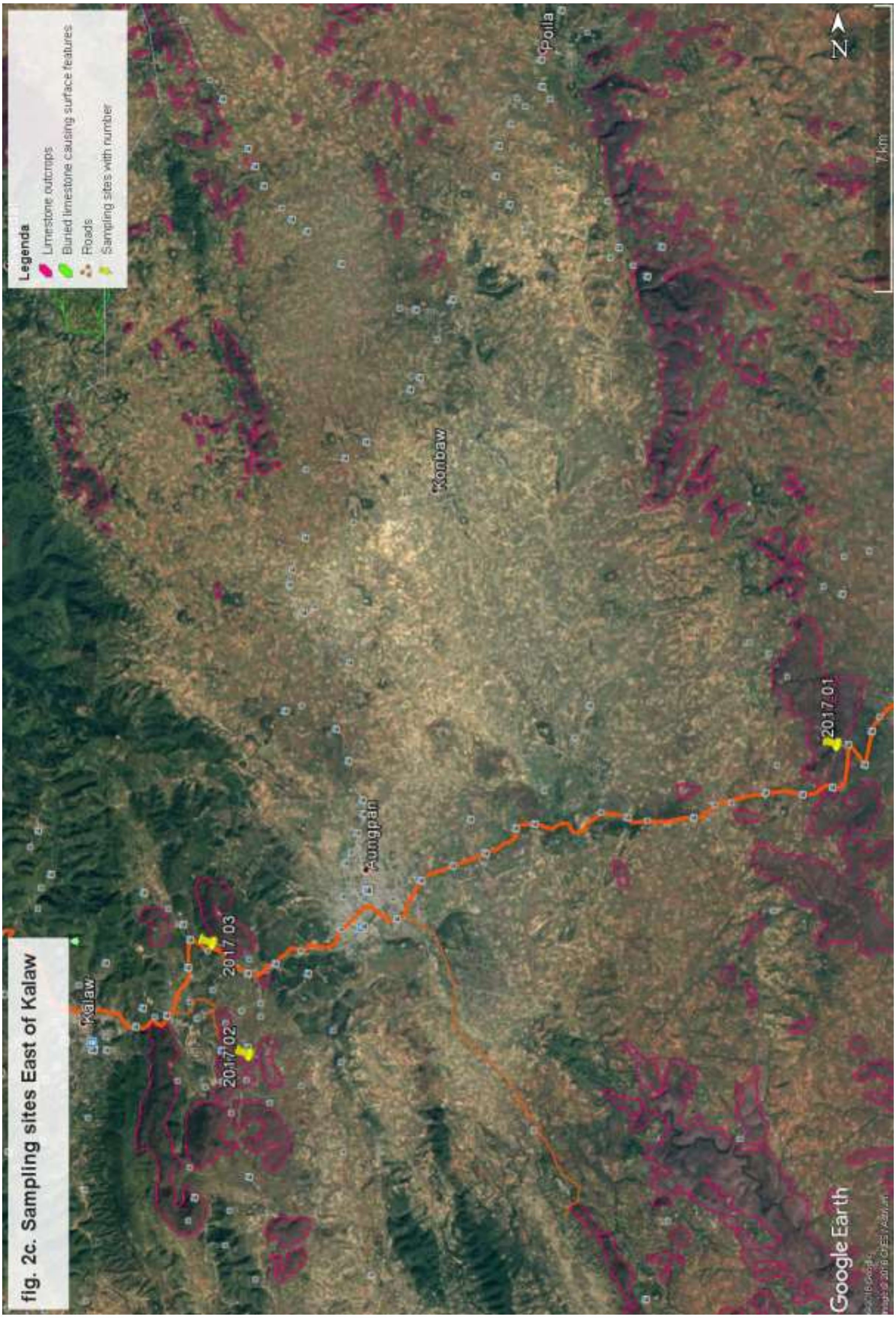


Fig. 3a – Division of the limestone range in sectors

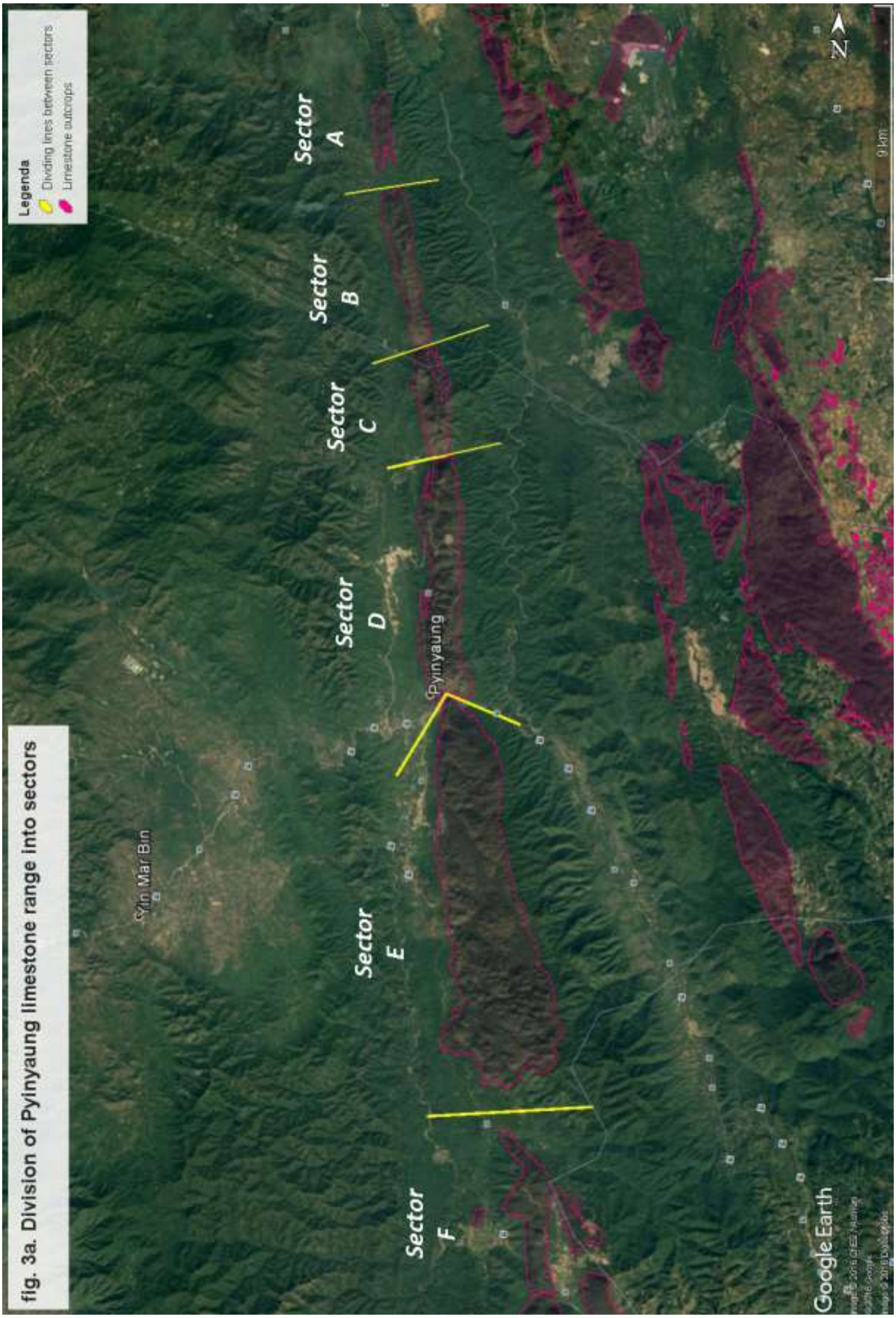
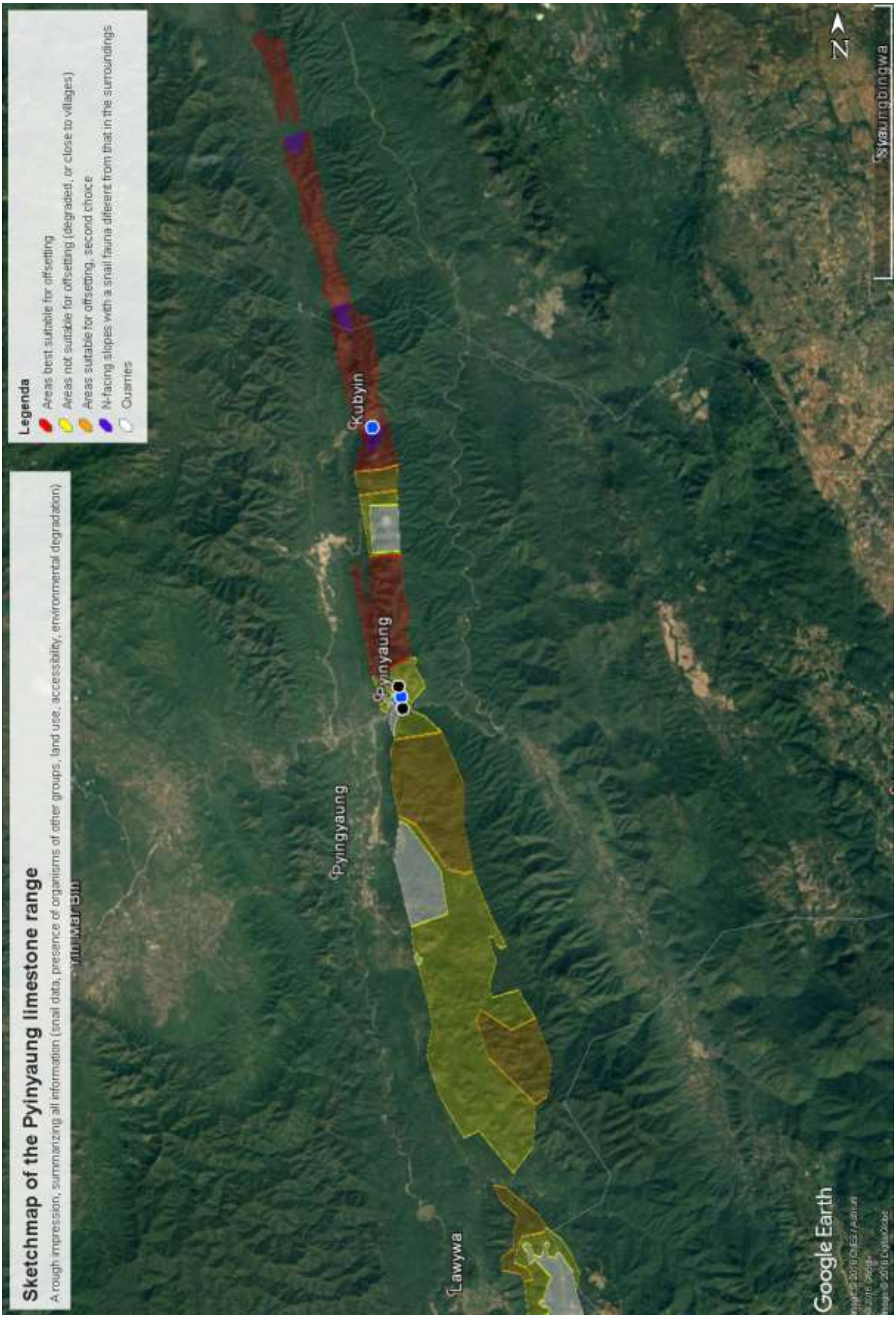


Fig. 3b – Sketchmap summarizing information



Blue dots: karst wells - Black dots: caves or remnants of caves

Fig. 4 – List of the snail species recorded

FAMILY	SPECIES	AUTHOR, YEAR	INFORMAL IDENTIFYERS	RSC	9	10	11	8	4	5	6	7	16	17	14	12	13	1	2	3
RSC = Range Size Category: 1=site-endemic; 2=local-endemic; 3=regional-endemic; 4=widespread; 5=introduced Localities 4 to 17 arranged from North to South					N of concession				Concession				S of concession					Heho to Kalaw		
Assimineidae	***Acmella hyalina***	(Theob. & Stol., 1872)		3	1									1						
Cyclophoridae	***Alycaeus pyramidalis***	Benson, 1856	RSC based on assumed synonymy with *A. jagori*	4	1	1	1	1	1	1	1	1		1			1			
	Alycaeus (?) ***rubinus***	Godwin Austen, 1893	Shells smaller than in lit., >5 mm high	4		1			1	1		1		1						
	Cyclophorus aurantiacus	(Schumacher, 1817)		4											1					
	Cyclophorus crassilabella	Godwin Austen, 1888		3	1	1		1	1	1	1	1	1				1	1		
	Cyclophorus malayanus	(Benson, 1852)		4	1	1	1	1	1	1	1									
	Cycloryx graphicus	(Blanford, 1862)		4											1		1			
	Dicharax armillatus	(Benson, 1856)		3	1	1	1	1	1	1	1	1		1			1		1	
	Dicharax ataranensis	(Godwin Austen, 1914)		3	1			1									1			
	Dicharax sp.			2			1	1												
	Dioryx pingoungensis	(Godwin Austen, 1914)		2			1								1					
	Japonia leporina	(Blanford, 1865)		3	1		1	1	1	1	1				1	1	1			
	Japonia tomotrema	(Benson, 1857)		4	1															
	Pterocyclos insignis	Theobald, 1865		3	1		1	1	1	1		1		1						
	Scabrina (?) ***calyx***	(Benson, 1857)	Larger than in lit.: d=>15 mm	3											1			1	1	
Diplommatinidae	***Diplommatina insignis***	(Godwin Austen, 1870	Sinistral, r.ribs close	4						1	1			1				1	1	1
	Diplommatina scalaroidea	Theobald, 1870	Sinistral, r.ribs distant	3	1	1	1	1	1	1	1	1								
	Diplommatina (?) ***nana***	Blanford, 1865	Less ventricose than in lit.	4	1		1			1		1			1		1			
	Diplommatina labiosa	Blanford 1868	Dextral, medium, 2 palatales	4	1		1													
	Diplommatina crispata new subsp.	Stoliczka, 1871	Spire higher than in type	2			1	1			1	1		1	1	1				
Helicinidae	***Aphanoconia gratulata***	(Sowerby 1866)		3	1		1													
Hydrocenidae	***Georissa pyxis***	(Benson, 1856)		3	1		1	1	1	1	1			1			1			
Pupinidae	***Pseudopomatias peguensis***	(Theobald, 1864)		3	1															
	Pupina artata	Benson, 1856		4	1		1		1	1		1			1	1				
Achatinidae	***Achatina fulica***	(Bowdich, 1822)	(NOT VOUCHERED)	5			1													
Ariophantidae	***Austenia*** (?) ***nagaensis***	(Godwin Austen, 1880)		4												1				
	Durgella (?) ***assamica***	Godwin Austen 1881		?	1		1		1	1				1	1	1	1			
	Durgella levicula	(Benson, 1859)	(Panha fig. 4.2)	4	1	1	1	1	1	1	1	1		1	1					
	Euplecta langkaensis	Preston, 1909		3	1	1	1	1	1	1	1	1		1	1	1	1	1		1
	Girasia (?) ***dikrangensis***	(Godwin Austen, 1888)		4			1				1						1			
	Khasiella pingoungensis	(Godwin Austen, 1888)		2	1	1	1	1	1	1	1	1			1	1	1			
	Macrochlamys (?) ***causia***	(Benson, 1859)		3	1															
	Macrochlamys chaos	Blanford, 1904		3	1															1
	Macrochlamys consepta	(Benson, 1860)	Labiate	3	1	1	1	1						1	1		1	1		
	Macrochlamys hypoleuca	(Blanford, 1865)		4			1		1		1	1			1		1			
	Macrochlamys molecula	(Benson, 1859)		4			1				1					1	1			1
	Macrochlamys (?) ***perpaula***	(Benson, 1859)		4				1	1	1	1				1	1	1	1	1	1
	Macrochlamys salwinensis	Godwin Austen 1907		3				1		1		1		1						
	Macrochlamys spreta	Blanford, 1904		3	1	1	1	1	1	1	1	1		1	1	1		1		
	(?) ***Macrochlamys*** sp.		Subglobose, reticulate sc.	3	1		1	1	1	1	1	1		1			1			1
	Megaustenia sp.			?	1	1	1	1	1	1	1	1		1	1	1	1			
	(?) ***Microcystina*** sp. 1		Minute, white	?						1		1								
	(?) ***Microcystina*** sp. 2		Minute, corneous, possibly *M sinica*	?				1												
Bradybaenidae	***Bradybaena pilidion***	(Benson, 1860)		3										1		1				
	Bradybaena scalpturita	(Benson, 1857)		3		1												1		
	Bradybaena schanorum	(Moellendorff 1899)		2	1	1	1	1	1	1		1		1		1	1			
	Bradybaena zoroaster	(Theobald, 1859)		3	1		1	1	1	1	1									
	Cathaica new sp.		flat, wide umb.	2															1	
	Plectotropis (?) ***diplogramme***	(Von Moellendorff, 19(	Smaller than in lit.	?														1		
	Plectotropis emensa	(Godwin Austen, 1888)		3								1		1	1					1
	Plectotropis tapeina	(Benson, 1836)		4	1	1	1	1	1	1	1	1		1	1		1		1	
	Plectotropis new sp.		Like *P. Perplanata* , but flatter	2	1	1														
Camaenidae	***Chloritis anserina***	(Theobald, 1866)		2	1	1	1	1	1	1	1	1					1			
	Ganesella capitium	(Benson, 1848)		4											1	1				
Clausiliidae	***Phaedusa arakana***	(Stoliczka, 1872)		3															1	
	Phaedusa burmanica	(Gude, 1909)		3			1	1	1	1	1	1		1			1			
	Pseudonenia nicobarica	(Gude, 1909)	larger than type (30 vs 24 mm)	3	1															
	Pseudonenia shanica	(Godwin Austen, 1888)		2	1	1	1			1		1		1						
Endodontidae	***Philalanka*** sp.			3	1		1	1	1	1	1	1		1		1	1	1		1
Enidae	***Ena vicaria***	(Blanford, 1870)		4															1	1
Euconulidae	***Kaliella barrakporensis***	(Pfeiffer, 1852)		4			1							1				1	1	1
	Kaliella calculosa	(Gould 1852)		4	1															
	Kaliella microconus	(Mousson, 1865)		4																1
Ferussaciidae	***Caecilioides balanus***	(Reeve, 1850)	RSC based on assumed synonymy with *C. caledonica*	4										1						
Plectopylinidae	***Chersaecia kengtungensis***	(Gude, 1914)		3	1	1	1		1	1				1	1	1	1		1	
	Plectopylis (?) new sp.		As *P. Leucochila* , but long.parietals approaching	3		1	1	1			1	1								
Punctidae	***Paralaoma halyi***	(Jousseaume, 1894)		4															1	
Pyramidulidae	***Pyramidula rupestris***	(Draparnaud, 1801)		4															1	1

Family	Species	Author, year	Information	RSC	9	10	11	8	4	5	6	7	16	17	14	12	13	1	2	3
Streptaxidae	***Haploptychius burmanicus***	(Blanford, 1864)		3				1			1									
	Sinoennea new sp.		aff. *S. Woodthorpei* , but 1	2	1															
Subulinidae	***Curvella pusilla***	(Benson, 1865)		3				1									1			
	Curvella sp.		As *C. pusilla* , but more slender	?	1															
	Glessula crassilabris	(Benson, 1836)		4			1			1	1						1			
	Glessula gemma	(Reeve, 1850)		4	1		1	1	1	1	1	1		1	1	1	1	1		
	Opeas innocens	Preston, 1910	Very small & slender	3	1		1	1	1	1	1			1	1	1	1		1	1
	Paropeas clavulinus	(Pot. & Mich., 1822)		4	1		1	1	1	1	1	1		1			1			
	Paropeas gracilis	(Hutton, 1834)		4	1		1													
	Prosopeas walkeri	(Benson, 1863)		3														1		
Trochomorphidae	***Videna castra***	(Benson, 1852)		4											1	1	1			
	Videna percompressa	(Blanford, 1869)		3	1	1	1	1	1	1	1	1					1			
Vertiginidae	***Acinolaemus*** **new sp.**			3	1		1	1	1	1	1	1		1				1	1	1
	Anauchen new sp.			2					1	1										
	Gastrocopta avanica	(Benson, 1863)		4				1		1									1	1
	Gyliotrachela bensoniana	(Blanford, 1863)		3		1	1	1						1						
	Nesopupa malayana	(Issel, 1874)		4	1									1						
	Paraboysidia salwiniana	(Theobald, 1871)		3	1	1	1		1	1	1									
	Paraboysidia sp. 1, new sp.		3 mm high	2															1	1
	Paraboysidia sp. 2		2,5 mm high	2															1	
	Ptychopatula evezardi	(Blanford, 1875)		4				1		1								1		1
	Ptychopatula orcula	(Benson, 1850)		4														1	1	1
	Pupisoma lignicola	(Stoliczka, 1873)		3		1	1	1		1	1	1		1		1				
		Total # species per locality			46	24	46	39	33	41	34	31	1	33	24	20	31	16	18	18
		Among these, # potential local-endemic species			6	5	7	5	4	5	3	5	0	3	3	3	3	0	3	1
		Fraction locally endemic species			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Locality number			9	10	11	8	4	5	6	7	16	17	14	12	13	1	2	3

Fig. 5 – Local endemic species of the Pyinyaung limestone range, and their distribution

SPECIES	AUTHOR, YEAR	INFORMATION ON RSC-STATUS	RSC	9	10	11	8	4	5	6	7	16	17	14	12	13
Local-endemic species (RSC=2) of the Pyinyaung limestone range only Localities 4 to 17 arranged from North to South				N of concession				Concession				S of concession				
Dicharax sp.		No known records in collections	2			1	1									
Dioryx pingoungensis	(Godwin Austen, 1914	Recorded in literature from Pyinyaung only	2			1								1		
Diplommatina crispata **new subsp.**	Stoliczka, 1871	A local form of a widespread complex species	2			1	1			1	1		1	1	1	
Khasiella pingoungensis	(Godwin Austen, 1888	Recorded in literature from Pyinyaung only. May prove to be more widespread	2	1	1	1	1	1	1	1	1			1	1	1
Bradybaena schanorum	(Moellendorff 1899)	Recorded in literature from Kalaw only	2	1	1	1	1	1	1		1		1		1	1
Plectotropis **new sp.**		No known records in collections	2	1	1											
Chloritis anserina	(Theobald, 1866)	Recorded in literature from `Shan States` only, without precise locality data	2	1	1	1	1	1	1	1	1					1
Pseudonenia shanica	(Godwin Austen, 1888	Recorded in literature from Pyinyaung only	2	1	1	1			1		1		1			
Sinoennea **new sp.**		No known records in collections	2	1												
Anauchen **new sp.**		No known records in collections	2					1	1							
# local-endemic species per locality				6	5	7	5	4	5	3	5	0	3	3	3	3

Fig 6 – Similarities between sampling sites

# species shared	N of concession	concession	S of concession	Pyinyaung Ist range	E of Kalaw	low alt. (see text)	high alt. (see text)
N of concession	**67**	44	44				
concession		**48**	38				
S of concession			**54**				
Pyinyaung Ist range				**79**	22		
E of Kalaw					**33**		
low alt. (see text)						**58**	43
high alt. (see text)							**56**

Dice Similarity Coefficient	N of concession	concession	S of concession	Pyinyaung Ist range	E of Kalaw	low alt. (see text)	high alt. (see text)
N of concession		0,77	0,73				
concession			0,75				
S of concession							
Pyinyaung Ist range					0,39		
E of Kalaw							
low alt. (see text)							0,75
high alt. (see text)							

FLORA REPORT of APACHE CEMENT FACTORY, PYI-NYAUNG

February, 2017

Introduction

Flora survey group conducted the survey start from 31st January to 7th February 2017 in the area of limestone; mudstone sites, factory area, and residential areas of the factory.

During the survey we made (136) plots on (5) transects wherever possible to get assessments.

We could record 250 species as inventory of the area, among them 22 IUCN listed species and 10 invasive species. According to the included plant`s association, it could be categorized as deciduous and mixed evergreen forests, mixed broad-leaved deciduous forest and bamboo

Deciduous Forest

Mixed Evergreen Forest

Mixed Broad-leaved Deciduous Forest


Bamboo Forest


Dry Deciduous Forest

Objectives

- Identify main vegetation types including IUCN listed Species
- Invasive alien species
- Vegetative Maps and subsequently ground truth the above

Participants

Team Leader: Dr Win Myint, Ecologist

Taxonomist: U Nyo Maung,

Taxonomist: Dr Ei Ei Phyoe,

GIS/RS and Biotanist: U Tun Thura

Taxonomist assistant: U Thein Phyoe Aung

Survey Method

The Global Positioning System was used to navigate and mark the coordinates of the sample plots to know the species population for vegetation identification. In order to obtain essential data for species composition in the area and sample plots of 100 mx 100m, along line were set up. The species identification was carried out by using key to families of plants and relevant literature and was confirmed by literatures.

Random Transect Method

Sampling individual sites were built to get representative individual plant species, and plants collection was carried out.

Mapping

Location maps are set by the method based on the landsat 8 settilte image (LC 81330462017037LGN00), WGS 1984, coordinate system to determine the forests of the areas. Vegetion index is categorized by NDVI (Normalize Different Vgetative Index) as low medium and height indexes.

Data Analysis

After field survey, data entry is made in excel work sheet. Identify the collected data matching with the type specimens, checking their recorded characteristic features and confirm by plant taxonomic websites of internet, after getting the inventory check list, match by the IUCN Red Data book categories, invasive species list and decides the vegetation types of the area according to the dominant plants species from representative areas. Eventually the results of forest types are developed on the maps depend on their coordinations.

IUCN Red List of Threatened Species

Recorded species are evaluated for their threats status according to the IUCN Red Data book categories. The Red Data book categories provide an easily and widely understood method for highlighting those species under higher extinction risk, so as to focus attention on conservation measures designed to protect them. The distribution of the Red Data categorized species is mentioned by their GPS positions.

Invasive Species

Collected species are evaluated by the list of forest invasive species of Myanmar.

Equipments

Equipments used for plotting and locating transects are compass and measuring tapes and other necessary equipment's are digital camera for photographic documentation, laptop computer for data storage, GPS for positioning and navigation, maps. For specimen collection, the following accessories will be needed, 10x hand lens for magnifying, permanent marker for marking, field note books for data entry.

I. Lime Stone Area

Table.1. Species List of Lime Stone Area

No.	Scientific Name	Common Name	Family Name	Habits
1	*Abelmoschus moschatus*	Taw-yon-pa-de	Malvaceae	S
2	*Acacia catechu* Willd.	Sha	Mimosaceae	T
3	*Acacia pennata* (L.) Willd.	Su-yit	Mimosaceae	Cl/Cr
4	*Achyranthes* aspera L.	Kyet-mauk-su-pyan	Amaranthaceae	H
5	*Acmella calva* (DC.) R.K. Jansen	Pe-le-nyin	Asteraceae	H
6	*Adenostemma viscosum*	Not known	Asteraceae	H
7	*Adina cordifolia* Hook. f.	Hnaw	Rubiaceae	T
8	*Aeginetia pedunculata* Wall.	Kauk-hlaing-di-yaing	Orobanchaceae	H
9	*Aegle marmelos* L.	Ok-shit	Rutaceae	T
10	*Ageratum conyzoides* L.	Khwe-thay-pan	Asteraceae	H
11	*Ajuga lupulina*	Not known	Lamiaceae	H
12	*Alangium chinense* (Lour.)Harms.	Hmaik	Alangiaceae	T
13	*Albizia lebbek* (L.)Benth.	Taung-ko-kko	Mimosaceae	T
14	*Albizia lebbekoides* (DC.) Benth.	Taung-ma-gyi	Mimosaceae	T
15	*Alternanthera sessilis* (L.) R.Br.	Pa-zun-sa-yaing	Amaranthaceae	H
16	*Amaranthus aspera*	Not known	Amaranthaceae	H
17	*Amaranthus gracilis* Desf.	Hin-nu-nwe-yaing	Amaranthaceae	H
18	*Anisomeles indica*	Not known	Lamiaceae	H
19	*Anogeissus acuminata* Wall.	Yon	Combretaceae	T
20	*Anthocephalus morindaefolius* Korth.	Ma-u-let-tan-shae	Rubiaceae	T
21	*Antidesma velutinum*Tul.	Kin-pa-lin	Euphorbiaceae	ST
22	*Aporusa dioica* (Roxb.) Mull.Arg.	Thit-khauk	Euphorbiaceae	T
23	*Argyreia nervosa*	Not known	Convolvulaceae	Cl/Cr
24	*Argyreia roxburghii* Choisy	Not known	Convolvulaceae	Cl/Cr
25	*Armillaria mellea* (VahlFr.) Kummer.	Not known	Physalacriaceae	M
26	*Bambusa bambos* (L.)Voss	Kya-khat-wa	Poaceae	B
27	*Bambusa polymorpha* Munro	Kya-thaung-wa	Poaceae	B
28	*Bauhinia malabarica* Roxb.	Pha-lan/Chin-byit	Caesalpiniaceae	T
29	*Bauhinia ornata* Kurz	Myauk-hle-kha	Caesalpiniaceae	Cl/Cr
30	*Bauhinia* sp.	Swe-daw-nwee	Caesalpiniaceae	Cl/Cr
31	*Bidens pilosa*	Hmwe-sok	Asteraceae	H
32	*Blechnum orientale*	Not known	Blechnaceae	F
33	*Bliospermum axillare* Blume	Hnat-cho	Euphorbiaceae	H
34	*Blume balsamifera* DC..	Phon-ma-thein	Asteraceae	S
35	*Blumea balsamifera*	Not known	Asteraceae	H
36	*Boehmeria* sp.	Not known	Urticaceae	S
37	*Bombax anceps* Pierre	Ko-khe	Bombacaceae	T
38	*Bombax ceiba* L.	Let-pan	Bombacaceae	T

No.	Scientific Name	Common Name	Family Name	Habits
39	*Bombax insigne* Wall.	De-du	Bombacaceae	T
40	*Bridelia retusa* L.	Seik-chee	Euphorbiaceae	ST
41	*Buchanania lazan* Spreng.	Lun-pho	Anacardiaceae	T
42	*Buddleja asiatica*	Pon-ma-gyi	Buddlejaceae	S
43	*Butea superba* Roxb.	Pauk-nwee	Fabaceae	Cl/Cr
44	*Caesalpinia decapetala (Roth.)Alston*	Suk-yan-bo /Kyant-sa-su-pin	Caesalpiniaceae	Cl/Cr
45	*Cajanus cajan*	Pe-sin-ngone	Fabaceae	S
46	*Callicarpa arborea* Roxb.	Kyun-na-lin	Verbenaceae	ST
47	*Callicarpa longifolia*	Kun-na-lin-thay	Verbenaceae	ST
48	*Callicarpa nudiflora*	Kyun-na-lin	Verbenaceae	T
49	*Calotropis gigantea*	Ma-yoe	Apocynaceae	S
50	*Calycopteris floribunda* Lam.	Gyut-nwe	Combretaceae	Cl/Cr
51	*Canscora diffusa* (Vahl) R.Br.	Kyauk-pan	Gentianaceae	H
52	*Careya arborea* Roxb.	Ban-bwe	Lecythidaceae	T
53	*Cassia fistula* L.	Ngu	Caesalpiniaceae	T
54	*Cassia timoriensis* DC.	Not known	Caesalpiniaceae	ST
55	*Cayratia trifolia*	Not known	Vitaceae	CL
56	*Celosia argentea* L.	Taw-kyet-mauk	Amaranthaceae	S
57	*Centratherum punctatum*	Not known	Asteraceae	H
58	*Cephalostachyum pergracile* Munro	Tin-wa	Poaceae	B
59	*Chloris barbata*	Not known	Poaceae	G
60	*Chromolaena odorata* (L.) R.M. King & H Robinson	Bi-zet	Asteraceae	S
61	*Chukrasia velutina* Roem.	Yin-ma	Meliaceae	T
62	*Cissampelos pareira* L.	Not known	Menispermaceae	Cl/Cr
63	*Clematic fasiculiflora* L.	Khwa-nyo	Ranunculaceae	CL
64	*Congea tomentosa* Roxb.	Tha-ma-ga-nwee	Verbenaceae	Cl/Cr
65	*Corchorus aestuans* L.	Byauk-o	Tiliaceae	S
66	*Corchorus capsularis* L.	Gon-shaw/Khwe-la-but	Tiliaceae	S
67	*Crassocephalum crepidioides* (Benth.) S. Moor.	Pan-zauk-htoe	Asteraceae	H
68	*Cratoxylum neriifolium* Kurz.	Be-bya	Hypericaceae	ST
69	*Cratoxylum polyanthum*Korth.	Be-bya	Hypericaceae	ST
70	*Crotalaria mucronata* L.	Taw-paik-san	Fabaceae	S
71	*Crotalaria multiflora* L.	Not known	Fabaceae	H
72	*Croton oblongifolius* Roxb.	Tha-yin-gyi	Euphorbiaceae	ST
73	*Crypteronia pubescens* Blume	A-nan-pho	Crypteroniaceae	T
74	*Cryptolepis buchanani* Rome.& Schult	Na-sha-gyi	Asclepiadaceae	Cl/Cr
75	*Curcuma aurantiaca*	Ma-la	Zingiberaceae	H
76	*Cymbidium aloifolium* (L.)Sw.	Thit-tet-lin-nae	Orchidaceae	E
77	*Dactyloctenium aegyptium*	Lay-gwa-myet	Poaceae	G
78	*Dalbergia cultrata* Grah.	Yin-daik	Fabaceae	T
79	*Dalbergia oliveri* Gamble	Ta-ma-lan	Fabaceae	T

No.	Scientific Name	Common Name	Family Name	Habits
80	*Dalbergia rimosa* Roxb.	Daung-ta-laung	Fabaceae	ST
81	*Dalbergia volubilis* Roxb.	Daung-ta-laung	Fabaceae	ST
82	*Dendrocalamus longispathus* (Kurz) Kurz	Wa-net	Poaceae	B
83	*Dendrocalamus membranaceus* Munro	Hmyin-wa	Poaceae	B
84	*Derris* sp.	Not known	Fabaceae	Cl/Cr
85	*Desmodium heterophyllum* (Willd.)DC.	Not known	Fabaceae	S
86	*Desmodium pulchellum* Benth.	Taung-da-min	Fabaceae	S
87	*Dillenia parviflora* Griff	Kyet-zin-byun	Dilleniaceae	T
88	*Dillenia pentagyna* Roxb.	Zin-byun	Dilleniaceae	T
89	*Dinochloa maclellandii* Kurz	Ba-du-ma-wa/Wa-nwee	Poaceae	B
90	*Dioscorea bulbifera*	Myauk-u	Dioscoreaceae	Cl/Cr
91	*Dioscorea cylindrica* Burm.	Kywe-thon-ywet	Dioscoreaceae	Cl/Cr
92	*Dioscorea pentaphylla* L.	Kywe-ngar-ywet	Dioscoreaceae	Cl/Cr
93	*Dioscorea sativa* L.	Kauk-yin-nwee	Dioscoreaceae	Cl/Cr
94	*Diospyros kika* L.f.	Te	Ebenaceae	T
95	*Dipterocarpus tuberculatus* Roxb.	In	Dipterocarpaceae	T
96	*Duabanga grandiflora*	Myauk-ngo	Lythraceae	T
97	*Ehretia acuminata* R.Br	Taung-poe-lu-lin	Boraginaceae	T
98	*Elephantopus scaber* L.	Not known	Asteraceae	H
99	*Entada scandens* Benth.	Doe-nwee	Mimosaceae	Cl/Cr
100	*Erythrina stricta* Roxb.	Ka-thit	Fabaceae	T
101	*Euphorbia antiquorum* L.	Tazaung-gyi	Euphorbiaceae	ST
102	*Euphorbia hypericifolia* L.	Kywe-kyaung-hmin-se	Euphorbiaceae	H
103	*Evolvulus nummularius* L.	Kyauk-kwe	Convolvulaceae	Cl/Cr
104	*Ficus hispida* L.	Kha-aung	Moraceae	ST
105	*Ficus lacor* Buch.-Ham.	Nyaung-gyin	Moraceae	T
106	*Ficus microcarpa*	Not known	Moraceae	S
107	*Ficus obtusifolia* Roxb.	Nyaung-gyat	Moraceae	T
108	*Flacourtia cataphracta* Roxb.	Na-ywe	Flacourtiaceae	T
109	*Flemingia congesta* Roxb.	Kye-hmi	Fabaceae	S
110	*Gardenia coronaria* Buch.-Ham.	Yin-gat-gyi	Rubiaceae	T
111	*Getonia floribunda* Roxb.	Kywet-nwee	Combretaceae	Cl/Cr
112	*Glochidion* sp.	Hta-min-sok	Euphorbiaceae	ST
113	*Goniothalamus laoticus*	Not known	Annonaceae	ST
114	*Grewia laevigata* Vahl	Kyet-ta-yaw	Tiliaceae	ST
115	*Harrisonia perforata* Merr.	Su-gyin	Simaroubaceae	S
116	*Hemigraphis brunelloides* (Lam.) Bremek.	Not known	Acanthaceae	S
117	*Hibiscus macrophyllus*	Taung-phet-wun	Malvaceae	T
118	*Hiptage benghalensis* (L.) Kurz	Bein-new	Malpighiaceae	ST
119	*Holarrhena pubescens* Wall. ex G. Don	Let-htok-gyi	Apocynaceae	ST
120	*Homalium tomentosum* Benth	Myauk-chaw	Flacourtiaceae	T

No.	Scientific Name	Common Name	Family Name	Habits
121	*Homonoia riparia*	Ye-mo-ma-kha	Euphorbiaceae	S
122	*Ipomoea quamoclit* L.	Myet-lay-ni	Convolvulaceae	Cl/Cr
123	*Justicia procumbens*L.	Not known	Acanthaceae	S
124	*Justicia* sp.(1)	Not known	Acanthaceae	H
125	*Justicia* sp.(2)	Not known	Acanthaceae	S
126	*Kleinhovia hospita* L.	O-tein/Pashu-phet-wun	Sterculiaceae	T
127	*Lagerstroemia parviflora* Roxb.	Zaung-pa-lae	Lythraceae	T
128	*Lagerstroemia speciosa* (L.) Pers.	Pyin-ma	Lythraceae	T
129	*Lagerstroemia tomentosa* Presl.	Le-sa	Lythraceae	T
130	*Lannea coromandelica* (Houtt.) Merrr.	Na-be	Anacardiaceae	T
131	*Lathyrus latifolius*	Not known	Fabaceae	S
132	*Leea hirta* Banks	Naga-mauk-phyu	Leeaceae	S
133	*Leea rubra* Blume.	Naga-mauk-ni	Leeaceae	S
134	*Lepidagathis semiherbacea* (Clarke) Nees	Not known	Acanthaceae	H
135	*Leptadenia reticulata* Wight & Arn.	Gon-kha	Asclepiadaceae	Cl/Cr
136	*Leucaena leucocephala* (Lam.) De.Wit	Baw-za-gaing	Mimosaceae	ST
137	*Lindenbergia philippensis* Benth.	Not known	Scrophulariaceae	H
138	*Lindenbergia urticaefolia* Lehm.	Not known	Scrophulariaceae	H
139	*Loranthus pulverulentus* Wall.	Kyi-paung	Loranthaceae	E
140	*Ludwigia hyssopifolia*	Lay-nyin-thay	Onagraceae	H
141	*Ludwigia octovalvis*	Lay-nyin-gyi	Onagraceae	H
142	*Luffa aegyptiaca* Mill.	Tha-but-kha	Cucurbitaceae	Cl/Cr
143	*Mangifera sylvatica* Roxb.	Taung-tha-yet	Anacardiaceae	T
144	*Markhamia stipulata* (Wall.) Seem.ex K.Schum.	Ma-hlwa	Bignoniaceae	ST
145	*Melanorrhoea usitata* Wall.	Sit-se	Anacardiaceae	T
146	*Merremia hederacea* Hallier f.	Nwe-shoke	Convolvulaceae	Cl/Cr
147	*Merremia vitifolia* (Burm.f.) Hallier. f.	Kyet-hinga-lae-new	Convolvulaceae	Cl/Cr
148	*Microcos paniculata* L.	Mya-ya	Meliaceae	ST
149	*Millettia extensa* Benth.	Win-u	Fabaceae	Cl/Cr
150	*Millettia ovalifolia* Kurz	Thin-win	Fabaceae	T
151	*Mimosa pudica* L.	Hti-ka-yone	Mimosaceae	H
152	*Mitragyna rotundifolia* (Roxb.) Kuntze	Bin-ga	Rubiaceae	T
153	*Moghania macrophylla* Runtze	Not known	Fabaceae	S
154	*Morinda tinctoria* Roxb.	Ni-ba-sae	Rubiaceae	S
155	*Mucuna pruriens* (L.)DC.	Khwe-lae-ya	Fabaceae	Cl/Cr
156	*Musa* sp.	Taw-nga-pyaw	Musaceae	H
157	*Nauclea orientalis* L.	Ma-u	Rubiaceae	T
158	*Operculina turpethum* (L.) Silva Mansa	Kyar-hin-nwe	Convolvulaceae	Cl/Cr
159	*Oroxylum indicum* (L.) Kurz.	Kyaung-sha	Bignoniaceae	ST
160	*Oxalis corniculata* L.	Hmo-chin	Oxalidaceae	H
161	*Paederia foetida* L.	Pe-bok-nwee	Rubiaceae	CL

No.	Scientific Name	Common Name	Family Name	Habits
162	*Pennisetum purpureum* Schum.	Yon-sa-myet	Poaceae	G
163	*Phyllanthus albizzioides* (Kurz)Hook.f.	Shit-sha	Euphorbiaceae	T
164	*Phyllanthus emblica* L.	Zi-phyu	Euphorbiaceae	ST
165	*Polygonum chinense* L.	Maha-gar-kyan-sit	Polygonaceae	H
166	*Potamogeton natans* L.	Floating-leaf Pondweed	Potamogetonaceae	Aq
167	*Prema pyramidata* Wall.	Kyun-na-lin/Kyun-pho	Verbenaceae	T
168	*Pteris vittata*	Brake Fern	Pteridaceae	F
169	*Pterocarpus indicus*Willd.	Taw-pa-dauk	Fabaceae	T
170	*Pterospermum semisagittatum* Buch.-Ham.	Na-gye	Sterculiaceae	T
171	*Pueraria lobata* var. *montana*	Not known	Fabaceae	CL
172	*Salvia regla*	Not known	Lamiaceae	S
173	*Salvia* sp.	Not known	Lamiaceae	S
174	*Salvia splendens*Ker Gawl.	Not known	Lamiaceae	H
175	*Samadera indica* Gaertn.	Ka-di	Simaroubaceae	ST
176	*Schleichera oleosa* (Lour.) Oken	Gyo	Sapindaceae	T
177	*Scoparia dulcis* L.	Dana-thu-kha	Scrophulariaceae	H
178	*Senna hirsuta* (L.) Irwin & Barneby	Ka-thaw-hmwe-htu	Caesalpiniaceae	S
179	*Senna timoriensis* (DC.)(DC.) H. S. Irwin & Barneby	Taw-ma-zeli	Caesalpiniaceae	T
180	*Senna tora* (L.) Roxb	Dan-gwe	Caesalpiniaceae	S
181	*Sesbania paludosa* Roxb.	Nyan	Fabaceae	S
182	*Setaria lutescens* Hubb.	Yon-sa	Poaceae	G
183	*Shorea obtusa* Wall.	Thit-ya	Dipterocarpaceae	T
184	*Shorea siamensis* (Kurz) Miq.	In-gyin	Dipterocarpaceae	T
185	*Sida acuta* Burm f.	Ta-byet-si	Malvaceae	S
186	*Smilax aspericaulis* Wall ex A. D.C.	Sein-na-baw-thay	Smilaceae	CL
187	*Smilax macrophylla* Roxb.	Sein-na-baw-gyi	Smilaceae	CL
188	*Spermacoce mauritiana*	Not known	Rubiaceae	H
189	*Spondias pinnata* (L. f.) Kurz.	Taw-gwe	Anacardiaceae	T
190	*Sterculia foetida* L.	Let-khok	Sterculiaceae	T
191	*Sterculia ornata* Wall. ex Kurz	Don-shaw	Sterculiaceae	T
192	*Sterculia versicolor* Wall.	Shaw-phyu	Sterculiaceae	T
193	*Stereospermum colais* (Buch.-Ham. ex Dillwyn) Mabb.	Than-thay	Bignoniaceae	T
194	*Stereospermum suaveolens* (Roxb.) DC.	Kywe-ma-gyo-lein	Bignoniaceae	T
195	*Strobilanthes auriculata*	Not known	Acanthaceae	S
196	*Strobilanthes rufescens* T. Anders.	Not known	Acanthaceae	H
197	*Strychnos nux-blanda* A.W. Hill	Ka-baung	Loganiaceae	ST
198	*Tadehagi triquetrum* (L.)H. Ohashi	Lauk-thay	Fabaceae	S
199	*Tectona grandis* L. f.	Kyun	Verbenaceae	T
200	*Terminalia alata* (Heyne) Roth	Htauk-kyant	Combretaceae	T
201	*Terminalia pyrifolia* Kurz	Lein-pin	Combretaceae	T
202	*Tetrameles nudiflora* R. Br.	Baing	Datiscaceae	T

No.	Scientific Name	Common Name	Family Name	Habits
203	*Tetrastigma planicaule*	Not known	Vitaceae	Cl/Cr
204	*Thunbergia grandiflora* (Roxb. ex Rottl.) Roxb.	Kyi-hnok-thi	Acanthaceae	Cl/Cr
205	*Thunbergia laurifolia* Lindl.	Kyi-hnok-thi	Acanthaceae	Cl/Cr
206	*Thyrsostachys oliveri* Gamble	Tha-net-wa	Poaceae	B
207	*Tinospora nudiflora* Kurz	Sin-don-ma-nwee	Menispermaceae	Cl/Cr
208	*Trema orientalis* (L.) Blume	Khwe-sha	Ulmaceae	ST
209	*Trichosanthes cordata* Roxb.	Kyi-ah	Cucurbitaceae	CL
210	*Tristaniopsis burmanica* (Griff.)P.G. Wilson & J.T. Waterh.	Taung-tha-bye	Myrtaceae	T
211	*Triumfetta bartramia* L.	Ket-si-ne-thay	Tiliaceae	S
212	*Urena lobata* L.	Ket-si-ne-gyi	Malvaceae	S
213	*Utricularia* sp.	Bladderwort	Lentibularaceae	Aq
214	*Uvaria cordata* Schum. & Thonn.	Tha-but-gyi	Annonaceae	ST
215	*Vangueria spinosa* Roxb.	Magyi-bauk	Rubiaceae	S
216	*Ventilago maderaspatana* Benth.	Ta-yaw-nyo	Rhamnaceae	Cl/Cr
217	*Vernonia arborea*	Not known	Asteraceae	S
218	*Vitex peduncularis* Wall.	Phet-le-zin	Verbenaceae	T
219	*Vitex pubescens* Vahl	Kyet-yoe	Verbenaceae	T
220	*Vitis discolour*	Ta-bin-taing-mya-nan-phyu	Vitaceae	Cl/Cr
221	*Vitis repens*	Ta-bin-taing-mya-nan-ni	Vitaceae	Cl/Cr
222	*Wrightia arborea* (Dennst.) Mabb.	Let-htok-thein	Apocynaceae	ST
223	*Xylia xylocarpa* (Roxb.)Taub.	Pyin-ka-doe	Mimosaceae	T
224	*Zanthoxylum budrunga* Wall.	Ma-yanin-kyet-su	Rutaceae	T
225	*Ziziphus glabra* Roxb.	Taw-zi-nwee/Paung-bet	Rhamnaceae	Cl/Cr
226	*Ziziphus jujuba* Lam.	Zi	Rhamnaceae	ST
Aq=Aquatic, B=Bamboo, CL=Climber, Cl/Cr=Climber/Creeper, E=Epiphyte, F=Fern, G=Grass, H=Herbs, M=Mushroom, S=Shrubs, ST=Small Tree, T=Tree				

Table.2. IUCN red list in Lime Stone Area (2016.3)

No.	Scientific Name	Common Name	Family Name	IUCN criteria
1	*Bauhinia ornata* Kurz	Myauk-hle-kha	Caesalpiniaceae	LC ver 3.1
2	*Dalbergia cultrata* Grah.	Yin-daik	Fabaceae	NT ver 3.1
3	*Dalbergia oliveri* Gamble	Ta-ma-lan	Fabaceae	EN A1cd ver 2.3
4	*Dalbergia rimosa* Roxb.	Daung-ta-laung	Fabaceae	LC ver 3.1
5	*Dendrocalamus membranaceus* Munro	Hmyin-wa	Poaceae	LCver 3.1
6	*Dipterocarpus tuberculatus* Roxb.	In	Dipterocarpaceae	LR/lc ver 2.3
7	*Holarrhena pubescens* Wall. ex G. Don	Let-htok-gyi	Apocynaceae	LC ver 3.1
8	*Homonoia riparia*	Ye-mo-ma-kha	Euphorbiaceae	LC ver 3.1
9	*Ludwigia hyssopifolia*	Lay-nyin-thay	Onagraceae	LC ver 3.1
10	*Ludwigia octovalvis*	Lay-nyin-gyi	Onagraceae	LC ver 3.1

11	*Lathyrus latifolius*	Not known	Fabaceae	LC ver 3.1
12	*Mangifera sylvatica* Roxb.	Taung-tha-yet	Anacardiaceae	LR/lc ver 2.3
13	*Millettia ovalifolia* Kurz	Thin-win	Fabaceae	DD ver 3.1
14	*Mimosa pudica* L.	Hti-ka-yone	Mimosaceae	LC ver 3.1
15	*Pennisetum purpureum* Schum.	Yon-sa-myet	Poaceae	LC ver 3.1
16	*Potamogeton natans* L.	Floating-leaf Pondweed	Potamogetonaceae	LC ver 3.1
17	*Pteris vittata*	Brake Fern	Pteridaceae	LC ver 3.1
18	*Pterocarpus indicus*Willd.	Taw-pa-dauk	Fabaceae	VU A1d ver 2.3
19	*Shorea obtusa* Wall.	Thit-ya	Dipterocarpaceae	LR/lc ver 2.3
20	*Shorea siamensis* (Kurz) Miq.	In-gyin	Dipterocarpaceae	LR/lc ver 2.3
21	*Tadehagi triquetrum* (L.)H. Ohashi	Lauk-thay	Fabaceae	LC ver 3.1
22	*Tetrameles nudiflora* R. Br.	Baing	Datiscaceae	LR/lc ver 2.3
23	*Ziziphus jujuba* Lam.	Zi	Rhamnaceae	LC ver 3.1
DD=Data Deficient, EN=Endangered, LC=Least Concern, LR/lc=Lower Risk/least concern, NT=Near Threatened, VU=Vulnerable				

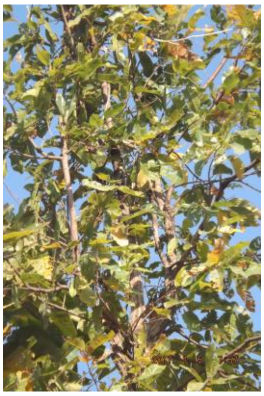
Dalbergia cultrata Grah.

Millettia ovalifolia Kurz

Tetrameles nudiflora R. Br.

Mimosa pudica L.

Dalbergia rimosa Roxb.



Shorea siamensis (Kurz) Miq.

Dendrocalamus membranaceus Munro

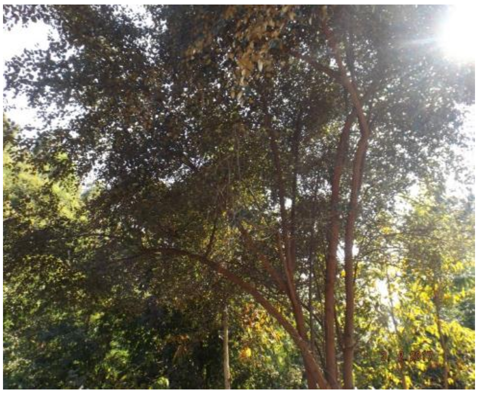
Dipterocarpus tuberculatus Roxb.

Holarrhena pubescens Wall. ex G.Don

Homonoia riparia Lour.

Dalbergia oliveri Gamble

*Pterocarpus indicus*Willd.



Ziziphus jujuba Lam

Potamogeton natans L

Shorea obtusa Wall

Pteris vittata

Pennisetum purpureum Schum.

Mangifera sylvatica Roxb.

Table.3. Invasive Species List Lime Stone Area

No	Scientific Names	Familiy	Common Names	Origin
1	*Ageratum conyzoides* L.	Asteraceae	Khwe-thay-pan	Tropical America
2	*Bidens pilosa*	Asteraceae	Hmwe-sok	Tropical America
3	*Caesalpinia decapetala (Roth.)Alston*	Caesalpinaceae	Suk-yan-bo /Kyant-sa-su-pin	Tropical Asia
4	*Chromolaena odorata* (L.) R.M. King & H Robinson	Asteraceae	Bi-zet	Central America, South America
5	*Hiptage benghalensis* (L.) Kurz	Malpighiaceae	Bein-new	Tropical America
6	*Leucaena leucocephala* (Lam.) De.Wit	Mimosaceae	Baw-za-gaing	Hawaii
7	*Mimosa pudica* L.	*Mimosaceae*	Hti-ka-yone	South America. Mexico, Amazon. Tropical America
8	*Oroxylum indicum* (L.) Kurz.	*Bignoniaceae*	Kyaung-sha	India
9	*Paederia foetida* L.	Rubiaceae	Pe-bok-nwee	Asia
10	*Ziziphus jujuba* Lam.	Rhamnaceae	Zi	China


Leucaena leucocephala (Lam.) De.Wit

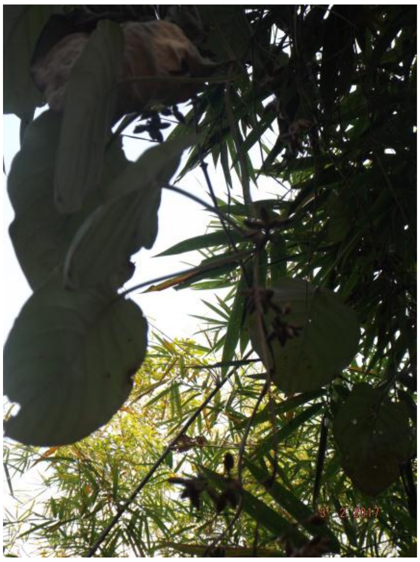

Ziziphus jujuba Lam.


Ziziphus jujuba Lam.


Oroxylum indicum (L.) Kurz.

Chromolaena odorata L.

Mimosa pudica L.



Paederia foetida L.

Bidens pilosa

Ageratum conyzoides L.

Table.4. Plant Association, Vegetation Types, and Red List Species according to their coordinations

PLANT ASSOCIATION	ELEVATION(m)	NAME	BAMBOO SPECIES	DOMINANT TREE SPECIES	VEGETATION TYPE	IUCN red list Species	Comment	POINT_X	POINT_Y
Association I. *Schleichera oleosa* (Lour.) Oken, *Adina cordifolia* Hook. f.,, and *Dendrocalamus membranaceus* Munro,	640	APL-1	*Dendrocalamus membranaceus* Munro, *Thyrsostachys oliveri* Gamble, *Cephalostachyum pergracile* Munro,*Bambusa polymorpha* Munro	*Schleichera oleosa* (Lour.) Oken, *Adina cordifolia* Hook. f., *Samadera indica* Gaertn., *Stereospermum suaveolens* (Roxb.) DC., *Terminalia alata* (Heyne) Roth, *Albizia lebbekoides* (DC.) Benth., *Anogeissus acuminata* Wall., *Anthocephalus morindaefolius* Korth., *Bombax insigne* Wall., *Croton oblongifolius* Roxb., *Dalbergia oliveri* Gamble, *Dillenia pentagyna* Roxb., *Harrisonia perforata* Merr., *Lagerstroemia tomentosa* Presl., *Tectona grandis* L. f.	Deciduous Forest	*Mangifera sylvatica* Roxb., *Millettia ovalifolia* Kurz	2017-02-02 8:25:35AM	96.404893	20.869484
	665	APL-2				*Dalbergia oliveri Gamble,Dendrocalamus membranaceus Munro*	2017-02-02 8:41:01AM	96.404949	20.868524
	705	APL-3				*Dalbergia oliveri Gamble, Dendrocalamus membranaceus Munro, Shorea obtusa* Wall.,	2017-02-02 9:05:57AM	96.405544	20.867816
	718	APL-4				*Dalbergia cultrata Grah.*	2017-02-02 9:34:29AM	96.406062	20.867064
	677	APL-5				*Dendrocalamus membranaceus Munro*	2017-02-02 9:56:00AM	96.406578	20.866301
	643	APL-6					2017-02-02 10:23:27AM	96.407261	20.865663
	639	APL-7				*Tetrameles nudiflora* R. Br.	2017-02-02 10:36:44AM	96.408239	20.865816
	646	APL-8				*Dendrocalamus membranaceus Munro*	2017-02-02 10:47:31AM	96.409245	20.866258
	644	APL-9				*Dendrocalamus membranaceus Munro*	2017-02-02 11:06:06AM	96.410258	20.866395
	641	APL-10				*Dalbergia oliveri Gamble, Dendrocalamus membranaceus Munro*	2017-02-02 11:17:55AM	96.411260	20.866320
Association II. *Tectona grandis* L. f., *Terminalia alata* (Heyne)	590	APL-11	*Dendrocalamus membranaceus* Munro, *Bambusa bambos* (L.)Voss,	*Tectona grandis* L. f., *Terminalia alata* (Heyne) Roth, *Acacia catechu* Willd.,*Croton oblongifolius* Roxb.,	Mixed Broad-leaved Deciduous Forest	*Dalbergia oliveri* Gamble, *Shorea siamensis* (Kurz) Miq., *Dendrocalamus membranaceus* Munro	2017-02-02 11:44:11AM	96.411847	20.867084

PLANT ASSOCIATION	ELEVATION(m)	NAME	BAMBOO SPECIES	DOMINANT TREE SPECIES	VEGETATION TYPE	IUCN red list Species	Comment	POINT_X	POINT_Y
Roth, and *Dendrocalamus membranaceus* Munro,	616	APL-12	*Thyrsostachys oliveri* Gamble	*Buchanania lazan* Spreng.,*Schleichera oleosa* (Lour.) Oken, *Shorea siamensis* (Kurz) Miq.,*Adina cordifolia* Hook. f., *Anogeissus acuminata Wall.*,*Bauhinia malabarica* Roxb.,*Bombax ceiba* L.,*Stereospermum suaveolens* (Roxb.) DC.		*Dalbergia oliveri* Gamble, *Shorea siamensis* (Kurz) Miq., *Dendrocalamus membranaceus* Munro	2017-02-02 11:54:58AM	96.411689	20.867927
	618	APL-13				*Dendrocalamus membranaceus* Munro, *Millettia ovalifolia* Kurz	2017-02-02 12:24:54PM	96.411506	20.868810
	631	APL-14				*Pterocarpus indicus*Willd.	2017-02-02 12:41:49PM	96.411173	20.869597
	650	APL-15					2017-02-02 12:58:46PM	96.410832	20.870485
	566	APL-16					2017-02-03 8:12:36AM	96.403377	20.877603
	566	APL-17					2017-02-03 8:20:11AM	96.403407	20.878699
	575	APL-18				*Dendrocalamus membranaceus* Munro	2017-02-03 8:27:17AM	96.403914	20.879477
	589	APL-19				*Dendrocalamus membranaceus* Munro, *Shorea obtusa* Wall.	2017-02-03 8:35:08AM	96.404919	20.880737
	597	APL-20				*Shorea obtusa* Wall.	2017-02-03 8:43:10AM	96.405066	20.881647
Association III. *Xylia xylocarpa* (Roxb.)Taub., *Croton oblongifolius* Roxb. and *Dendrocalamus membranaceus* Munro,	607	APL-21	*Dendrocalamus membranaceus* Munro, *Thyrsostachys oliveri* Gamble	*Xylia xylocarpa* (Roxb.)Taub., *Croton oblongifolius* Roxb., *Bombax insigne* Wall., *Tectona grandis* L. f., *Terminalia alata* (Heyne) Roth, *Schleichera oleosa* (Lour.) Oken, *Acacia catechu* Willd., *Chukrasia velutina* Roem., *Harrisonia perforata* Merr., *Lannea coromandelica* (Houtt.) Merrr., *Samadera indica* Gaertn., *Shorea siamensis* (Kurz) Miq.,	Deciduous Forest	*Shorea obtusa* Wall., *Dalbergia cultrata* Grah.	2017-02-03 8:51:07AM	96.405605	20.882413
	634	APL-22				*Dendrocalamus membranaceus* Munro, *Shorea siamensis* (Kurz) Miq., *Dalbergia rimosa* Roxb.	2017-02-03 9:00:59AM	96.406543	20.882641
	671	APL-23				*Dendrocalamus membranaceus* Munro, *Shorea siamensis* (Kurz) Miq.	2017-02-03 9:13:36AM	96.407484	20.882734

PLANT ASSOCIATION	ELEVATION(m)	NAME	BAMBOO SPECIES	DOMINANT TREE SPECIES	VEGETATION TYPE	IUCN red list Species	Comment	POINT_X	POINT_Y
	702	APL-24				*Dendrocalamus membranaceus* Munro	2017-02-03 9:27:06AM	96.408504	20.882351
	734	APL-25				*Dendrocalamus membranaceus* Munro	2017-02-03 9:40:41AM	96.408260	20.881470
	757	APL-26				*Dendrocalamus membranaceus* Munro	2017-02-03 9:58:36AM	96.408687	20.880636
	804	APL-27				*Dalbergia rimosa* Roxb.	2017-02-03 10:09:26AM	96.408598	20.879663
	816	APL-28				*Millettia ovalifolia* Kurz	2017-02-03 10:31:24AM	96.408622	20.878761
	797	APL-29				*Dendrocalamus membranaceus* Munro	2017-02-03 10:45:03AM	96.408796	20.877880
	742	APL-30				*Dendrocalamus membranaceus* Munro	2017-02-03 10:59:13AM	96.408819	20.876972
Association IV. *Acacia catechu* Willd., *Harrisonia perforata* Merr. and *Dendrocalamus membranaceus* Munro,	738	APL-31	*Dendrocalamus membranaceus* Munro, *Bambusa bambos* (L.)Voss	*Acacia catechu Willd.*, *Harrisonia perforata* Merr.,*Tectona grandis* L. f., *Terminalia alata* (Heyne) Roth, *Trema orientalis* (L.) Blume, *Xylia xylocarpa* (Roxb.)Taub., *Croton oblongifolius* Roxb., *Shorea siamensis* (Kurz) Miq., *Adina cordifolia* Hook. f.,*Bombax insigne* Wall., *Chukrasia velutina* Roem., *Phyllanthus emblica* L, *Spondias pinnata* (L. f.) Kurz.	Dry Deciduous Forest		2017-02-03 11:09:47AM	96.408668	20.876077
	750	APL-32				*Shorea siamensis* (Kurz) Miq.	2017-02-03 11:18:00AM	96.409670	20.875214
	740	APL-33				*Shorea siamensis* (Kurz) Miq.	2017-02-03 11:21:13AM	96.409965	20.874139
	717	APL-34					2017-02-03 11:26:25AM	96.408544	20.872726
	613	APL-35				*Dendrocalamus membranaceus* Munro, *Holarrhena pubescens* Wall. ex G. Don	2017-02-03 1:10:06PM	96.403684	20.871978
	569	APL-36				*Dendrocalamus membranaceus* Munro	2017-02-03 1:26:22PM	96.402791	20.872282
	512	APL-37				*Dendrocalamus membranaceus* Munro	2017-02-03 1:44:30PM	96.401805	20.872472
	486	APL-38					2017-02-03 1:54:44PM	96.401488	20.871437
	469	APL-39					2017-02-03 2:01:38PM	96.401227	20.869555

PLANT ASSOCIATION	ELEVATION(m)	NAME	BAMBOO SPECIES	DOMINANT TREE SPECIES	VEGETATION TYPE	IUCN red list Species	Comment	POINT_X	POINT_Y
	449	APL-40				*Dendrocalamus membranaceus* Munro, *Mimosa pudica* L., *Homonoia riparia*	2017-02-03 2:06:41PM	96.400988	20.867468
Association V. *Harrisonia perforata* Merr., *Mitragyna rotundifolia* (Roxb.) Kuntze and *Bambusa bambos* (L.)Voss,	431	APL-41	*Bambusa bambos* (L.)Voss, *Dinochloa maclellandii* Kurz, *Thyrsostachys oliveri* Gamble	*Harrisonia perforata* Merr., *Mitragyna rotundifolia* (Roxb.) Kuntze, *Tectona grandis* L. f., *Strychnos nux-blanda* A.W. Hill, *Cratoxylum neriifolium* Kurz., *Acacia catechu* Willd., *Anthocephalus morindaefolius* Korth., *Bombax ceiba* L., *Bombax insigne* Wall., *Cassia fistula* L., *Lagerstroemia speciosa* (L.) Pers., *Lagerstroemia tomentosa* Presl., *Phyllanthus emblica* L., *Schleichera oleosa* (Lour.) Oken, *Shorea siamensis* (Kurz) Miq., *Trema orientalis* (L.) Blume	Dry Deciduous Forest		2017-02-03 2:13:15PM	96.400109	20.865858
	423	APL-42				*Tadehagi triquetrum* (L.)H. Ohashi	2017-02-03 2:15:54PM	96.398960	20.865830
	414	APL-43				*Dalbergia rimosa* Roxb.	2017-02-03 2:29:12PM	96.399346	20.864798
	424	APL-44					2017-02-03 2:39:27PM	96.400090	20.863871
	418	APL-45					2017-02-03 2:47:34PM	96.399702	20.862906
	398	APL-46					2017-02-03 2:55:58PM	96.399336	20.862013
	373	APL-47					2017-02-03 3:03:36PM	96.398438	20.861299
	359	APL-48				*Pterocarpus indicus*Willd., *Potamogeton natans* L.	2017-02-03 3:11:16PM	96.397372	20.860686
	342	APL-49					2017-02-03 3:19:21PM	96.395859	20.860922
	748	APL50				*Dalbergia oliveri* Gamble, *Pterocarpus indicus*Willd.	2017-02-06 7:45:29AM	96.408779	20.871521
Association VI *Tectona grandis* L. f., *Lagerstroemia tomentosa* Presl. and *Thyrsostachys oliveri* Gamble	745	APL51	*Thyrsostachys oliveri* Gamble, *Dendrocalamus membranaceus* Munro, *Bambusa polymorpha* Munro, *Cephalostachyum pergracile* Munro, *Dendrocalamus*	*Tectona grandis* L. f., *Lagerstroemia tomentosa* Presl., *Terminalia alata* (Heyne) Roth, *Anogeissus acuminata* Wall., *Croton oblongifolius* Roxb., *Pterocarpus indicus*Willd., *Bombax insigne* Wall., *Acacia catechu* Willd., *Harrisonia*	Mixed Broad-leaved Deciduous Forest	*Shorea siamensis* (Kurz) Miq., *Pterocarpus indicus*Willd.	2017-02-06 7:59:45AM	96.409335	20.870601
	721	APL52				*Pterocarpus indicus*Willd.	2017-02-06 8:13:51AM	96.409860	20.871484
	650	APL53				*Dendrocalamus membranaceus* Munro,*Pterocarpus indicus*Willd.	2017-02-06 8:34:18AM	96.405896	20.869794

PLANT ASSOCIATION	ELEVATION(m)	NAME	BAMBOO SPECIES	DOMINANT TREE SPECIES	VEGETATION TYPE	IUCN red list Species	Comment	POINT_X	POINT_Y
	674	APL54	*longispathus* (Kurz) Kurz	*perforata* Merr., *Shorea siamensis* (Kurz) Miq., *Xylia xylocarpa* (Roxb.)Taub.		*Dendrocalamus membranaceus* Munro,*Pterocarpus indicus*Willd.	2017-02-06 8:43:20AM	96.407114	20.869651
	701	APL55				*Dendrocalamus membranaceus* Munro,*Pterocarpus indicus*Willd.	2017-02-06 8:56:06AM	96.408429	20.869592
	734	APL56				*Dendrocalamus membranaceus* Munro, *Pterocarpus indicus*Willd.	2017-02-06 9:11:27AM	96.408598	20.868645
	754	APL57					2017-02-06 9:47:59AM	96.408206	20.868031
	617	APL58				*Pterocarpus indicus*Willd., *Shorea siamensis* (Kurz) Miq., *Dendrocalamus membranaceus* Munro	2017-02-06 10:43:58AM	96.403676	20.872599
	607	APL59				*Pterocarpus indicus*Willd., , *Dendrocalamus membranaceus* Munro	2017-02-06 10:48:23AM	96.403286	20.873623
	581	APL60					2017-02-06 12:24:27PM		
Associattion VII *Acacia catechu* Willd., *Terminalia alata* (Heyne) Roth and *Dendrocalamus longispathus* (Kurz) Kurz	558	APL61	*Dendrocalamus longispathus* (Kurz) Kurz, *Dendrocalamus membranaceus* Munro,	*Acacia catechu* Willd., *Terminalia alata* (Heyne) Roth, *Anogeissus acuminata* Wall., *Croton oblongifolius* Roxb., *Stereospermum suaveolens* (Roxb.) DC., *Mitragyna rotundifolia* (Roxb.) Kuntze, *Harrisonia perforata* Merr., *Pterocarpus indicus*Willd., *Tectona grandis* L. f., *Trema*	Dry Deciduous Forest		2017-02-06 12:28:27PM	96.402453	20.877251
	564	APL62					2017-02-06 12:33:28PM	96.402870	20.879042
	555	APL63					2017-02-06 12:36:54PM	96.401951	20.879462
	546	APL64				*Dalbergia oliveri* Gamble, *Dendrocalamus membranaceus* Munro	2017-02-06 12:39:46PM	96.402576	20.879150
	535	APL65				*Dendrocalamus*	2017-02-06	96.401925	20.877930

PLANT ASSOCIATION	ELEVATION(m)	NAME	BAMBOO SPECIES	DOMINANT TREE SPECIES	VEGETATION TYPE	IUCN red list Species	Comment	POINT_X	POINT_Y
				orientalis (L.) Blume		*membranaceus* Munro	12:43:17PM		
	521	APL66				*Dendrocalamus membranaceus* Munro,*Pterocarpus indicus*Willd.	2017-02-06 12:47:01PM	96.401896	20.876315
	509	APL67				*Dendrocalamus membranaceus* Munro,*Pterocarpus indicus*Willd.	2017-02-06 12:49:57PM	96.401483	20.874709
	488	APL68				*Dendrocalamus membranaceus* Munro	2017-02-06 12:58:05PM	96.401372	20.873494
	459	APL69				*Pterocarpus indicus*Willd., *Holarrhena pubescens* Wall. ex G. Don	2017-02-06 1:14:06PM	96.401197	20.872367
	451	APL70				*Dalbergia cultrata* Grah.	2017-02-06 1:30:26PM	96.400266	20.872026
Association VIII *Tectona grandis* L. f., *Xylia xylocarpa* (Roxb.)Taub and *Bambusa polymorpha* Munro	452	APL71	*Bambusa polymorpha* Munro, *Dendrocalamus longispathus* (Kurz) Kurz, *Cephalostachyum pergracile Munro,*	*Tectona grandis* L. f., *Xylia xylocarpa* (Roxb.)Taub., *Harrisonia perforata* Merr., *Acacia catechu* Willd., *Cratoxylum polyanthum* Korth, *Anogeissus acuminata* Wall., *Cratoxylum neriifolium* Kurz.,*Mitragyna rotundifolia* (Roxb.) Kuntze, *Phyllanthus emblica* L., *Spondias pinnata* (L. f.) Kurz., *Strychnos nux-blanda* A.W. Hill, *Trema orientalis* (L.) Blume,	Mixed Broad-leaved Deciduous Forest	*Dalbergia oliveri* Gamble	2017-02-06 1:35:25PM	96.399856	20.872851
	440	APL72				*Mangifera sylvatica* Roxb.	2017-02-06 1:39:35PM	96.398710	20.872710
	439	APL73				*Mangifera sylvatica* Roxb.	2017-02-06 1:44:10PM	96.397910	20.873414
	419	APL74					2017-02-06 1:47:37PM	96.397588	20.874721
	402	APL75				*Holarrhena pubescens* Wall. ex G. Don	2017-02-06 1:52:13PM	96.397295	20.875878
	392	APL76				*Shorea obtusa* Wall., *Pterocarpus indicus*Willd.	2017-02-06 1:58:18PM	96.396193	20.876336
	388	APL77				*Dalbergia cultrata* Grah., *Homonoia riparia*	2017-02-06 2:01:03PM	96.395405	20.876518
	361	APL78				*Dalbergia rimosa* Roxb.	2017-02-06 2:09:53PM	96.394297	20.876300

PLANT ASSOCIATION	ELEVATION(m)	NAME	BAMBOO SPECIES	DOMINANT TREE SPECIES	VEGETATION TYPE	IUCN red list Species	Comment	POINT_X	POINT_Y
	355	APL79				*Pterocarpus indicus*Willd.	2017-02-06 2:13:15PM	96.393457	20.875567
	347	APL80				*Pterocarpus indicus*Willd.	2017-02-06 2:17:47PM	96.392880	20.874745
	338	APL81					2017-02-06 2:21:25PM	96.392436	20.873933
APL=Apache Lime Stone									

II. Mud Stone Area

Table.5. Species List of Mud Stone Area

No.	Scientific Name	Common Name	Family Name	Habits
1	*Acacia arabica* Willd.	Pok-thin-thwa/Su-phyu	Mimosaceae	ST
2	*Acacia catechu* Willd.	Sha	Mimosaceae	T
3	*Acacia concinna* (Willd.) DC.	Taw-kin-mon-chin	Mimosaceae	Cl/Cr
4	*Acacia intsia* Willd.	Su-pok-gyi	Mimosaceae	CL
5	*Acacia pennata* (L.) Willd.	Su-yit	Mimosaceae	Cl/Cr
6	*Acmella calva* (DC.) R.K. Jansen	Pe-le-nyin	Asteraceae	H
7	*Aegle marmelos* L.	Ok-shit	Rutaceae	T
8	*Ageratum conyzoides* L.	Khwe-thay-pan	Asteraceae	H
9	*Albizia lebbek* (L.)Benth.	Taung-ko-kko	Mimosaceae	T
10	*Albizia lebbekoides* (DC.) Benth.	Taung-ma-gyi	Mimosaceae	T
11	*Amaranthus aspera*	Not known	Amaranthaceae	H
12	*Anogeissus acuminata* Wall.	Yon	Combretaceae	T
13	*Anthocephalus morindaefolius* Korth.	Ma-u-let-tan-shae	Rubiaceae	T
14	*Antidesma velutinum*Tul.	Kin-pa-lin	Euphorbiaceae	ST
15	*Aporusa dioica* (Roxb.) Mull.Arg.	Thit-khauk	Euphorbiaceae	T
16	*Argyreia nervosa*	Not known	Convolvulaceae	Cl/Cr
17	*Argyreia roxburghii* Choisy	Not known	Convolvulaceae	Cl/Cr
18	*Bambusa bambos* (L.)Voss	Kya-khat-wa	Poaceae	B
19	*Bambusa polymorpha* Munro	Kya-thaung-wa	Poaceae	B
20	*Bambusa tulda* Roxb.	Thaik-wa	Poaceae	B
21	*Bauhinia malabarica* Roxb.	Pha-lan/Chin-byit	Caesalpiniaceae	T
22	*Bauhinia* sp.	Swe-daw-nwee	Caesalpiniaceae	Cl/Cr
23	*Bliospermum axillare* Blume	Hnat-cho	Euphorbiaceae	H
24	*Boehmeria grandifolia*	Not known	Urticaceae	S
25	*Bombax ceiba* L.	Let-pan	Bombacaceae	T
26	*Bombax insigne* Wall.	De-du	Bombacaceae	T
27	*Bridelia retusa* L.	Seik-chee	Euphorbiaceae	ST
28	*Buchanania lazan* Spreng.	Lun-pho	Anacardiaceae	T
29	*Buddleja asiatica*	Pon-ma-gyi	Buddlejaceae	S
30	*Butea superba* Roxb.	Pauk-nwee	Fabaceae	Cl/Cr
31	*Caesalpinia decapetala (Roth.)Alston*	Suk-yan-bo /Kyant-sa-su-pin	Caesalpiniaceae	Cl/Cr
32	*Callicarpa nudiflora*	Kyun-na-lin	Verbenaceae	T
33	*Calotropis gigantea*	Ma-yoe	Apocynaceae	S
34	*Careya arborea* Roxb.	Ban-bwe	Lecythidaceae	T
35	*Cassia fistula* L.	Ngu	Caesalpiniaceae	T
36	*Cayratia trifolia*	Not known	Vitaceae	CL
37	*Centratherum punctatum*	Not known	Asteraceae	H
38	*Cephalostachyum pergracile* Munro	Tin-wa	Poaceae	B

No.	Scientific Name	Common Name	Family Name	Habits
39	*Chromolaena odorata* (L.) R.M. King & H Robinson	Bi-zet	Asteraceae	S
40	*Chukrasia velutina* Roem.	Yin-ma	Meliaceae	T
41	*Congea tomentosa* Roxb.	Tha-ma-ga-nwee	Verbenaceae	Cl/Cr
42	*Cosmos caudatus*	Sein-chel	Asteraceae	H
43	*Costus specious* Sm.	Pha-lan-taung-hmwe	Costaceae	H
44	*Crassocephalum crepidioides*	Pan-Zauk-htoe	Asteraceae	H
45	*Cratoxylum neriifolium* Kurz.	Be-bya	Hypericaceae	ST
46	*Cratoxylum polyanthum*Korth.	Be-bya	Hypericaceae	ST
47	*Croton oblongifolius* Roxb.	Tha-yin-gyi	Euphorbiaceae	ST
48	*Cryptolepis buchanani* Rome.& Schult	Na-sha-gyi	Asclepiadaceae	Cl/Cr
49	*Cucumis maderaspatanus*	Not known	Cucurbitaceae	Cl/Cr
50	*Curcuma aurantiaca*	Ma-la	Zingiberaceae	H
51	*Dalbergia cultrata* Grah.	Yin-daik	Fabaceae	T
52	*Dalbergia oliveri* Gamble	Ta-ma-lan	Fabaceae	T
53	*Dalbergia rimosa* Roxb.	Daung-ta-laung	Fabaceae	ST
54	*Dalbergia volubilis* Roxb.	Daung-ta-laung	Fabaceae	ST
55	*Dendrocalamus longispathus* (Kurz) Kurz	Wa-net	Poaceae	B
56	*Dendrocalamus membranaceus* Munro	Hmyin-wa	Poaceae	B
57	*Derris* sp.	Not known	Fabaceae	Cl/Cr
58	*Dillenia parviflora* Griff	Kyet-zin-byun	Dilleniaceae	T
59	*Dillenia pentagyna* Roxb.	Zin-byun	Dilleniaceae	T
60	*Dinochloa maclellandii* Kurz	Ba-du-ma-wa/Wa-nwee	Poaceae	B
61	*Dioscorea bulbifera*	Myauk-u	Dioscoreaceae	Cl/Cr
62	*Dioscorea pentaphylla* L.	Kywe-ngar-ywet	Dioscoreaceae	Cl/Cr
63	*Diospyros kika* L.f.	Te	Ebenaceae	T
64	*Diospyros montana* Roxb.	Gyok	Ebenaceae	T
65	*Dipterocarpus tuberculatus* Roxb.	In	Dipterocarpaceae	T
66	*Ehretia acuminata* R.Br	Taung-poe-lu-lin	Boraginaceae	T
67	*Elephantopus scaber* L.	Not known	Asteraceae	H
68	*Entada scandens* Benth.	Doe-nwee	Mimosaceae	Cl/Cr
69	*Eugenia balsamea* Wight	Ye-tha-bye	Myrtaceae	T
70	*Ficus hispida* L.	Kha-aung	Moraceae	ST
71	*Ficus microcarpa* L.	Tha-phan	Moraceae	S
72	*Ficus obtusifolia* Roxb.	Nyaung-gyat	Moraceae	T
73	*Ficus racemosa* L.	Ye-tha-phan	Moraceae	ST
74	*Flacourtia cataphracta* Roxb.	Na-ywe	Flacourtiaceae	T
75	*Flemingia macrophylla* (Willd.) Merr.	Pha-lan-phyu	Fabaceae	S
76	*Gardenia coronaria* Buch.-Ham.	Yin-gat-gyi	Rubiaceae	T
77	*Getonia floribunda* Roxb.	Kywet-nwee	Combretaceae	Cl/Cr
78	*Glochidion eriocarpum*	Not known	Euphorbiaceae	S
79	*Grewia laevigata* Vahl	Kyet-ta-yaw	Tiliaceae	ST
80	*Harrisonia perforata* Merr.	Su-gyin	Simaroubaceae	S

No.	Scientific Name	Common Name	Family Name	Habits
81	*Heterophragma adenophyllum* Seem.	Phet-than	Bignoniaceae	ST
82	*Hibiscus macrophyllus*	Taung-phet-wun	Malvaceae	T
83	*Homonoia riparia*	Ye-mo-ma-kha	Euphorbiaceae	S
84	*Ipomoea angustifolia* Jacq.	Not known	Convolvulaceae	Cl/Cr
85	*Ipomoea quamoclit* L.	Myet-lay-ni	Convolvulaceae	Cl/Cr
86	*Ipomoea triloba*	Not known	Convolvulaceae	Cl/Cr
87	*Kleinhovia hospita* L.	O-tein/Pashu-phet-wun	Sterculiaceae	T
88	*Lagerstroemia macrocarpa* Kurz	Pyin-ma-ywet-gyi	Lythraceae	T
89	*Lagerstroemia speciosa* (L.)Pers.	Pyin-ma-ywet-thay	Lythraceae	T
90	*Lagerstroemia tomentosa* Presl.	Lae-sa	Lythraceae	T
91	*Lannea coromandelica* (Houtt.) Merrr.	Na-be	Anacardiaceae	T
92	*Lathyrus latifolius*	Not known	Fabaceae	S
93	*Leea hirta* Banks	Naga-mauk-phyu	Leeaceae	S
94	*Leea rubra* Blume.	Naga-mauk-ni	Leeaceae	S
95	*Lepidagathis semiherbacea* (Clarke) Nees	Not known	Acanthaceae	H
96	*Leptadenia reticulata* Wight & Arn.	Gon-kha	Asclepiadaceae	Cl/Cr
97	*Lespedeza bicolor* var. *japonica*	Not known	Fabaceae	S
98	*Leucaena leucocephala* (Lam.) De.Wit	Baw-za-gaing	Mimosaceae	ST
99	*Lindenbergia philippensis* Benth.	Not known	Scrophulariaceae	H
100	*Ludwigia hyssopifolia*	Lay-nyin-thay	Onagraceae	H
101	*Mallotus philippensis* (Lam.)Muell.Arg.	Taw-thi-din	Euphorbiaceae	ST
102	*Mangifera sylvatica* Roxb.	Taung-tha-yet	Anacardiaceae	T
103	*Markhamia stipulata* (Wall.) Seem.ex K.Schum.	Ma-hlwa	Bignoniaceae	ST
104	*Melanorrhoea usitata* Wall.	Sit-se	Anacardiaceae	T
105	*Merremia vitifolia* (Burm.f.) Hallier. f.	Kyet-hinga-lae-new	Convolvulaceae	Cl/Cr
106	*Microcos paniculata* L.	Mya-ya	Meliaceae	ST
107	*Millettia extensa* Benth.	Win-u	Fabaceae	Cl/Cr
108	*Millettia ovalifolia* Kurz	Thin-win	Fabaceae	T
109	*Mimosa pudica* L.	Hti-ka-yone	Mimosaceae	H
110	*Mitragyna rotundifolia* (Roxb.) Kuntze	Bin-ga	Rubiaceae	T
111	*Morinda tinctoria* Roxb.	Ni-ba-sae	Rubiaceae	S
112	*Mucuna pruriens* (L.)DC.	Khwe-lae-ya	Fabaceae	Cl/Cr
113	*Oroxylum indicum* (L.) Kurz.	Kyaung-sha	Bignoniaceae	ST
114	*Oxystelma esculentum* R.Br.	Kauk-yo-nwee	Asclepiadaceae	Cl/Cr
115	*Paederia foetida* L.	Pe-bok-nwee	Rubiaceae	CL
116	*Phoenix paludosa* Roxb.	Thin-baung	Arecaceae	ST
117	*Phyllanthus albizzioides* (Kurz)Hook.f.	Shit-sha	Euphorbiaceae	T
118	*Phyllanthus emblica* L.	Zi-phyu	Euphorbiaceae	ST
119	*Pseudoxytenanthera parvifolia* (Brandis ex Gamble)T.Q.Nguyen	Thaiktu-hmyintu	Poaceae	B
120	*Pterocarpus indicus*Willd.	Taw-pa-dauk	Fabaceae	T
121	*Pterospermum semisagittatum* Buch.-Ham.	Na-gye	Sterculiaceae	T

No.	Scientific Name	Common Name	Family Name	Habits
122	*Ricinus communis* L.	Kyet-su	Euphorbiaceae	ST
123	*Samadera indica* Gaertn.	Ka-di	Simaroubaceae	ST
124	*Schleichera oleosa* (Lour.) Oken	Gyo	Sapindaceae	T
125	*Senna hirsuta* (L.) Irwin & Barneby	Ka-thaw-hmwe-htu	Caesalpiniaceae	S
126	*Setaria lutescens* Hubb.	Yon-sa	Poaceae	G
127	*Shorea obtusa* Wall.	Thit-ya	Dipterocarpaceae	T
128	*Shorea siamensis* (Kurz) Miq.	In-gyin	Dipterocarpaceae	T
129	*Sida acuta* Burm f.	Ta-byet-si	Malvaceae	S
130	*Smilax aspericaulis* Wall ex A. D.C.	Sein-na-baw-thay	Smilaceae	CL
131	*Smilax macrophylla* Roxb.	Sein-na-baw-gyi	Smilaceae	CL
132	*Spermacoce mauritiana*	Not known	Rubiaceae	H
133	*Spondias pinnata* (L. f.) Kurz.	Taw-gwe	Anacardiaceae	T
134	*Sterculia ornata* Wall. ex Kurz	Don-shaw	Sterculiaceae	T
135	*Sterculia versicolor* Wall.	Shaw-phyu	Sterculiaceae	T
136	*Stereospermum colais* (Buch.-Ham. ex Dillwyn) Mabb.	Than-thay	Bignoniaceae	T
137	*Strychnos nux-blanda* A.W.Hill	Kha-baung	Loganiaceae	ST
138	*Tadehagi triquetrum* (L.)H. Ohashi	Lauk-thay	Fabaceae	S
139	*Tectona grandis* L. f.	Kyun	Verbenaceae	T
140	*Terminalia alata* (Heyne) Roth	Htauk-kyant	Combretaceae	T
141	*Tetrameles nudiflora* R. Br.	Baing	Datiscaceae	T
142	*Tetrastigma planicaule*	Not known	Vitaceae	Cl/Cr
143	*Thunbergia laurifolia* Lindl.	Kyi-hnok-thi	Acanthaceae	Cl/Cr
144	*Thyrsostachys oliveri* Gamble	Tha-net-wa	Poaceae	B
145	*Tinospora nudiflora* Kurz	Sin-don-ma-nwee	Menispermaceae	Cl/Cr
146	*Trema orientalis* (L.) Blume	Khwe-sha	Ulmaceae	ST
147	*Tristaniopsis burmanica* (Griff.)P.G. Wilson & J.T. Waterh.	Taung-tha-bye	Myrtaceae	T
148	*Triumfetta bartramia* L.	Ket-si-ne-thay	Tiliaceae	S
149	*Urena lobata* L.	Ket-si-ne-gyi	Malvaceae	S
150	*Uvaria cordata* Schum. & Thonn.	Tha-but-gyi	Annonaceae	ST
151	*Vangueria spinosa* Roxb.	Magyi-bauk	Rubiaceae	S
152	*Ventilago maderaspatana* Benth.	Ta-yaw-nyo	Rhamnaceae	Cl/Cr
153	*Vitex peduncularis* Wall.	Phet-le-zin	Verbenaceae	T
154	*Vitex pubescens* Vahl	Kyet-yoe	Verbenaceae	T
155	*Vitis discolour*	Ta-bin-taing-mya-nan-phyu	Vitaceae	Cl/Cr
156	*Wendlandia tinctoria* DC.	Thit-ni/Hta-min-chauk	Rubiaceae	ST
157	*Xylia xylocarpa* (Roxb.)Taub.	Pyin-ka-doe	Mimosaceae	T
158	*Zanthoxylum budrunga* Wall.	Ma-yanin-kyet-su	Rutaceae	T
159	*Ziziphus glabra* Roxb.	Taw-zi-nwee/Paung-bet	Rhamnaceae	Cl/Cr
160	*Ziziphus jujuba* Lam.	Zi	Rhamnaceae	ST
B=Bamboo, CL=Climber, Cl/Cr=Climber/Creeper, G=Grass, H=Herbs, S=Shrubs, ST=Small Tree, T=Tree				

Table.6. IUCN red list in Mud Stone Area (2016.3)

No.	Scientific Name	Common Name	Family Name	IUCN criteria
1	*Dalbergia cultrata* Grah.	Yin-daik	Fabaceae	NT ver 3.1
2	*Dalbergia rimosa* Roxb.	Daung-ta-laung	Fabaceae	LC ver 3.1
3	*Dendrocalamus membranaceus* Munro	Hmyin-wa	Poaceae	LCver 3.1
4	*Dipterocarpus tuberculatus* Roxb.	In	Dipterocarpaceae	LR/lc ver 2.3
5	*Homonoia riparia*	Ye-mo-ma-kha	Euphorbiaceae	LC ver 3.1
6	*Ludwigia hyssopifolia*	Lay-nyin-thay	Onagraceae	LC ver 3.1
7	*Lathyrus latifolius*	Not known	Fabaceae	LC ver 3.1
8	*Millettia ovalifolia* Kurz	Thin-win	Fabaceae	DD ver 3.1
9	*Mimosa pudica* L.	Hti-ka-yone	Mimosaceae	LC ver 3.1
10	*Pennisetum purpureum* Schum.	Yon-sa-myet	Poaceae	LC ver 3.1
11	*Pterocarpus indicus*Willd.	Taw-pa-dauk	Fabaceae	VU A1d ver 2.3
12	*Shorea obtusa* Wall.	Thit-ya	Dipterocarpaceae	LR/lc ver 2.3
13	*Shorea siamensis* (Kurz) Miq.	In-gyin	Dipterocarpaceae	LR/lc ver 2.3
14	*Tetrameles nudiflora* R. Br.	Baing	Datiscaceae	LR/lc ver 2.3
DD=Data Deficient, LC=Least Concern, LR/lc=Lower Risk/least concern, NT=Near Threatened, VU=Vulnerable				

Ludwigia octovalvis

Homonoia riparia

Mimosa pudica L.

*Pterocarpus indicus*Willd.

Dendrocalamus membranaceus Munro

Dipterocarpus tuberculatus Roxb.

Dalbergia cultrata Grah.

Ludwigia hyssopifolia

Shorea siamensis (Kurz) Miq.

DATA DEFICIENT (DD)
A taxon is Data Deficient when there is inadequate information to make a direct, or indirect, assessment of its risk of extinction based on its distribution and/or population status. A taxon in this category may be well studied, and its biology well known, but appropriate data on abundance and/or distribution are lacking. Data Deficient is therefore not a category of threat. Listing of taxa in this category indicates that more information is required and acknowledges the possibility that future research will show that threatened classification is appropriate. It is important to make positive use of whatever data are available. In many cases great care should be exercised in choosing between DD and a threatened status. If the range of a taxon is suspected to be relatively circumscribed, and a considerable period of time has elapsed since the last record of the taxon, threatened status may well be justified.

ENDANGERED (EN)

A taxon is Endangered when the best available evidence indicates that it meets any of the following criteria (A to E), and it is therefore considered to be facing a very high risk of extinction in the wild:

A. Reduction in population size based on any of the following:

1. An observed, estimated, inferred or suspected population size reduction of ≥ 70% over the last 10 years or three generations, whichever is the longer, where the causes of the reduction are clearly reversible AND understood AND ceased, based on (and specifying) any of the following:

(c) a decline in area of occupancy, extent of occurrence and/or quality of habitat

(d) actual or potential levels of exploitation

LEAST CONCERN (LC)
A taxon is Least Concern when it has been evaluated against the criteria and does not qualify for Critically Endangered, Endangered, Vulnerable or Near Threatened. Widespread and abundant taxa are included in this category.

Version 3.1: IUCN (2001)
The IUCN Council adopted this latest version, which incorporated changes as a result of comments from the IUCN and SSC memberships and from a final meeting of the Criteria Review Working Group, in February 2000.

NEAR THREATENED (NT)
A taxon is Near Threatened when it has been evaluated against the criteria but does not qualify for Critically Endangered, Endangered or Vulnerable now, but is close to qualifying for or is likely to qualify for a threatened category in the near future.

VULNERABLE (VU)

A taxon is Vulnerable when the best available evidence indicates that it meets any of the following criteria (A to E), and it is therefore considered to be facing a high risk of extinction in the wild:

A. Reduction in population size based on any of the following:

1. An observed, estimated, inferred or suspected population size reduction of ≥ 50% over the last 10 years or three generations, whichever is the longer, where the causes of the reduction are: clearly reversible AND understood AND ceased, based on (and specifying) any of the following:

(d) actual or potential levels of exploitation

Table.7. Invasive Species List Lime Stone Area

No	Scientific Names	Familiy	Common Names	Origin
1	*Ageratum conyzoides* L.	Asteraceae	Khwe-thay-pan	Tropical America
2	*Caesalpinia decapetala (Roth.)Alston*	Caesalpiniaceae	Suk-yan-bo /Kyant-sa-su-pin	Tropical Asia
3	*Chromolaena odorata* (L.) R.M. King & H Robinson	Asteraceae	Bi-zet	Central America, South America
4	*Leucaena leucocephala* (Lam.) De.Wit	Mimosaceae	Baw-za-gaing	Hawaii
5	*Mimosa pudica* L.	Mimosaceae	Hti-ka-yone	"South America. Mexico, Amazon. Tropical America"
6	*Oroxylum indicum* (L.) Kurz.	Bignoniaceae	Kyaung-sha	India
7	*Paederia foetida* L.	Rubiaceae	Pe-bok-nwee	Asia
8	*Ricinus communis* L.	Euphorbiaceae	Kyet-su	India
9	*Ziziphus jujuba* Lam.	Rhamnaceae	Zi	China

Paederia foetida L.

Chromolaena odorata (L.) R.M. King & H Robinson

Caesalpinia decapetala (Roth.)Alston

Ageratum conyzoides L.

Mimosa pudica L.

Ricinus communis L.

Oroxylum indicum (L.) Kurz.

Leucaena leucocephala (Lam.) De.Wit

Table.8. Plant Association, Vegetation Types, and Red List Species according to their coordinations

PLANT ASSOCIATION	ELEVATION(m)	NAME	BAMBOO SPECIES	DOMINANT TREE SPECIES	VEGETATION TYPE	IUCN red list Species	Comment	POINT_X	POINT_Y
Association I. *Xylia xylocarpa* (Roxb.)Taub., *Mitragyna rotundifolia* (Roxb.) Kuntze and *Bambusa polymorpha* Munro	440	APM-1	*Bambusa polymorpha* Munro,*Thyrsostachys oliveri* Gamble, *Dinochloa maclellandii* Kurz, *Cephalostachyum pergracile* Munro, *Dendrocalamus longispathus* (Kurz) Kurz, *Bambusa bambos* (L.)Voss	*Xylia xylocarpa* (Roxb.)Taub., *Mitragyna rotundifolia* (Roxb.) Kuntze, *Grewia laevigata* Vahl, *Tectona grandis* L. f., *Harrisonia perforata* Merr., *Croton oblongifolius* Roxb., *Strychnos nux-blanda* A.W.Hill, *Vitex pubescens* Vahl, *Lagerstroemia tomentosa* Presl., *Hibiscus macrophyllus*, *Pterocarpus indicus*Willd., *Acacia pennata* (L.) Willd., *Anogeissus acuminata* Wall.	Deciduous Forest		2017-02-04 7:47:04AM	96.379104	20.868413
	460	APM-2				*Dalbergia rimosa* Roxb., *Pterocarpus indicus*Willd.	2017-02-04 7:56:01AM	96.378058	20.868839
	477	APM-3					2017-02-04 8:04:26AM	96.377359	20.869741
	483	APM-4				*Dalbergia oliveri* Gamble	2017-02-04 8:12:03AM	96.376073	20.870653
	468	APM-5				*Dalbergia cultrata* Grah.	2017-02-04 8:30:03AM	96.376202	20.871723
	439	APM-6					2017-02-04 8:55:44AM	96.376809	20.872382
	401	APM-7				*Shorea siamensis* (Kurz) Miq., *Dalbergia rimosa* Roxb.,	2017-02-04 9:15:45AM	96.377427	20.873084
	392	APM-8				*Dalbergia rimosa* Roxb.,*Pterocarpus indicus*Willd.	2017-02-04 9:23:24AM	96.378265	20.872450

PLANT ASSOCIATION	ELEVATION(m)	NAME	BAMBOO SPECIES	DOMINANT TREE SPECIES	VEGETATION TYPE	IUCN red list Species	Comment	POINT_X	POINT_Y
	383	APM-9				*Dalbergia oliveri* Gamble	2017-02-04 9:32:59AM	96.379369	20.872356
	382	APM-10					2017-02-04 9:55:28AM	96.380506	20.872592
	376	APM-11				*Pterocarpus indicusWilld., Tetrameles nudiflora* R. Br., *Shorea obtusa* Wall.	2017-02-04 10:02:48AM	96.381528	20.873290
Association II. *Xylia xylocarpa*(Roxb.)Taub., *Tectona grandis* L. f. **a**nd *Bambusa polymorpha* Munro,	362	APM-12	*Bambusa polymorpha* Munro,*Thyrsostachys oliveri* Gamble, *Dinochloa maclellandii* Kurz, *Cephalostachyum pergracile* Munro, *Dendrocalamus longispathus* (Kurz) Kurz, *Bambusa bambos* (L.)Voss, *Pseudoxytenanthera parvifolia* (Brandis ex Gamble)T.Q.Nguyen, *Bambusa tulda* Roxb.	*Xylia xylocarpa*(Roxb.)Taub., *Tectona grandis* L. f., *Harrisonia perforata* Merr., *Mitragyna rotundifolia* (Roxb.) Kuntze, *Anthocephalus morindaefolius* Korth., *Strychnos nux-blanda* A.W.Hill, *Pterospermum semisagittatum* Buch.-Ham.	Mixed Broad-leaved Deciduous Forest	*Dalbergia cultrata* Grah., *Pterocarpus indicus*Willd., *Shorea obtusa* Wall.	2017-02-04 10:10:50AM	96.382538	20.873666
	353	APM-13				*Pterocarpus indicusWilld., Tetrameles nudiflora* R. Br., *Millettia ovalifolia* Kurz	2017-02-04 10:18:28AM	96.383400	20.874311
	349	APM-14				*Dalbergia cultrata* Grah., *Dalbergia oliveri* Gamble, *Pterocarpus indicus*Willd.,	2017-02-04 10:26:02AM	96.384434	20.874851
	347	APM-15				*Dalbergia cultrata* Grah., *Dalbergia oliveri* Gamble, *Pterocarpus indicus*Willd., *Tetrameles nudiflora* R. Br., *Mangifera sylvatica* Roxb., *Shorea siamensis* (Kurz) Miq., *Shorea obtusa* Wall.	2017-02-04 10:33:29AM	96.385107	20.875549

PLANT ASSOCIATION	ELEVATION(m)	NAME	BAMBOO SPECIES	DOMINANT TREE SPECIES	VEGETATION TYPE	IUCN red list Species	Comment	POINT_X	POINT_Y
	340	APM-16				*Dalbergia cultrata* Grah., *Pterocarpus indicus* Willd., *Homonoia riparia*	2017-02-04 10:46:39AM	96.386005	20.876201
	336	APM-17				*Dalbergia cultrata* Grah., *Pterocarpus indicus* Willd.	2017-02-04 10:55:04AM	96.386412	20.877271
	337	APM-18				*Pterocarpus indicus*Willd., *Shorea obtusa* Wall.	2017-02-04 11:02:57AM	96.386797	20.878228
	336	APM-19				*Dalbergia cultrata Grah., Pterocarpus indicus Willd., Shorea obtusa* Wall.	2017-02-04 11:08:48AM	96.387445	20.879140
	339	APM-20				*Dalbergia cultrata* Grah., *Dalbergia rimosa* Roxb.,	2017-02-04 11:23:03AM	96.388520	20.879090
	346	APM-21				*Dalbergia cultrata* Grah., *Dalbergia oliveri* Gamble, *Pterocarpus indicus*Willd.,	2017-02-04 11:29:46AM	96.389222	20.878532
	335	APM-22				*Dalbergia cultrata* Grah., *Dalbergia oliveri* Gamble, *Pterocarpus indicus*Willd.,	2017-02-04 11:37:16AM	96.389630	20.877679
Association III. *Tristaniopsis burmanica* (Griff.)P.G. Wilson & J.T. Waterh., *Tectona grandis* L. f., and *Dinochloa maclellandii*	330	APM-23	*Dinochloa maclellandii* Kurz, *Bambusa polymorpha* Munro,	*Tristaniopsis burmanica* (Griff.)P.G. Wilson & J.T. Waterh., *Tectona grandis* L. f., *Dipterocarpus tuberculatus* Roxb., *Ziziphus glabra* Roxb., *Trema*	Mixed Evergreen Forest	*Dalbergia oliveri* Gamble, *Homonoia riparia, Mangifera sylvatica* Roxb., *Shorea obtusa* Wall., *Millettia ovalifolia* Kurz	2017-02-04 11:47:03AM	96.390627	20.877732

PLANT ASSOCIATION	ELEVATION(m)	NAME	BAMBOO SPECIES	DOMINANT TREE SPECIES	VEGETATION TYPE	IUCN red list Species	Comment	POINT_X	POINT_Y
Kurz	329	APM-24		*orientalis* (L.) Blume, *Wendlandia tinctoria* DC., *Mitragyna rotundifolia* (Roxb.) Kuntze, *Pterocarpus indicus*Willd., *Harrisonia perforata* Merr., *Anthocephalus morindaefolius* Korth.,*Xylia xylocarpa* (Roxb.)Taub., *Melanorrhoea usitata* Wall., *Shorea obtusa* Wall., *Cratoxylum polyanthum*Korth., *Albizia lebbekoides* (DC.) Benth., *Dalbergia oliveri* Gamble		*Dalbergia cultrata* Grah., *Dalbergia oliveri* Gamble, *Homonoia riparia*, *Pterocarpus indicus*Willd	2017-02-04 11:58:18AM	96.391085	20.876780
	330	APM-25				*Dalbergia cultrata* Grah., *Dalbergia oliveri* Gamble, *Homonoia riparia*,	2017-02-04 12:04:32PM	96.391166	20.875372
	337	APM-26				*Dalbergia cultrata* Grah., *Shorea obtusa* Wall., *Shorea siamensis* (Kurz) Miq.	2017-02-04 12:15:27PM	96.392290	20.874311
	341	APM-27				*Dalbergia rimosa* Roxb.,*Pterocarpus indicus*Willd.	2017-02-04 12:17:41PM	96.392448	20.873938
	348	APM-28					2017-02-04 12:22:37PM	96.392460	20.872359
	358	APM-29					2017-02-04 12:27:28PM	96.392614	20.871414
	504	APM-30				*Dipterocarpus tuberculatus* Roxb.,Shorea obtusa Wall., Shorea siamensis (Kurz) Miq.	2017-02-05 7:56:55AM	96.375571	20.870139
	528	APM-31				*Dalbergia oliveri* Gamble, *Dipterocarpus tuberculatus* Roxb.,*Shorea obtusa* Wall., *Shorea siamensis* (Kurz) Miq., *Pterocarpus indicus*Willd	2017-02-05 8:07:55AM	96.374747	20.870647

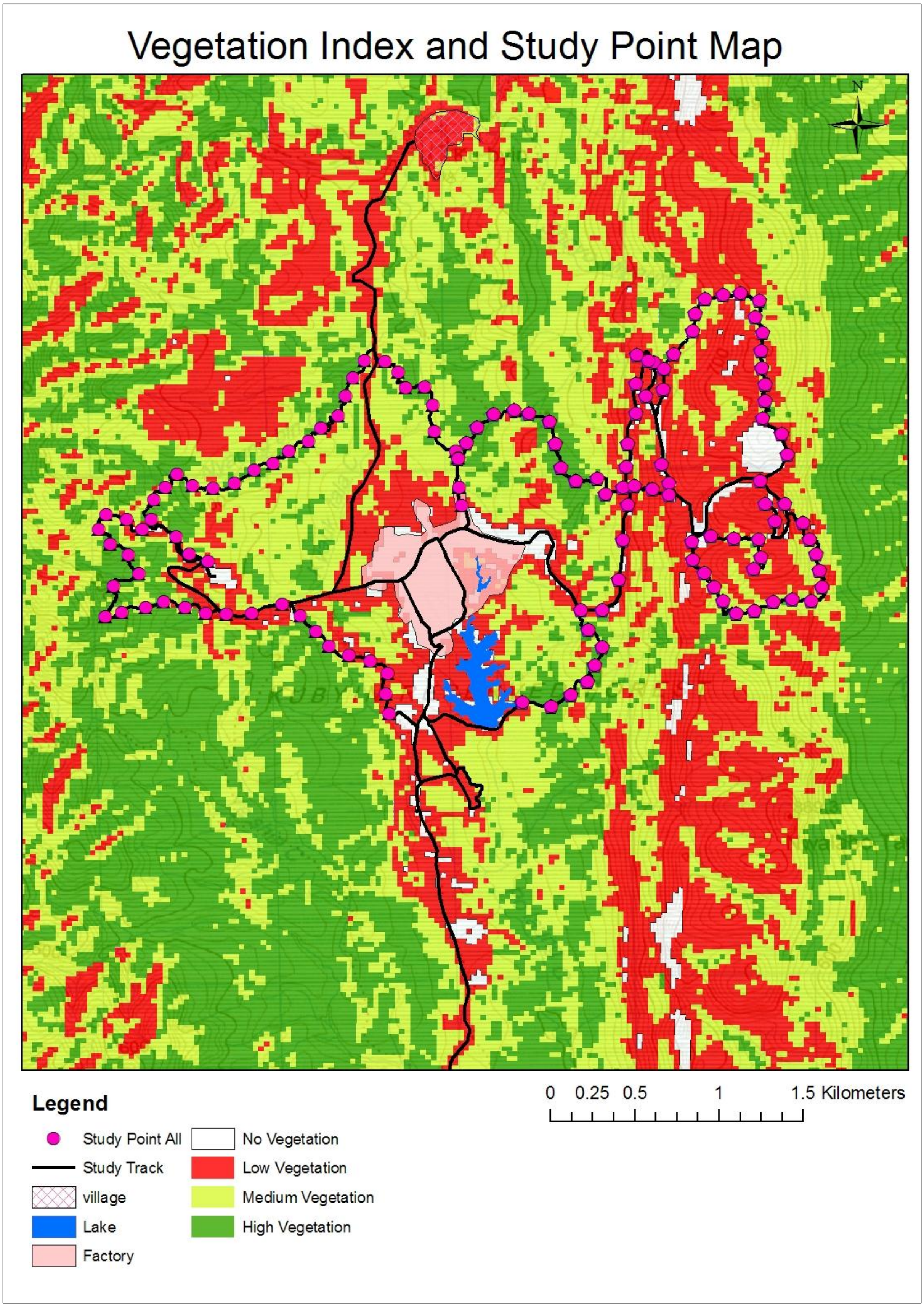
PLANT ASSOCIATION	ELEVATION(m)	NAME	BAMBOO SPECIES	DOMINANT TREE SPECIES	VEGETATION TYPE	IUCN red list Species	Comment	POINT_X	POINT_Y
	543	APM-32				*Dalbergia oliveri* Gamble, *Dipterocarpus tuberculatus Roxb.,Shorea obtusa Wall., Shorea siamensis (Kurz) Miq.,*	2017-02-05 8:23:04AM	96.373630	20.870909
	549	APM-33				*Dalbergia oliveri* Gamble, *Dalbergia rimosa* Roxb., *Dipterocarpus tuberculatus Roxb.,Shorea obtusa Wall., Shorea siamensis (Kurz) Miq.,Dendrocalamus membranaceus* Munro	2017-02-05 8:36:06AM	96.373262	20.870129
Association IV. *Tectona grandis* L. f., *Xylia xylocarpa* (Roxb.)Taub., and *Thyrsostachys oliveri* Gamble	482	APM-34	*Thyrsostachys oliveri* Gamble, *Bambusa polymorpha* Munro, *Dendrocalamus longispathus* (Kurz) Kurz, *Dendrocalamus membranaceus* Munro, *Dinochloa maclellandii* Kurz	*Tectona grandis* L. f., *Xylia xylocarpa* (Roxb.)Taub., *Dipterocarpus tuberculatus* Roxb., *Dalbergia oliveri* Gamble, *Mitragyna rotundifolia* (Roxb.) Kuntze, *Pterocarpus indicus*Willd., *Harrisonia perforata* Merr., *Trema orientalis* (L.) Blume, *Shorea siamensis* (Kurz) Miq., *Grewia laevigata* Vahl, *Lagerstroemia tomentosa* Presl., *Anthocephalus morindaefolius* Korth., *Phyllanthus albizzioides* (Kurz)Hook.f., *Melanorrhoea usitata* Wall., *Shorea obtusa* Wall.	Mixed Broad-leaved Deciduous Forest	*Dalbergia cultrata* Grah., *Dalbergia oliveri* Gamble, *Pterocarpus indicus*Willd., *Dendrocalamus membranaceus* Munro, *Millettia ovalifolia* Kurz	2017-02-05 9:04:34AM	96.373877	20.869372
	458	APM-35				*Dalbergia cultrata* Grah., *Dalbergia oliveri* Gamble, *Pterocarpus indicus*Willd., *Millettia ovalifolia* Kurz	2017-02-05 9:33:39AM	96.374824	20.868780
	442	APM-36					2017-02-05 9:41:02AM	96.375380	20.867756
	461	APM-37				*Pterocarpus indicus*Willd., *Millettia ovalifolia* Kurz	2017-02-05 9:54:36AM	96.374059	20.867108

PLANT ASSOCIATION	ELEVATION(m)	NAME	BAMBOO SPECIES	DOMINANT TREE SPECIES	VEGETATION TYPE	IUCN red list Species	Comment	POINT_X	POINT_Y
	532	APM-38				*Dalbergia cultrata* Grah., *Dalbergia oliveri* Gamble, *Pterocarpus indicus*Willd., *Millettia ovalifolia* Kurz	2017-02-05 10:21:15AM	96.373606	20.865480
	515	APM-39				*Dalbergia cultrata* Grah., *Dalbergia oliveri* Gamble, *Pterocarpus indicus*Willd., *Dendrocalamus membranaceus* Munro, *Millettia ovalifolia* Kurz	2017-02-05 10:35:13AM	96.374459	20.865723
	481	APM-40				*Dalbergia cultrata* Grah., *Dalbergia oliveri* Gamble, *Pterocarpus indicus*Willd.,	2017-02-05 10:47:52AM	96.375768	20.865950
	450	APM-41				*Dalbergia cultrata* Grah., *Pterocarpus indicus*Willd., Shorea obtusa Wall., *Dipterocarpus tuberculatus Roxb.,Shorea obtusa Wall., Shorea siamensis (Kurz) Miq.,*	2017-02-05 10:55:26AM	96.376735	20.866259
	443	APM-42				*Dalbergia cultrata* Grah., *Pterocarpus indicus*Willd., *Dipterocarpus tuberculatus* Roxb.	2017-02-05 11:03:29AM	96.377860	20.865964
	422	APM-43				*Dalbergia oliveri* Gamble	2017-02-05 11:24:29AM	96.378946	20.865674

PLANT ASSOCIATION	ELEVATION(m)	NAME	BAMBOO SPECIES	DOMINANT TREE SPECIES	VEGETATION TYPE	IUCN red list Species	Comment	POINT_X	POINT_Y
	400	APM-44				*Pterocarpus indicus*Willd., *Dendrocalamus membranaceus* Munro	2017-02-05 11:29:57AM	96.380064	20.865611
Association V. *Xylia xylocarpa* (Roxb.)Taub., *Tectona grandis* L. f., and *Bambusa polymorpha* Munro	389	APM-45	*Bambusa polymorpha* Munro, *Thyrsostachys oliveri* Gamble, *Dendrocalamus longispathus* (Kurz) Kurz, *Bambusa tulda* Roxb., *Dinochloa maclellandii* Kurz	*Xylia xylocarpa* (Roxb.)Taub., *Tectona grandis* L. f., *Harrisonia perforata* Merr., *Pterocarpus indicus*Willd., *Anthocephalus morindaefolius* Korth., *Trema orientalis* (L.) Blume, *Mitragyna rotundifolia* (Roxb.) Kuntze, *Grewia laevigata* Vahl, *Terminalia alata* (Heyne) Roth, *Lagerstroemia tomentosa* Presl., *Croton oblongifolius* Roxb.	Mixed Broad-leaved Deciduous Forest		2017-02-05 11:35:10AM	96.381425	20.865675
	389	APM-46				*Pterocarpus indicus*Willd.	2017-02-05 11:38:35AM	96.383042	20.866146
	394	APM-47				*Dalbergia cultrata* Grah., *Pterocarpus indicus*Willd.	2017-02-05 11:43:40AM	96.383992	20.865522
	367	APM-48				*Dalbergia cultrata* Grah., *Pterocarpus indicus*Willd.	2017-02-05 11:49:30AM	96.384851	20.864678
	364	APM-49				*Dalbergia oliveri* Gamble, *Pterocarpus indicus*Willd.	2017-02-05 11:53:57AM	96.385532	20.863907
	371	APM-50				*Dalbergia oliveri* Gamble, *Pterocarpus indicus*Willd.	2017-02-05 11:58:23AM	96.386608	20.863440
	373	APM-51				*Pterocarpus indicus*Willd.	2017-02-05 12:03:25PM	96.387754	20.863106
	364	APM-52				*Dalbergia oliveri* Gamble, *Pterocarpus indicus*Willd.	2017-02-05 12:07:59PM	96.388676	20.862448

PLANT ASSOCIATION	ELEVATION(m)	NAME	BAMBOO SPECIES	DOMINANT TREE SPECIES	VEGETATION TYPE	IUCN red list Species	Comment	POINT_X	POINT_Y
	355	APM-53				*Dalbergia cultrata* Grah., *Dalbergia oliveri* Gamble, *Pterocarpus indicus*Willd., *Tetrameles nudiflora* R. Br.	2017-02-05 12:10:47PM	96.388553	20.861350
	350	APM-54					2017-02-05 12:13:43PM	96.388765	20.860306
APM=Apache Mud Stone									

Map. I. Vegetation Indax and Study Point Map



Map. II. Forest Type and Red list Species Distribution Map

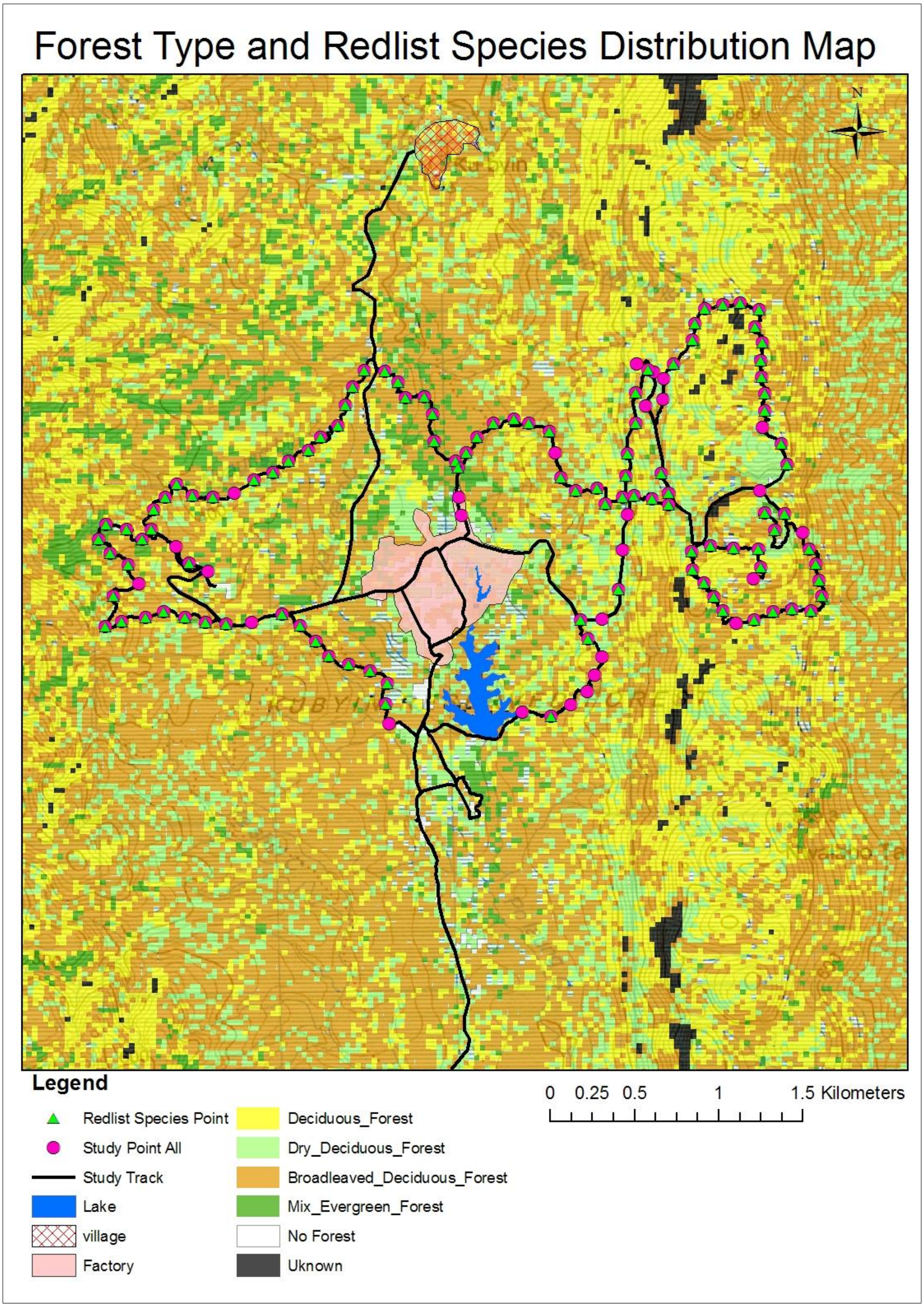


Table.7. Checklist of Lime Stone and Mud Stone Areas

No.	Scientific Name	Common Name	Family Name
1	*Abelmoschus moschatus*	Taw-yon-pa-de	Malvaceae
2	*Acacia arabica* Willd.	Pok-thin-thwa/Su-phyu	Mimosaceae
3	*Acacia catechu* Willd.	Sha	Mimosaceae
4	*Acacia concinna* (Willd.) DC.	Taw-kin-mon-chin	Mimosaceae
5	*Acacia intsia* Willd.	Su-pok-gyi	Mimosaceae
6	*Acacia pennata* (L.) Willd.	Su-yit	Mimosaceae
7	*Achyranthes* aspera L.	Kyet-mauk-su-pyan	Amaranthaceae
8	*Acmella calva* (DC.) R.K. Jansen	Pe-le-nyin	Asteraceae
9	*Adenostemma viscosum*	Not known	Asteraceae
10	*Adina cordifolia* Hook. f.	Hnaw	Rubiaceae
11	*Aeginetia pedunculata* Wall.	Kauk-hlaing-di-yaing	Orobanchaceae
12	*Aegle marmelos* L.	Ok-shit	Rutaceae
13	*Ageratum conyzoides* L.	Khwe-thay-pan	Asteraceae
14	*Ajuga lupulina*	Not known	Lamiaceae
15	*Alangium chinense* (Lour.)Harms.	Hmaik	Alangiaceae
16	*Albizia lebbek* (L.)Benth.	Taung-ko-kko	Mimosaceae
17	*Albizia lebbekoides* (DC.) Benth.	Taung-ma-gyi	Mimosaceae
18	*Alternanthera sessilis* (L.) R.Br.	Pa-zun-sa-yaing	Amaranthaceae
19	*Amaranthus aspera*	Not known	Amaranthaceae
20	*Amaranthus gracilis* Desf.	Hin-nu-nwe-yaing	Amaranthaceae
21	*Anisomeles indica*	Not known	Lamiaceae
22	*Anogeissus acuminata* Wall.	Yon	Combretaceae
23	*Anthocephalus morindaefolius* Korth.	Ma-u-let-tan-shae	Rubiaceae
24	*Antidesma velutinum*Tul.	Kin-pa-lin	Euphorbiaceae
25	*Aporusa dioica* (Roxb.) Mull.Arg.	Thit-khauk	Euphorbiaceae
26	*Argyreia nervosa*	Not known	Convolvulaceae
27	*Argyreia roxburghii* Choisy	Not known	Convolvulaceae
28	*Armillaria mellea* (VahlFr.) Kummer.	Not known	Physalacriaceae
29	*Bambusa bambos* (L.)Voss	Kya-khat-wa	Poaceae
30	*Bambusa polymorpha* Munro	Kya-thaung-wa	Poaceae
31	*Bambusa tulda* Roxb.	Thaik-wa	Poaceae
32	*Bauhinia malabarica* Roxb.	Pha-lan/Chin-byit	Caesalpiniaceae
33	*Bauhinia ornata* Kurz	Myauk-hle-kha	Caesalpiniaceae
34	*Bauhinia* sp.	Swe-daw-nwee	Caesalpiniaceae
35	*Bidens pilosa*	Hmwe-sok	Asteraceae
36	*Blechnum orientale*	Not known	Blechnaceae
37	*Bliospermum axillare* Blume	Hnat-cho	Euphorbiaceae
38	*Bliospermum axillare* Blume	Hnat-cho	Euphorbiaceae
39	*Blumea balsamifera* DC..	Phon-ma-thein	Asteraceae
40	*Boehmeria grandifolia*	Not known	Urticaceae

No.	Scientific Name	Common Name	Family Name
41	*Boehmeria* sp.	Not known	Urticaceae
42	*Bombax anceps* Pierre	Ko-khe	Bombacaceae
43	*Bombax ceiba* L.	Let-pan	Bombacaceae
44	*Bombax insigne* Wall.	De-du	Bombacaceae
45	*Bridelia retusa* L.	Seik-chee	Euphorbiaceae
46	*Buchanania lazan* Spreng.	Lun-pho	Anacardiaceae
47	*Buddleja asiatica*	Pon-ma-gyi	Buddlejaceae
48	*Butea superba* Roxb.	Pauk-nwee	Fabaceae
49	*Caesalpinia decapetala (Roth.)Alston*	Suk-yan-bo /Kyant-sa-su-pin	Caesalpiniaceae
50	*Cajanus cajan*	Pe-sin-ngone	Fabaceae
51	*Callicarpa arborea* Roxb.	Kyun-na-lin	Verbenaceae
52	*Callicarpa longifolia*	Kun-na-lin-thay	Verbenaceae
53	*Callicarpa nudiflora*	Kyun-na-lin	Verbenaceae
54	*Calotropis gigantea*	Ma-yoe	Apocynaceae
55	*Calycopteris floribunda* Lam.	Gyut-nwe	Combretaceae
56	*Canscora diffusa* (Vahl) R.Br.	Kyauk-pan	Gentianaceae
57	*Careya arborea* Roxb.	Ban-bwe	Lecythidaceae
58	*Cassia fistula* L.	Ngu	Caesalpiniaceae
59	*Cassia timoriensis* DC.	Not known	Caesalpiniaceae
60	*Cayratia trifolia*	Not known	Vitaceae
61	*Celosia argentea* L.	Taw-kyet-mauk	Amaranthaceae
62	*Centratherum punctatum*	Not known	Asteraceae
63	*Cephalostachyum pergracile* Munro	Tin-wa	Poaceae
64	*Chloris barbata*	Not known	Poaceae
65	*Chromolaena odorata* (L.) R.M. King & H Robinson	Bi-zet	Asteraceae
66	*Chukrasia velutina* Roem.	Yin-ma	Meliaceae
67	*Cissampelos pareira* L.	Not known	Menispermaceae
68	*Clematic fasiculiflora* L.	Khwa-nyo	Ranunculaceae
69	*Congea tomentosa* Roxb.	Tha-ma-ga-nwee	Verbenaceae
70	*Corchorus aestuans* L.	Byauk-o	Tiliaceae
71	*Corchorus capsularis* L.	Gon-shaw/Khwe-la-but	Tiliaceae
72	*Cosmos caudatus*	Sein-chel	Asteraceae
73	*Costus specious* Sm.	Pha-lan-taung-hmwe	Costaceae
74	*Crassocephalum crepidioides* (Benth.) S. Moor.	Pan-zauk-htoe	Asteraceae
75	*Cratoxylum neriifolium* Kurz.	Be-bya	Hypericaceae
76	*Cratoxylum polyanthum*Korth.	Be-bya	Hypericaceae
77	*Crotalaria mucronata* L.	Taw-paik-san	Fabaceae
78	*Crotalaria multiflora* L.	Not known	Fabaceae
79	*Croton oblongifolius* Roxb.	Tha-yin-gyi	Euphorbiaceae
80	*Crypteronia pubescens* Blume	A-nan-pho	Crypteroniaceae
81	*Cryptolepis buchanani* Rome.& Schult	Na-sha-gyi	Asclepiadaceae

No.	Scientific Name	Common Name	Family Name
82	*Cucumis maderaspatanus*	Not known	Cucurbitaceae
83	*Curcuma aurantiaca*	Ma-la	Zingiberaceae
84	*Cymbidium aloifolium* (L.)Sw.	Thit-tet-lin-nae	Orchidaceae
85	*Dactyloctenium aegyptium*	Lay-gwa-myet	Poaceae
86	*Dalbergia cultrata* Grah.	Yin-daik	Fabaceae
87	*Dalbergia oliveri* Gamble	Ta-ma-lan	Fabaceae
88	*Dalbergia rimosa* Roxb.	Daung-ta-laung	Fabaceae
89	*Dalbergia volubilis* Roxb.	Daung-ta-laung	Fabaceae
90	*Dendrocalamus longispathus* (Kurz) Kurz	Wa-net	Poaceae
91	*Dendrocalamus membranaceus* Munro	Hmyin-wa	Poaceae
92	*Derris* sp.	Not known	Fabaceae
93	*Desmodium heterophyllum* (Willd.)DC.	Not known	Fabaceae
94	*Desmodium pulchellum* Benth.	Taung-da-min	Fabaceae
95	*Dillenia parviflora* Griff	Kyet-zin-byun	Dilleniaceae
96	*Dillenia pentagyna* Roxb.	Zin-byun	Dilleniaceae
97	*Dinochloa maclellandii* Kurz	Ba-du-ma-wa/Wa-nwee	Poaceae
98	*Dioscorea bulbifera*	Myauk-u	Dioscoreaceae
99	*Dioscorea cylindrica* Burm.	Kywe-thon-ywet	Dioscoreaceae
100	*Dioscorea pentaphylla* L.	Kywe-ngar-ywet	Dioscoreaceae
101	*Dioscorea sativa* L.	Kauk-yin-nwee	Dioscoreaceae
102	*Diospyros kika* L.f.	Te	Ebenaceae
103	*Diospyros montana* Roxb.	Gyok	Ebenaceae
104	*Dipterocarpus tuberculatus* Roxb.	In	Dipterocarpaceae
105	*Duabanga grandiflora*	Myauk-ngo	Lythraceae
106	*Ehretia acuminata* R.Br	Taung-poe-lu-lin	Boraginaceae
107	*Elephantopus scaber* L.	Not known	Asteraceae
108	*Entada scandens* Benth.	Doe-nwee	Mimosaceae
109	*Erythrina stricta* Roxb.	Ka-thit	Fabaceae
110	*Eugenia balsamea* Wight	Ye-tha-bye	Myrtaceae
111	*Euphorbia antiquorum* L.	Tazaung-gyi	Euphorbiaceae
112	*Euphorbia hypericifolia* L.	Kywe-kyaung-hmin-se	Euphorbiaceae
113	*Evolvulus nummularius* L.	Kyauk-kwe	Convolvulaceae
114	*Ficus hispida* L.	Kha-aung	Moraceae
115	*Ficus lacor* Buch.-Ham.	Nyaung-gyin	Moraceae
116	*Ficus microcarpa*	Not known	Moraceae
117	*Ficus obtusifolia* Roxb.	Nyaung-gyat	Moraceae
118	*Ficus racemosa* L.	Ye-tha-phan	Moraceae
119	*Flacourtia cataphracta* Roxb.	Na-ywe	Flacourtiaceae
120	*Flemingia congesta* Roxb.	Kye-hmi	Fabaceae
121	*Flemingia macrophylla* (Willd.) Merr.	Pha-lan-phyu	Fabaceae
122	*Gardenia coronaria* Buch.-Ham.	Yin-gat-gyi	Rubiaceae

No.	Scientific Name	Common Name	Family Name
123	*Getonia floribunda* Roxb.	Kywet-nwee	Combretaceae
124	*Glochidion eriocarpum*	Not known	Euphorbiaceae
125	*Glochidion* sp.	Hta-min-sok	Euphorbiaceae
126	*Goniothalamus laoticus*	Not known	Annonaceae
127	*Grewia laevigata* Vahl	Kyet-ta-yaw	Tiliaceae
128	*Harrisonia perforata* Merr.	Su-gyin	Simaroubaceae
129	*Hemigraphis brunelloides* (Lam.) Bremek.	Not known	Acanthaceae
130	*Heterophragma adenophyllum* Seem.	Phet-than	Bignoniaceae
131	*Hibiscus macrophyllus*	Taung-phet-wun	Malvaceae
132	*Hiptage benghalensis* (L.) Kurz	Bein-new	Malpighiaceae
133	*Holarrhena pubescens* Wall. ex G. Don	Let-htok-gyi	Apocynaceae
134	*Homalium tomentosum* Benth	Myauk-chaw	Flacourtiaceae
135	*Homonoia riparia*	Ye-mo-ma-kha	Euphorbiaceae
136	*Ipomoea angustifolia* Jacq.	Not known	Convolvulaceae
137	*Ipomoea quamoclit* L.	Myet-lay-ni	Convolvulaceae
138	*Ipomoea triloba*	Not known	Convolvulaceae
139	*Justicia procumbens*L.	Not known	Acanthaceae
140	*Justicia* sp.(1)	Not known	Acanthaceae
141	*Justicia* sp.(2)	Not known	Acanthaceae
142	*Kleinhovia hospita* L.	O-tein/Pashu-phet-wun	Sterculiaceae
143	*Lagerstroemia macrocarpa* Kurz	Pyin-ma-ywet-gyi	Lythraceae
144	*Lagerstroemia parviflora* Roxb.	Zaung-pa-lae	Lythraceae
145	*Lagerstroemia speciosa* (L.) Pers.	Pyin-ma	Lythraceae
146	*Lagerstroemia tomentosa* Presl.	Lae-sa	Lythraceae
147	*Lannea coromandelica* (Houtt.) Merrr.	Na-be	Anacardiaceae
148	*Lathyrus latifolius*	Not known	Fabaceae
149	*Leea hirta* Banks	Naga-mauk-phyu	Leeaceae
150	*Leea rubra* Blume.	Naga-mauk-ni	Leeaceae
151	*Lepidagathis semiherbacea* (Clarke) Nees	Not known	Acanthaceae
152	*Leptadenia reticulata* Wight & Arn.	Gon-kha	Asclepiadaceae
153	*Lespedeza bicolor* var. *japonica*	Not known	Fabaceae
154	*Leucaena leucocephala* (Lam.) De.Wit	Baw-za-gaing	Mimosaceae
155	*Lindenbergia philippensis* Benth.	Not known	Scrophulariaceae
156	*Lindenbergia urticaefolia* Lehm.	Not known	Scrophulariaceae
157	*Loranthus pulverulentus* Wall.	Kyi-paung	Loranthaceae
158	*Ludwigia hyssopifolia*	Lay-nyin-thay	Onagraceae
159	*Ludwigia octovalvis*	Lay-nyin-gyi	Onagraceae
160	*Luffa aegyptiaca* Mill.	Tha-but-kha	Cucurbitaceae
161	*Mallotus philippensis* (Lam.)Muell.Arg.	Taw-thi-din	Euphorbiaceae
162	*Mangifera sylvatica* Roxb.	Taung-tha-yet	Anacardiaceae
163	*Markhamia stipulata* (Wall.) Seem.ex K.Schum.	Ma-hlwa	Bignoniaceae

No.	Scientific Name	Common Name	Family Name
164	*Melanorrhoea usitata* Wall.	Sit-se	Anacardiaceae
165	*Merremia hederacea* Hallier f.	Nwe-shoke	Convolvulaceae
166	*Merremia vitifolia* (Burm.f.) Hallier. f.	Kyet-hinga-lae-new	Convolvulaceae
167	*Microcos paniculata* L.	Mya-ya	Meliaceae
168	*Millettia extensa* Benth.	Win-u	Fabaceae
169	*Millettia ovalifolia* Kurz	Thin-win	Fabaceae
170	*Mimosa pudica* L.	Hti-ka-yone	Mimosaceae
171	*Mitragyna rotundifolia* (Roxb.) Kuntze	Bin-ga	Rubiaceae
172	*Moghania macrophylla* Runtze	Not known	Fabaceae
173	*Morinda tinctoria* Roxb.	Ni-ba-sae	Rubiaceae
174	*Mucuna pruriens* (L.)DC.	Khwe-lae-ya	Fabaceae
175	*Musa* sp.	Taw-nga-pyaw	Musaceae
176	*Nauclea orientalis* L.	Ma-u	Rubiaceae
177	*Operculina turpethum* (L.) Silva Mansa	Kyar-hin-nwe	Convolvulaceae
178	*Oroxylum indicum* (L.) Kurz.	Kyaung-sha	Bignoniaceae
179	*Oxalis corniculata* L.	Hmo-chin	Oxalidaceae
180	*Oxystelma esculentum* R.Br.	Kauk-yo-nwee	Asclepiadaceae
181	*Paederia foetida* L.	Pe-bok-nwee	Rubiaceae
182	*Pennisetum purpureum* Schum.	Yon-sa-myet	Poaceae
183	*Phoenix paludosa* Roxb.	Thin-baung	Arecaceae
184	*Phyllanthus albizzioides* (Kurz)Hook.f.	Shit-sha	Euphorbiceae
185	*Phyllanthus emblica* L.	Zi-phyu	Euphorbiaceae
186	*Polygonum chinense* L.	Maha-gar-kyan-sit	Polygonaceae
187	*Potamogeton natans* L.	Floating-leaf Pondweed	Potamogetonaceae
188	*Prema pyramidata* Wall.	Kyun-na-lin/Kyun-pho	Verbenaceae
189	*Pseudoxytenanthera parvifolia* (Brandis ex Gamble)T.Q.Nguyen	Thaiktu-hmyintu	Poaceae
190	*Pteris vittata*	Brake Fern	Pteridaceae
191	*Pterocarpus indicus*Willd.	Taw-pa-dauk	Fabaceae
192	*Pterospermum semisagittatum* Buch.-Ham.	Na-gye	Sterculiaceae
193	*Pueraria lobata* var. *montana*	Not known	Fabaceae
194	*Ricinus communis* L.	Kyet-su	Euphorbiaceae
195	*Salvia regla*	Not known	Lamiaceae
196	*Salvia* sp.	Not known	Lamiaceae
197	*Salvia splendens*Ker Gawl.	Not known	Lamiaceae
198	*Samadera indica* Gaertn.	Ka-di	Simaroubaceae
199	*Schleichera oleosa* (Lour.) Oken	Gyo	Sapindaceae
200	*Scoparia dulcis* L.	Dana-thu-kha	Scrophulariaceae
201	*Senna hirsuta* (L.) Irwin & Barneby	Ka-thaw-hmwe-htu	Caesalpiniaceae
202	*Senna timoriensis* (DC.)(DC.) H. S. Irwin & Barneby	Taw-ma-zeli	Caesalpiniaceae
203	*Senna tora* (L.) Roxb	Dan-gwe	Caesalpiniaceae
204	*Sesbania paludosa* Roxb.	Nyan	Fabaceae

No.	Scientific Name	Common Name	Family Name
205	*Setaria lutescens* Hubb.	Yon-sa	Poaceae
206	*Shorea obtusa* Wall.	Thit-ya	Dipterocarpaceae
207	*Shorea siamensis* (Kurz) Miq.	In-gyin	Dipterocarpaceae
208	*Sida acuta* Burm f.	Ta-byet-si	Malvaceae
209	*Smilax aspericaulis* Wall ex A. D.C.	Sein-na-baw-thay	Smilaceae
210	*Smilax macrophylla* Roxb.	Sein-na-baw-gyi	Smilaceae
211	*Spermacoce mauritiana*	Not known	Rubiaceae
212	*Spondias pinnata* (L. f.) Kurz.	Taw-gwe	Anacardiaceae
213	*Sterculia foetida* L.	Let-khok	Sterculiaceae
214	*Sterculia ornata* Wall. ex Kurz	Don-shaw	Sterculiaceae
215	*Sterculia versicolor* Wall.	Shaw-phyu	Sterculiaceae
216	*Stereospermum colais* (Buch.-Ham. ex Dillwyn) Mabb.	Than-thay	Bignoniaceae
217	*Stereospermum suaveolens* (Roxb.) DC.	Kywe-ma-gyo-lein	Bignoniaceae
218	*Strobilanthes auriculata*	Not known	Acanthaceae
219	*Strobilanthes rufescens* T. Anders.	Not known	Acanthaceae
220	*Strychnos nux-blanda* A.W. Hill	Ka-baung	Loganiaceae
221	*Tadehagi triquetrum* (L.)H. Ohashi	Lauk-thay	Fabaceae
222	*Tectona grandis* L. f.	Kyun	Verbenaceae
223	*Terminalia alata* (Heyne) Roth	Htauk-kyant	Combretaceae
224	*Terminalia pyrifolia* Kurz	Lein-pin	Combretaceae
225	*Tetrameles nudiflora* R. Br.	Baing	Datiscaceae
226	*Tetrastigma planicaule*	Not known	Vitaceae
227	*Thunbergia grandiflora* (Roxb. ex Rottl.) Roxb.	Kyi-hnok-thi	Acanthaceae
228	*Thunbergia laurifolia* Lindl.	Kyi-hnok-thi	Acanthaceae
229	*Thyrsostachys oliveri* Gamble	Tha-net-wa	Poaceae
230	*Tinospora nudiflora* Kurz	Sin-don-ma-nwee	Menispermaceae
231	*Trema orientalis* (L.) Blume	Khwe-sha	Ulmaceae
232	*Trichosanthes cordata* Roxb.	Kyi-ah	Cucurbitaceae
233	*Tristaniopsis burmanica* (Griff.)P.G. Wilson & J.T. Waterh.	Taung-tha-bye	Myrtaceae
234	*Triumfetta bartramia* L.	Ket-si-ne-thay	Tiliaceae
235	*Urena lobata* L.	Ket-si-ne-gyi	Malvaceae
236	*Utricularia* sp.	Bladderwort	Lentibularaceae
237	*Uvaria cordata* Schum. & Thonn.	Tha-but-gyi	Annonaceae
238	*Vangueria spinosa* Roxb.	Magyi-bauk	Rubiaceae
239	*Ventilago maderaspatana* Benth.	Ta-yaw-nyo	Rhamnaceae
240	*Vernonia arborea*	Not known	Asteraceae
241	*Vitex peduncularis* Wall.	Phet-le-zin	Verbenaceae
242	*Vitex pubescens* Vahl	Kyet-yoe	Verbenaceae
243	*Vitis discolour*	Ta-bin-taing-mya-nan-phyu	Vitaceae
244	*Vitis repens*	Ta-bin-taing-mya-nan-ni	Vitaceae
245	*Wendlandia tinctoria* DC.	Thit-ni/Hta-min-chauk	Rubiaceae

No.	Scientific Name	Common Name	Family Name
246	*Wrightia arborea* (Dennst.) Mabb.	Let-htok-thein	Apocynaceae
247	*Xylia xylocarpa* (Roxb.)Taub.	Pyin-ka-doe	Mimosaceae
248	*Zanthoxylum budrunga* Wall.	Ma-yanin-kyet-su	Rutaceae
249	*Ziziphus glabra* Roxb.	Taw-zi-nwee/Paung-bet	Rhamnaceae
250	*Ziziphus jujuba* Lam.	Zi	Rhamnaceae

Plant Survey Documentorty of Lime Stone Area

Plant Survey Documentorty of Mud Stone Area

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FLORA REPORT of COAL MINE AREA, PALUZAWA

February, 2017

I. Coal Mine Area

Introduction

Flora survey group conducted the survey start from 8th February to 15th February 2017 in the area of Palusawa Coal Mine area.

During the survey we made (141) plots on (5) transects wherever possible to get assessments.

We could record 235 species as inventory of the area, among them 28 IUCN listed species and 12 invasive species were found. According to the included plant`s association, it could be categorized as deciduous forests, mixed broad-leaved, decidiuos forest and bamboo forest.

Deciduous Forest

Mixed Broad-leaved Deciduous Forest

Bamboo Forest

Objectives

- Identify main vegetation types including IUCN listed species
- Invasive alien species
- Vegetative Maps and subsequently ground truth the above

Participants

Team Leader: Dr Win Myint, Ecologist
Taxonomist: U Nyo Maung,
Taxonomist: Dr Ei Ei Phyoe,
GIS/RS and Biotanist: U Tun Thura
Taxonomist assistant: U Thein Phyoe Aung

Survey Method

The Global Positioning System was used to navigate and mark the coordinates of the sample plots to know the species population for vegetation identification. In order to obtain essential data for species composition in the area and sample plots of 100 mx 100m, along line were set up. The species identification was carried out by using key to families of plants and relevant literature and was confirmed by literatures.

Random Transect Method

Sampling individual sites were built to get representative individual plant species, and plants collection was carried out.

Mapping

Location maps are set by the method based on the landsat 8 settilte image (LANDSAT-7="LE71350442017043EDC00", WGS 1984, coordinate system to determine the forests of the areas. Vegetion index is categorized by NDVI (Normalized Difference Vgetation Index) values indicate the amount of green vegetation present in the pixel. Higher NDVRI values indicate more green vegetation. ENVI's NDVI uses the standard algorithm: NDVI=(NIR-RED/NIR+RED)

Data Analysis

After field survey, data entry is made in excel work sheet. Identify the collected data matching with the type specimens, checking their recorded characteristic features and confirm by plant taxonomic websites of internet, after getting the inventory check list, match by the IUCN Red Data book categories, invasive species list and decides the vegetation types of the area according to the dominant plants species from representative areas. Eventually the results of forest types are developed on the maps depend on their coordinations.

IUCN Red List of Threatened Species

Recorded species are evaluated for their threats status according to the IUCN Red Data book categories. The Red Data book categories provide an easily and widely understood method for highlighting those species under higher extinction risk, so as to focus attention on conservation measures designed to protect them. The distribution of the Red Data categorized species is mentioned by their GPS positions.

Invasive Species

Collected species are evaluated by the list of forest invasive species of Myanmar.

Equipments

Equipments used for plotting and locating transects are compass and measuring tapes and other necessary equipment's are digital camera for photographic documentation, laptop computer for data storage, GPS for positioning and navigation, maps. For specimen collection, the following accessories will be needed, 10x hand lens for magnifying, permanent marker for marking, field note books for data entry.

Table.1. Species List of Coal Mine Area

No.	Scientific Name	Common Name	Family Name	Habits
1	*Abelmoschus crinitus* Wall.	Taw-wa	Malvaceae	S
2	*Abelmoschus moschatus*	Taw-yon-pa-de	Malvaceae	S
3	*Abutilon indicum* (L.) Sweet	Bauk-khway	Malvaceae	S
4	*Acacia intsia* Willd.	Su-pok-gyi	Mimosaceae	CL
5	*Acacia pennata* (L.) Willd.	Su-yit	Mimosaceae	S
6	*Achyranthes aspera* L.	Kyet-mauk-su-pyan	Amaranthaceae	H
7	*Adina cordifolia* Hook. f.	Hnaw	Rubiaceae	T
8	*Aegle marmelos* L.	Ok-shit	Rutaceae	T
9	*Ageratum conyzoides* L.	Khwe-thay-pan	Asteraceae	H
10	*Albizia lebbek* (L.)Benth.	Taung-ko-kko	Mimosaceae	T
11	*Albizia lebbekoides* (DC.) Benth.	Taung-ma-gyi	Mimosaceae	T
12	*Albizia odoratissima* (L.f.)Benth.	Gote-kye	Mimosaceae	T
13	*Alstonia scholaris*(L.) R. Br.	Taung-ma-yoe/Say-kha-gyi	Apocynaceae	T
14	*Amaranthus spinosus* L.	Hnin-nu-new-su-bauk	Amaranthaceae	H
15	*Ampelocissus barbata* Planch.	Not known	Vitaceae	CL
16	*Anogeissus acuminata* Wall.	Yone	Combretaceae	T
17	*Anthocephalus morindaefolius* Korth.	Ma-u-let-lan	Rubiaceae	T
18	*Antidesma velutinum*Tul.	Kin-pa-lin	Euphorbiaceae	ST
19	*Ardisia polycephala* Roxb.	Kyet-ma-ok	Myrsinaceae	S
20	*Argemone mexicana* L.Sp.	Kon-kha-ya	Papaveraceae	S
21	*Argyreia nervosa*	Not known	Convolvulaceae	Cl/Cr
22	*Armillaria mellea* (VahlFr.) Kummer.	Not known	Physalacriaceae	M

No.	Scientific Name	Common Name	Family Name	Habits
23	*Artocarpus chaplasha* Roxb.	Taung-pein-ne	Moraceae	T
24	*Artocarpus lakoocha* Roxb.	Myauk-la-khauk	Moraceae	T
25	*Arundinella hispida* (Humb.& Bonpl. ex Willd.)Kuntze	Pyaung-sa-myet	Poaceae	G
26	*Asparagus densiflorus*	Shint-ma-tet	Asparagaceae	CL
27	*Auricularia auricula-judae*	Kywet-na-ywet-hmo	Auriculariaceae	M
28	*Bambusa tulda* Roxb.	Thaik-wa	Poaceae	B
29	*Bauhinia forficata* Link	Min-ka-daw-kyet-kyay-kite	Caesalpiniaceae	Cl
30	*Bauhinia malabarica* Roxb.	Pha-lan/Chin-byit	Caesalpiniaceae	T
31	*Bauhinia* sp.	Swe-daw-nwee	Caesalpiniaceae	Cl/Cr
32	*Beilschmiedia roxburghiana* Nees	Myauk-ok-shit	Lauraceae	T
33	*Bidens pilosa*	Hmwe-sok	Asteraceae	H
34	*Bliospermum axillare* Blume	Hnat-cho	Euphorbiaceae	H
35	*Blume balsamifera* DC..	Phon-ma-thein	Asteraceae	S
36	*Bombax ceiba* L.	Let-pan	Bombacaceae	T
37	*Bombax insigne* Wall.	Taung-let-pan	Bombacaceae	T
38	*Bridelia retusa* L.	Seik-chee	Euphorbiaceae	ST
39	*Buchanania latifolia* Roxb.	Lun-pho	Anacardiaceae	T
40	*Buddleja asiatica*	Pon-ma-gyi	Buddlejaceae	S
41	*Butea monosperma* (Lam.)Kuntze	Pauk-pin	Fabaceae	T
42	*Butea superba* Roxb.	Pauk-nwee	Fabaceae	CL
43	*Caesalpinia decapetala* (Roth.)Alston	Suk-yan-bo /Kyant-sa-su-pin	Caesalpiniaceae	Cl/Cr
44	*Calamus erectus* Roxb.	Taung-kyein	Arecaceae	Cl/Cr
45	*Callicarpa nudiflora*	Kyun-na-lin	Verbenaceae	T
46	*Calotropis gigantea*	Ma-yoe	Apocynaceae	S
47	*Canscora diffusa* (Vahl) R.Br.	Kyauk-pan	Gentianaceae	H
48	*Cardiospermum halicacabum* L.	Ka-la-myet-si	Sapindaceae	Cl/Cr
49	*Careya arborea* Roxb.	Ban-bwe	Lecythidaceae	T
50	*Caryota mitis* Lour.	Min-baw	Arecaceae	T
51	*Cassia fistula* L.	Ngu	Caesalpiniaceae	T
52	*Cayratia trifolia*	Not known	Vitaceae	CL
53	*Cedrela febrifuga* Blume	Ye-ta-ma	Meliaceae	T
54	*Celosia argentea*	Kyet-mauk	Amaranthaceae	S
55	*Cephalostachyum pergracile* Munro	Tin-wa	Poaceae	B
56	*Chassalia curviflora*	Phet-ya	Rubiaceae	S
57	*Chromolaena odorata* (L.) R.M. King & H Robinson	Bi-zet	Asteraceae	S
58	*Chukrasia velutina* Roem.	Yin-ma	Meliaceae	T
59	*Clausena excavata* Burm.f.	Seik-nan	Rutaceae	S
60	*Clausena heptaphylla* (Roxb.) Wight & Arn.	Taw-pyin-daw-thein	Rutaceae	S
61	*Clematic fasiculiflora* L.	Khwa-nyo	Ranunculaceae	CL
62	*Cleome viscosa* L.	Hin-ga-la-yaing	Capparaceae	H
63	*Clerodendrum infortunatum* Gaertn.	Phet-kha	Verbenaceae	S

No.	Scientific Name	Common Name	Family Name	Habits
64	*Clerodendrum villosum* Blume	Thin-gyan-pan	Verbenaceae	S
65	*Colona floribunda*	Pet-shat	Tiliaceae	T
66	*Congea tomentosa* Roxb.	Tha-ma-ga-nwee	Verbenaceae	Cl/Cr
67	*Corchorus capsularis* L.	Gon-shaw/Khwe-la-but	Tiliaceae	S
68	*Cordia myxa* L.	Tha-net	Boraginaceae	T
69	*Costus specious* Sm.	Pha-lan-taung-hmwe	Costaceae	H
70	*Crassandra* sp.	Not known	Acanthaceae	H
71	*Cratoxylum cochinchinense*	Pe-ma-kyit	Hypericaceae	ST
72	*Cratoxylum polyanthum* Korth	Pe-ma-kyit	Hypericaceae	ST
73	*Crotalaria albida* Heyne ex Roth	Not known	Fabaceae	S
74	*Croton oblongifolius* Roxb.	Tha-yin-gyi	Euphorbiaceae	ST
75	*Cryptolepis buchanani* Rome.& Schult.	Na-sha-gyi	Asclepiadaceae	Cl/Cr
76	*Curculigo recurvata* Dryand.	Kywet-ma-lut-ohn	Hypoxidaceae	H
77	*Cymbidium aloifolium* (L.) Sw.	Thit-tet-lin-nae	Orchidaceae	E
78	*Dalbergia cultrata* Grah.	Yin-daik	Fabaceae	T
79	*Dalbergia paniculata* Roxb.	Ta-pauk	Fabaceae	T
80	*Dalbergia rimosa* Roxb.	Daung-ta-laung	Fabaceae	ST
81	*Dalbergia stipulacea* Roxb.	Ta-ma-lan-nwee	Fabaceae	Cl/Cr
82	*Dalbergia volubilis* Roxb.	Daung-ta-laung	Fabaceae	ST
83	*Dendrocalamus calostachyus* (Kurz)Kurz	Wa-bo-wa	Poaceae	B
84	*Dendrocalamus membranaceus* Munro	Hmyin-wa	Poaceae	B
85	*Derris* sp.	Leik-yoe	Fabaceae	ST
86	*Desmodium polycarpum* (Poir)DC.	Myay-pe-htwe	Fabaceae	S
87	*Desmodium triflorum* (L.)DC.	Than-ma-naing-kyauk-ma-naing	Fabaceae	H
88	*Dillenia parviflora* Griff	Kyet-zin-byun	Dilleniaceae	T
89	*Dillenia pentagyna* Roxb.	Zin-byun	Dilleniaceae	T
90	*Dioscorea cylindrica* Burm.	Kywe-thon-ywet	Dioscoreaceae	Cl/Cr
91	*Dioscorea pentaphylla* L.	Kywe-ngar-ywet	Dioscoreaceae	Cl/Cr
92	*Dioscorea sativa* L.	Kauk-yin-nwee	Dioscoreaceae	Cl/Cr
93	*Dioscorea wallichii* Hook.f.	Ka-det-nwee	Dioscoreaceae	Cl/Cr
94	*Diospyros kika* L.f.	Te/Te-net	Ebenaceae	T
95	*Diospyros ehretioides* Wall.	Auk-chin-sa	Ebenaceae	T
96	*Dipterocarpus* sp.	Ka-nyin-pho	Dipterocarpaceae	T
97	*Drynaria quercifolia*	Oak-leaf Fern	Polyporaceae	F
98	*Duabanga grandiflora*	Myauk-ngo	Lythraceae	T
99	*Eclipta alba* (L.) Hassk.	Kyeik-hman	Asteraceae	H
100	*Equisetum hyemale*	Equisetum	Equisetaceae	H
101	*Equisetum hyemale*	Not known	Equisetaceae	H
102	*Eranthemum roseum*	Not known	Acanthaceae	H
103	*Erythrina stricta* Roxb.	Taung-ka-thit	Fabaceae	T
104	*Euphorbia hypericifolia* L.	Kywe-kaung-hmin-sae	Euphorbiaceae	H

No.	Scientific Name	Common Name	Family Name	Habits
105	*Evolvulus nummularius* L.	Kyauk-kwe	Convolvulaceae	H
106	*Ficus hispida* L.	Kha-aung	Moraceae	T
107	*Ficus lacor* Buch.-Ham.	Nyaung-gyin	Moraceae	T
108	*Ficus obtusifolia* Roxb.	Nyaung-gyat	Moraceae	T
109	*Ficus racemosa* L.	Ye-tha-phan	Moraceae	T
110	*Firmiana colorata* (Roxb.)R.Br.	Wet-shaw	Sterculiaceae	T
111	*Flacourtia cataphracta* Roxb.	Na-ywe	Flacourtiaceae	T
112	*Flemingia congesta* Roxb.	Kye-hmi	Fabaceae	S
113	*Flueggea leucopyrus* Willd	Ye-chin-ya	Euphorbiaceae	S
114	*Gardenia coronaria* Buch.-Ham.	Yin-gat-gyi	Rubiaceae	T
115	*Garuga pinnata* Roxb.	Chin-yok/Gyi-yok	Burseraceae	T
116	*Getonia floribunda* Roxb.	Kywet-nwee	Combretaceae	S
117	*Glochidion* sp.	Hta-ma-sok	Euphorbiaceae	ST
118	*Gmelina arborea* Roxb.	Ya-ma-nae	Verbenaceae	T
119	*Grewia eriocarpa* Juss.	Ta-yaw	Tiliaceae	ST
120	*Grewia laevigata* Vahl	Kyet-tha-yaw	Tiliaceae	T
121	*Heliotropium indicum* L.	Sin-hna-maung	Boraginaceae	H
122	*Heterophragma adenophyllum* Seem.	Phet-than	Bignoniaceae	ST
123	*Hibiscus macrophyllus*	Taung-phet-wun	Malvaceae	T
124	*Holarrhena pubescens* Wall. ex G. Don	Let-htok-gyi	Apocynaceae	T
125	*Homalium tomentosum* Benth	Myauk-chaw	Flacourtiaceae	T
126	*Homonoia riparia* Lour.	Ye-mo-ma-kha	Euphorbiaceae	S
127	*Hoya* sp.	Not known	Asclepiadaceae	CL
128	*Hymenodictyon flaccidum* Wall.	Khu-san	Rubiaceae	ST
129	*Imperata cylindrica* (L.)P. Beauv.	Thet-ke	Poaceae	G
130	*Jasminum laurifolium* Roxb.	Taw-sabe	Oleaceae	Cl/Cr
131	*Juglans regia* L.	Thit-khwe/Thit-kya	Juglandaceae	T
132	*Justicia procumbens*	Not known	Acanthaceae	H
133	*Lagerstroemia macrocarpa* Kurz	Pyin-ma-gyi/Eik-hmwe	Lythraceae	T
134	*Lagerstroemia parviflora* Roxb.	Zaung-ba-lae	Lythraceae	T
135	*Lagerstroemia speciosa* (L.)Pers.	Pyin-ma/Eik-hmwe	Lythraceae	T
136	*Lagerstroemia tomentosa* Presl.	Lae-sa	Lythraceae	T
137	*Lagerstroemia villosa* Wall. ex Kurz	Kyet-ka-law	Lythraceae	T
138	*Lannea coromandelica* (Houtt.) Merrr.	Na-bae	Anacardiaceae	T
139	*Lathyrus latifolius*	Not known	Fabaceae	S
140	*Leea hirta* Banks	Na-ga-mauk-phyu	Leeaceae	S
141	*Leea rubra* Blume.	Na-ga-mauk-ni	Leeaceae	S
142	*Lepidagathis semiherbacea* (Clarke) Nees	Not known	Acanthaceae	H
143	*Leptadenia reticulata* Wight & Arn.	Gone-cho	Asclepiadaceae	Cl
144	*Leucas cephalotes* Spreng.	Pin-gu-hteik-peik	Lamiaceae	S
145	*Lindenbergia philippensis* Benth.	Not known	Scrophulariaceae	H

No.	Scientific Name	Common Name	Family Name	Habits
146	*Lophopetalum wallichii* Kurz	Mon-daing	Celastraceae	T
147	*Luffa aegyptiaca* Mill.	Tha-but-kha	Cucurbitaceae	CL
148	*Malaxis* sp.	Not known	Orchidaceae	H
149	*Mangifera sylvatica* Roxb.	Taw-tha-yet	Anacardiaceae	T
150	*Markhamia stipulata* (Wall.) Seem.ex K.Schum.	Ma-hlwa	Bignoniaceae	T
151	*Mazus pumilus* (Burm.f.)Steenis	Not known	Scrophulariaceae	H
152	*Merremia vitifolia* (Burm.f.) Hallier. f.	Kyet-hinga-lae-new	Convolvulaceae	Cl/Cr
153	*Mikania micrantha* H.B.K.	Bi-zet-nwee	Asteraceae	CL
154	*Miliusa roxburghiana* Hook.f.& Thomson	Tha-but-thein	Annonaceae	ST
155	*Miliusa velutina* Hook.f.& Thomson	Tha-but-gyi	Annonaceae	T
156	*Millettia extensa* Benth.	Win-u	Fabaceae	CL
157	*Millettia ovalifolia* Kurz	Thin-win	Fabaceae	T
158	*Millingtonia hortensis* L.f.	Ega-yit	Bignoniaceae	T
159	*Mimosa pudica* L.	Hti-ka-yone	Mimosaceae	H
160	*Miscanthus sinensis*	Not known	Poaceae	G
161	*Mitragyna parvifolia* (Roxb.)Korth.	Htein	Rubiaceae	T
162	*Mitragyna rotundifolia* (Roxb.) Kuntze	Bin-ga	Rubiaceae	T
163	*Moghania strobilifera* (L.) Aiton f.	Not known	Fabaceae	S
164	*Morus laevigata* Wall.	Po-sa-gyi	Moraceae	T
165	*Musa balbisiana*	Sin-chee-taing-nget-pyaw	Musaceae	H
166	*Musa* sp.	Taw-nget-pyaw	Musaceae	H
167	*Nauclea orientalis* L.	Ma-u	Rubiaceae	T
168	*Ocimum gratissimum* L.	Not known	Lamiaceae	H
169	*Oroxylum indicum* (L.) Kurz.	Kyaung-sha	Bignoniaceae	ST
170	*Paederia foetida* L.	Pe-bok-nwee	Rubiaceae	CL
171	*Pajanelia longifolia* (Willd.) K. Schum.	Kyaung-sha-pho	Bignoniaceae	ST
172	*Pandanus foetidus*Roxb.	Tha-baw	Pandanaceae	S
173	*Parthenocissus quinquefolia* (L.) Planch.	Not known	Vitaceae	Cl/Cr
174	*Pentasachme caudatum* Wall. Ex Wight	Not known	Asclepiadaceae	H
175	*Phaseolus velutina* Grah.	Pauk-net	Fabaceae	Cl/Cr
176	*Phyllanthus albizzioides* (Kurz)Hook.f.	Taun-zi-phyu	Euphorbiaceae	T
177	*Phyllanthus columnaris* Muell. Arg.	Kalon-letthe	Euphorbiaceae	ST
178	*Phyllanthus emblica* L.	Zi-phyu	Euphorbiaceae	ST
179	*Physalis minima* L.	Mi-pon/Bauk-thi	Solanaceae	S
180	*Picnoporus cinnabarina*	Not known	Polyporaceae	M
181	*Pilea scripta* Langtang	Kyet-chay-pin	Urticaceae	ST
182	*Polygonum barbatum* L.	Kywe-hna-khaung-gyate	Polygonaceae	H
183	*Prema pyramidata* Wall.	Kyun-na-lin/Kyun-pho	Verbenaceae	T
184	*Protium serratum* Engl.	Tha-di	Burseraceae	T
185	*Pterocarpus indicus*Willd.	Taw-pa-dauk	Fabaceae	T
186	*Pterospermum grandiflorum*	Not known	Sterculiaceae	ST

No.	Scientific Name	Common Name	Family Name	Habits
187	*Pterospermum semisagittatum* Buch.-Ham.	Na-gyi	Sterculiaceae	T
188	*Quercus lineata* Blume	Sa-gat	Fagaceae	ST
189	*Salvia* sp.	Not known	Lamiaceae	S
190	*Schima wallichii* (DC.)Korth.	Lauk-ya	Theaceae	T
191	*Schleichera oleosa* (Lour.) Oken	Gyo	Sapindaceae	T
192	*Senna hirsuta* (L.) Irwin & Barneby	Ka-thaw-hmwe-htu	Caesalpiniaceae	S
193	*Senna timoriensis* (DC.) Irwin & Barneby	Taw-ma-ze-li	Caesalpiniaceae	T
194	*Shorea obtusa* Wall.	Thit-ya	Dipterocarpaceae	T
195	*Shorea siamensis* (Kurz) Miq.	In-gyin	Dipterocarpaceae	T
196	*Smilax aspericaulis* Wall ex A. D.C.	Sein-na-baw-thay	Smilaceae	CL
197	*Smilax macrophylla* Roxb.	Sein-na-baw-gyi	Smilaceae	CL
198	*Solanum indicum* L.	Kha-yan-ka-zaw	Solanaceae	S
199	*Sonchus asper*	Not known	Asteraceae	H
200	*Spondias pinnata* (L. f.) Kurz.	Taw-gwe	Anacardiaceae	T
201	*Sterculia foetida* L.	Shaw-wa	Sterculiaceae	T
202	*Sterculia versicolor* Wall.	Shaw-phyu	Sterculiaceae	T
203	*Sterculia villosa* Roxb.	Shaw-ni	Sterculiaceae	T
204	*Stereospermum fimbriatum*(Wall. ex G.Don.) A.DC.	Than-thet	Bignoniaceae	T
205	*Stereospermum suaveolens* (Roxb.) DC.	Kywe-ma-gyo-lein	Bignoniaceae	T
206	*Streblus asper* Lour.	Ok-hne	Moraceae	T
207	*Streptocaulon tomentosum* Wight & Arn.	Myin-sa-gon-ni	Asclepiadaceae	CL
208	*Strychnos nux-blanda* A.W.Hill	Kha-baung	Loganiaceae	ST
209	*Tadehagi triquetrum* (L.)H. Ohashi	Lauk-thay	Fabaceae	S
210	*Tectona grandis* L. f.	Kyun	Verbenaceae	T
211	*Terminalia alata* (Heyne) Roth	Htauk-kyant	Combretaceae	T
212	*Terminalia bellirica* (Gaertn) Roxb.	Thit-seik	Combretaceae	T
213	*Terminalia chebula* Retz.	Phan-kha	Combretaceae	T
214	*Tetrameles nudiflora* R.Br.	Baing	Datiscaceae	T
215	*Tetrastigma planicaule*	Not known	Vitaceae	Cl/Cr
216	*Thladiantha cordifolia* (Blume)Cogn.	Ka-yin-ma-tin-pa	Cucurbitaceae	Cl/Cr
217	*Thunbergia laurifolia* Lindl.	Kyi-hnok-thi	Acanthaceae	CL
218	*Tinospora nudiflora* Kurz	Sin-don-ma-nwee	Menispermaceae	CL
219	*Trema orientalis* (L.) Blume	Kyet-chee-pho	Ulmaceae	ST
220	*Tristaniopsis burmanica* (Griff.)P.G. Wilson & J.T. Waterh.	Taung-tha-bye	Myrtaceae	T
221	*Triumfetta bartramia* L.	Kat-se-nae-thay	Tiliaceae	S
222	*Urea lobata* L.	Kat-se-nae	Malvaceae	S
223	*Vangueria spinosa* Roxb.	Magyi-bauk	Rubiaceae	S
224	*Vitex peduncularis* Wall.	Phet-le-zin/Thit-kyut	Verbenaceae	T
225	*Vitex pubescens* Vahl	Kyet-yoe/Thit-kyut	Verbenaceae	T
226	*Woodfordia fruticosa* (L.)Kurz	Pan-swe	Lythraceae	S
227	*Wrightia arborea* (Dennst.) Mabb.	Let-htok-thay	Apocynaceae	T

No.	Scientific Name	Common Name	Family Name	Habits
228	*Xylia xylocarpa* (Roxb.)Taub.	Pyin-ka-doe	Mimosaceae	T
229	*Zanthoxylum budrunga* Wall.	Ma-yanin-kyet-su	Rutaceae	T
230	*Zanthoxylum rhetsa*	Hmae-khaung	Rutaceae	T
231	*Zingiber fragile*	Not known	Zingiberaceae	H
232	*Zingiber squarrosum* Roxb.	Tauk-ta	Zingiberaceae	H
233	*Zingiber zerumbet* (L.)Roscoe ex J.E.Sm.	Lin-nay	Zingiberaceae	H
234	*Ziziphus glabra* Roxb.	Taw-zi-nwee/Paung-bet	Rhamnaceae	Cl/Cr
235	*Ziziphus jujuba* Lam.	Zi	Rhamnaceae	ST
B=Bamboo, CL=Climber, Cl/Cr=Climber/Creeper, E=Epiphyte, F=Fern, G=Grass, H=Herbs, M=Mushroom, S=Shrubs, ST=Small Tree, T=Tree				

Table.2. IUCN red list in Coal Mine Area (2016.3)

No.	Scientific Name	Common Name	Family Name	IUCN criteria
1	*Acacia intsia* Willd.	Su-pok-gyi	Mimosaceae	LC ver 3.1
2	*Acacia pennata* (L.) Willd.	Su-yit	Mimosaceae	LC ver 3.1
3	*Alstonia scholaris*(L.) R. Br.	Taung-ma-yoe/Say-kha-gyi	Apocynaceae	LR/lc ver 2.3
4	*Bauhinia forficata* Link	Min-ka-daw-kyet-kyay-kite	Caesalpiniaceae	LC ver 3.1
5	*Crotalaria albida* Heyne ex Roth	Not known	Fabaceae	LC ver 3.1
6	*Dalbergia cultrata* Grah.	Yin-daik	Fabaceae	NT ver 3.1
7	*Dalbergia rimosa* Roxb.	Daung-ta-laung	Fabaceae	LC ver 3.1
8	*Dendrocalamus membranaceus* Munro	Hmyin-wa	Poaceae	LC ver 3.1
9	*Desmodium triflorum* (L.)DC.	Than-ma-naing-kyauk-ma-naing	Fabaceae	LC ver 3.1
10	*Dioscorea wallichii* Hook.f.	Ka-det-nwee	Dioscoreaceae	LC ver 3.1
11	*Eclipta alba* (L.) Hassk.	Kyeik-hman	Asteraceae	DD ver 3.1
12	*Equisetum hyemale*	Equisetum	Equisetaceae	LC ver 3.1
13	*Holarrhena pubescens* Wall. ex G. Don	Let-htok-gyi	Apocynaceae	LC ver 3.1
14	*Homonoia riparia* Lour.	Ye-mo-ma-kha	Euphorbiaceae	LC ver 3.1
15	*Juglans regia* L.	Thit-khwe/Thit-kya	Juglandaceae	NT ver 3.1
16	*Lathyrus latifolius*	Not known	Fabaceae	LC ver 3.1
17	*Mangifera sylvatica* Roxb.	Taw-tha-yet	Anacardiaceae	LR/lc ver 2.3
18	*Millettia ovalifolia* Kurz	Thin-win	Fabaceae	DD ver 3.1
19	*Mimosa pudica* L.	Hti-ka-yone	Mimosaceae	LC ver 3.1
20	*Polygonum barbatum* L.	Kywe-hna-khaung-gyate	Polygonaceae	LC ver 3.1
21	*Pterocarpus indicus*Willd.	Taw-pa-dauk	Fabaceae	VU A1d ver 2.3
22	*Shorea obtusa* Wall.	Thit-ya	Dipterocarpaceae	LR/lc ver 2.3
23	*Shorea siamensis* (Kurz) Miq.	In-gyin	Dipterocarpaceae	LR/lc ver 2.3
24	*Tadehagi triquetrum* (L.)H. Ohashi	Lauk-thay	Fabaceae	LC ver 3.1
25	*Tetrameles nudiflora* R.Br.	Baing	Datiscaceae	LR/lc ver 2.3
26	*Woodfordia fruticosa* (L.)Kurz	Pan-swe	Lythraceae	LR/lc ver 2.3
27	*Zingiber fragile*	Not known	Zingiberaceae	NT ver 3.1
28	*Ziziphus jujuba* Lam.	Zi	Rhamnaceae	LC ver 3.1
DD=Data Deficient, LC=Least Concern, LR/lc=Lower Risk/least concern, NT=Near Threatened, VU=Vulnearble				

Woodfordia fruticosa (L.)Kurz

Juglans regia L.

Dalbergia cultrata Grah.

Crotalaria albida Heyne ex Roth

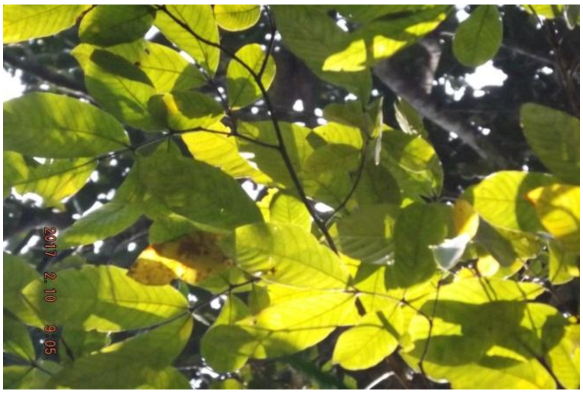
Bauhinia forficata Link

Lathyrus latifolius

Zingiber fragile

Alstonia scholaris(L.) R. Br.

Tadehagi triquetrum (L.)H. Ohashi

Ziziphus jujuba Lam.

Holarrhena pubescens Wall. ex G. Don


Desmodium triflorum (L.)DC.

*Pterocarpus indicus*Willd.


Shorea obtusa Wall.

Shorea siamensis (Kurz) Miq.


Dalbergia rimosa Roxb.

Tetrameles nudiflora R. Br.

Polygonum barbatum L.

Homonoia riparia

Eclipta aba (L.)Hassk

Acacia intsia Willd.

Dendrocalamus membranaceus Munro

Millettia ovalifolia Kurz

Equisetum hyemale

Mimosa pudica L.

DATA DEFICIENT (DD)
A taxon is Data Deficient when there is inadequate information to make a direct, or indirect, assessment of its risk of extinction based on its distribution and/or population status. A taxon in this category may be well studied, and its biology well known, but appropriate data on abundance and/or distribution are lacking. Data Deficient is therefore not a category of threat. Listing of taxa in this category indicates that more information is required and acknowledges the possibility that future research will show that threatened classification is appropriate. It is important to make positive use of whatever data are available. In many cases great care should be exercised in choosing between DD and a threatened status. If the range of a taxon is suspected to be relatively circumscribed, and a considerable period of time has elapsed since the last record of the taxon, threatened status may well be justified.

LEAST CONCERN (LC)
A taxon is Least Concern when it has been evaluated against the criteria and does not qualify for Critically Endangered, Endangered, Vulnerable or Near Threatened. Widespread and abundant taxa are included in this category.

Version 3.1: IUCN (2001)
The IUCN Council adopted this latest version, which incorporated changes as a result of comments from the IUCN and SSC memberships and from a final meeting of the Criteria Review Working Group, in February 2000.

NEAR THREATENED (NT)
A taxon is Near Threatened when it has been evaluated against the criteria but does not qualify for Critically Endangered, Endangered or Vulnerable now, but is close to qualifying for or is likely to qualify for a threatened category in the near future.

VULNERABLE (VU)

A taxon is Vulnerable when the best available evidence indicates that it meets any of the following criteria (A to E), and it is therefore considered to be facing a high risk of extinction in the wild:

A. Reduction in population size based on any of the following:

1. An observed, estimated, inferred or suspected population size reduction of ≥ 50% over the last 10 years or three generations, whichever is the longer, where the causes of the reduction are: clearly reversible AND understood AND ceased, based on (and specifying) any of the following:

(d) actual or potential levels of exploitation

Table.3. Invasive Species Coal Mine Area

No	Scientific Names	Familiy	Common Names	Origin
1	*Ageratum conyzoides* L.	Asteraceae	Khwe-thay-pan	Tropical America
2	*Amaranthus spinosus* L.	Amaranthaceae	Hnin-nu-new-su-bauk	Tropical America
3	*Bidens pilosa*	Asteraceae	Hmwe-sok	Tropical America
4	*Caesalpinia decapetala* (Roth.)Alston	Caesalpinaceae	Suk-yan-bo /Kyant-sa-su-pin	Tropical Asia
5	*Chromolaena odorata* (L.) R.M. King & H Robinson	Asteraceae	Bi-zet	Central America, South America
6	*Hiptage benghalensis* (L.) Kurz	Malpighiaceae	Bein-new	Tropical America
7	*Imperata cylindrica* (L.)P. Beauv.	Poaceae	Thet-ke	Old world
8	*Mikania micrantha* H.B.K.	Asteraceae	Bi-zet-nwee	Central and south America
9	*Mimosa pudica* L.	*Mimosaceae*	Hti-ka-yone	South America. Mexico, Amazon. Tropical America
10	*Oroxylum indicum* (L.) Kurz.	*Bignoniaceae*	Kyaung-sha	India
11	*Paederia foetida* L.	Rubiaceae	Pe-bok-nwee	Asia
12	*Ziziphus jujuba* Lam.	Rhamnaceae	Zi	China

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Ziziphus jujuba Lam

Amaranthus spinosus L.

Chromolaena odorata (L.)

Bidens pilosa

Paederia foetida L.

Mimosa pudica L.

Ageratum conyzoides L.

Imperata cylindrica (L.)P. Beauv.

Caesalpinia decapetala (Roth.)Alston

Ageratum conyzoides L

Mikania micrantha H.B.K.

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Table.4. Plant Association, Vegetation Types, and Red List Species according to their coordinations

PLANT ASSSOCIATION	ELEVATION(m)	NAME	BAMBOO SPECIES	DOMINANT TREE SPECIES	VEGETATION TYPE	IUCN redlist Species	Comment	POINT_X	POINT_Y
Association I. *Xylia xylocarpa* (Roxb.)Taub., *Dillenia pentagyna* Roxb. and *Cephalostachyum pergracile* Munro,	266	APC-1	*Cephalostachyum pergracile* Munro, *Dendrocalamus membranaceus* Munro, *Bambusa tulda* Roxb.	*Xylia xylocarpa* (Roxb.)Taub., *Dillenia pentagyna* Roxb., *Mitragyna rotundifolia* (Roxb.) Kuntze, *Adina cordifolia* Hook. f., *Terminalia alata* (Heyne) Roth, *Tectona grandis* L. f., *Prema pyramidata* Wall., *Anthocephalus morindaefolius* Korth., *Lagerstroemia speciosa* (L.)Pers., *Careya arborea* Roxb., *Homalium tomentosum* Benth,*Vitex peduncularis* Wall.	Deciduous Forest	*Dendrocalamus membranaceus* Munro, *Acacia intsia* Willd., *Millettia ovalifolia* Kurz, *Tadehagi triquetrum* (L.)H. Ohashi, *Homonoia riparia* Lour.	2017-02-10 7:33:11AM	94.277481	23.381097
	274	APC-2				*Acacia intsia* Willd., *Millettia ovalifolia* Kurz, *Juglans regia* L.	2017-02-10 7:58:49AM	94.277079	23.380232
	298	APC-3				*Acacia intsia* Willd., *Millettia ovalifolia* Kurz	2017-02-10 8:23:48AM	94.276617	23.379301
	322	APC-4					2017-02-10 8:40:18AM	94.275825	23.378782
	346	APC-5				*Holarrhena pubescens* Wall. ex G. Don	2017-02-10 9:03:52AM	94.274940	23.378270
	347	APC-6				*Millettia ovalifolia* Kurz, *Pterocarpus indicus*Willd., *Dalbergia cultrata* Grah.	2017-02-10 9:23:02AM	94.274846	23.377366
	351	APC-7				*Pterocarpus indicus*Willd., *Dalbergia cultrata* Grah., *Shorea obtusa* Wall.	2017-02-10 9:48:36AM	94.274807	23.376397
	363	APC-8				*Dendrocalamus membranaceus* Munro, *Pterocarpus indicus*Willd., *Alstonia scholaris*(L.) R. Br.	2017-02-10 10:08:36AM	94.273863	23.375903

PLANT ASSSOCIATION	ELEVATION(m)	NAME	BAMBOO SPECIES	DOMINANT TREE SPECIES	VEGETATION TYPE	IUCN redlist Species	Comment	POINT_X	POINT_Y
	372	APC-9				*Dendrocalamus membranaceus* Munro, *Millettia ovalifolia* Kurz, *Acacia intsia* Willd.,	2017-02-10 10:31:57AM	94.273304	23.375031
	387	APC-10				*Dendrocalamus membranaceus* Munro, *Millettia ovalifolia* Kurz, *Alstonia scholaris*(L.) R. Br.	2017-02-10 10:49:21AM	94.273262	23.374102
	411	APC-11					2017-02-10 11:03:35AM	94.272954	23.373149
	447	APC-12				*Dendrocalamus membranaceus* Munro, *Millettia ovalifolia* Kurz, *Tetrameles nudiflora* R.Br.	2017-02-10 11:19:15AM	94.272217	23.372465
Association II. *Xylia xylocarpa* (Roxb.)Taub., *Terminalia alata* (Heyne) Roth and *Dendrocalamus membranaceus* Munro	452	APC-13	*Dendrocalamus membranaceus* Munro, *Bambusa tulda* Roxb.	*Xylia xylocarpa* (Roxb.)Taub., *Terminalia alata* (Heyne) Roth, *Tectona grandis* L. f., *Adina cordifolia* Hook. f., *Mitragyna rotundifolia* (Roxb.) Kuntze, *Dillenia pentagyna* Roxb., *Cratoxylum cochinchinense, Shorea siamensis* (Kurz) Miq., *Markhamia stipulata* (Wall.) Seem.ex K.Schum., *Pterospermum semisagittatum* Buch.-Ham.,*Vitex peduncularis* Wall., *Dalbergia paniculata* Roxb.	Deciduous Forest	*Millettia ovalifolia* Kurz, *Tetrameles nudiflora* R.Br.	2017-02-10 11:23:20AM	94.271486	23.371830
	441	APC-14				*Acacia intsia* Willd., *Millettia ovalifolia* Kurz, *Dalbergia cultrata* Grah.	2017-02-10 11:34:32AM	94.271819	23.369974
		APC-15				*Dendrocalamus membranaceus* Munro, *Millettia ovalifolia* Kurz, *Tetrameles nudiflora* R.Br.			
	471	APC-16				*Millettia ovalifolia* Kurz	2017-02-10 12:23:02PM	94.271821	23.367757
	452	APC-17				*Dendrocalamus membranaceus* Munro, *Tetrameles nudiflora* R.Br.	2017-02-10 12:37:51PM	94.272026	23.366042

PLANT ASSSOCIATION	ELEVATION(m)	NAME	BAMBOO SPECIES	DOMINANT TREE SPECIES	VEGETATION TYPE	IUCN redlist Species	Comment	POINT_X	POINT_Y
	446	APC-18				*Millettia ovalifolia* Kurz	2017-02-10 12:47:36PM	94.272492	23.365148
	422	APC-19				*Millettia ovalifolia* Kurz	2017-02-10 12:54:07PM	94.272919	23.364445
	419	APC-20				*Dendrocalamus membranaceus* Munro, *Millettia ovalifolia* Kurz	2017-02-10 12:55:38PM	94.273126	23.364354
	372	APC-21				*Dendrocalamus membranaceus* Munro, *Millettia ovalifolia* Kurz, *Dalbergia cultrata* Grah.	2017-02-10 1:08:25PM	94.273803	23.363322
	363	APC-22				*Dendrocalamus membranaceus* Munro, *Millettia ovalifolia* Kurz, *Tetrameles nudiflora* R.Br., *Homonoia riparia* Lour.	2017-02-10 1:22:36PM	94.274672	23.362454
	354	APC-23				*Acacia intsia* Willd., *Tetrameles nudiflora* R.Br.,	2017-02-10 1:27:49PM	94.274878	23.361420
	357	APC-24				*Millettia ovalifolia* Kurz, *Tetrameles nudiflora* R.Br.,	2017-02-10 1:35:15PM	94.275127	23.359956
Asssociation III. *Terminalia alata* (Heyne) Roth, *Tectona grandis* L. f., and *Dendrocalamus membranaceus* Munro,	377	APC-25	*Dendrocalamus membranaceus* Munro,	*Terminalia alata* (Heyne) Roth, *Tectona grandis* L. f., *Xylia xylocarpa* (Roxb.)Taub., *Dalbergia paniculata* Roxb., *Mitragyna rotundifolia* (Roxb.) Kuntze, *Schleichera oleosa* (Lour.) Oken, *Adina cordifolia* Hook. f., *Pterospermum*	Deciduous Forest	*Dendrocalamus membranaceus* Munro, *Millettia ovalifolia* Kurz	2017-02-10 1:40:38PM	94.274385	23.359265
	400	APC-26				*Dendrocalamus membranaceus* Munro, *Millettia ovalifolia* Kurz	2017-02-10 1:48:28PM	94.273876	23.358343
	408	APC-27				*Millettia ovalifolia* Kurz	2017-02-10 1:52:50PM	94.272976	23.357276

PLANT ASSSOCIATION	ELEVATION(m)	NAME	BAMBOO SPECIES	DOMINANT TREE SPECIES	VEGETATION TYPE	IUCN redlist Species	Comment	POINT_X	POINT_Y
	391	APC-28		*semisagittatum* Buch.-Ham., *Spondias pinnata* (L. f.) Kurz., *Dillenia pentagyna* Roxb.		*Millettia ovalifolia* Kurz, *Holarrhena pubescens* Wall. ex G. Don	2017-02-10 1:55:31PM	94.273000	23.356281
	380	APC-29				*Dendrocalamus membranaceus* Munro, *Millettia ovalifolia* Kurz	2017-02-10 1:58:59PM	94.273302	23.355283
	372	APC-30				*Millettia ovalifolia* Kurz, *Holarrhena pubescens* Wall. ex G. Don, *Shorea siamensis* (Kurz) Miq.	2017-02-10 2:05:18PM	94.274324	23.354254
	377	APC-31				*Dendrocalamus membranaceus* Munro,	2017-02-10 2:08:37PM	94.274956	23.353347
	374	APC-32					2017-02-10 2:14:02PM	94.275312	23.352040
	363	APC-33				*Dendrocalamus membranaceus* Munro, *Millettia ovalifolia* Kurz, *Shorea siamensis* (Kurz) Miq.	2017-02-10 2:16:47PM	94.275495	23.350953
	366	APC-34				*Millettia ovalifolia* Kurz	2017-02-10 2:19:25PM	94.275597	23.349878
	352	APC-35				*Dendrocalamus membranaceus* Munro,	2017-02-10 2:23:12PM	94.275484	23.348736
	345	APC-36				*Millettia ovalifolia* Kurz	2017-02-10 2:27:37PM	94.275718	23.347199
Association IV. *Terminalia alata* (Heyne) Roth, *Tectona grandis* L. f., and *Dendrocalamus*	342	APC-37	*Dendrocalamus membranaceus* Munro,	*Terminalia alata* (Heyne) Roth, *Tectona grandis* L. f., *Hymenodictyon flaccidum* Wall., *Dillenia pentagyna* Roxb., *Millettia ovalifolia* Kurz, *Terminalia bellirica*	Deciduous Forest	*Millettia ovalifolia* Kurz	2017-02-10 2:32:12PM	94.275519	23.346130
	333	APC-38				*Millettia ovalifolia* Kurz	2017-02-10 2:38:57PM	94.275831	23.344865
	326	APC-39				*Millettia ovalifolia* Kurz,	2017-02-10 2:41:24PM	94.275851	23.343703

PLANT ASSSOCIATION	ELEVATION(m)	NAME	BAMBOO SPECIES	DOMINANT TREE SPECIES	VEGETATION TYPE	IUCN redlist Species	Comment	POINT_X	POINT_Y
membranaceus Munro	312	APC-40		(Gaertn) Roxb.			2017-02-10 2:46:33PM	94.275831	23.342678
	289	APC-41				*Millettia ovalifolia* Kurz, *Shorea siamensis* (Kurz) Miq.	2017-02-10 2:49:30PM	94.276320	23.341740
	267	APC-42					2017-02-10 2:58:56PM	94.276180	23.340619
	266	APC-43					2017-02-10 3:00:57PM	94.275403	23.339697
	260	APC-44					2017-02-10 3:02:50PM	94.274936	23.338720
	259	APC-45					2017-02-10 3:05:09PM	94.274739	23.337609
	252	APC-46					2017-02-10 3:08:33PM	94.275350	23.336127
	249	APC-47				*Ziziphus jujuba* Lam.	2017-02-10 3:12:22PM	94.274628	23.335245
	248	APC-48				*Polygonum barbatum* L.	2017-02-10 3:17:28PM	94.274662	23.334094
Association V. *Anthocephalus morindaefolius* Korth., *Adina cordifolia* Hook. f., and *Cephalostachyum pergracile* Munro	247	APC-49	*Cephalostachyum pergracile* Munro	*Anthocephalus morindaefolius* Korth., *Adina cordifolia* Hook. f., *Prema pyramidata* Wall., *Duabanga grandiflora, Vitex peduncularis* Wall., *Dillenia pentagyna* Roxb.	Deciduous Forest		2017-02-10 3:19:45PM	94.274611	23.333011
	248	APC-50					2017-02-10 3:22:54PM	94.274878	23.332022
	246	APC-51					2017-02-10 3:26:42PM	94.274668	23.330876
	246	APC-52					2017-02-10 3:29:14PM	94.274526	23.329719
	238	APC-53				*Equisetum hyemale*	2017-02-10 3:33:35PM	94.275485	23.329205
	237	APC-54				*Alstonia scholaris*(L.) R. Br.	2017-02-10 3:37:15PM	94.276685	23.328672
	237	APC-55					2017-02-10 3:39:56PM	94.276737	23.327492

PLANT ASSSOCIATION	ELEVATION(m)	NAME	BAMBOO SPECIES	DOMINANT TREE SPECIES	VEGETATION TYPE	IUCN redlist Species	Comment	POINT_X	POINT_Y
	230	APC-56				*Equisetum hyemale*	2017-02-10 3:43:36PM	94.277503	23.326691
	178	APC-57				*Millettia ovalifolia* Kurz	2017-02-11 7:08:28AM	94.285515	23.454928
	201	APC-58					2017-02-11 7:12:24AM	94.284645	23.454157
	221	APC-59				*Holarrhena pubescens* Wall. ex G. Don, *Alstonia scholaris*(L.) R. Br., *Tetrameles nudiflora* R.Br., *Pterocarpus indicus*Willd.,	2017-02-11 7:15:54AM	94.284002	23.453355
	231	APC-60				*Acacia intsia* Willd.,	2017-02-11 7:20:30AM	94.283665	23.452386
Association VI. *Tectona grandis* L. f., *Terminalia alata* (Heyne) Roth and *Dendrocalamus membranaceus* Munro	247	APC-61	*Dendrocalamus membranaceus* Munro, *Cephalostachyum pergracile* Munro	*Tectona grandis* L. f., *Terminalia alata* (Heyne) Roth, *Dalbergia paniculata* Roxb., *Adina cordifolia* Hook. f., *Strychnos nux-blanda* A.W.Hill, *Prema pyramidata* Wall., *Anthocephalus morindaefolius* Korth., *Sterculia villosa* Roxb., *Lagerstroemia parviflora* Roxb., *Millettia ovalifolia* Kurz, *Cratoxylum cochinchinense, Mitragyna rotundifolia* (Roxb.) Kuntze, *Erythrina stricta* Roxb.	Mixed Broad-leaved Deciduous Forest	*Tetrameles nudiflora R.Br., Millettia ovalifolia Kurz*	2017-02-11 7:26:42AM	94.282619	23.452601
	273	APC-62					2017-02-11 7:32:57AM	94.281529	23.452588
	290	APC-63				*Dendrocalamus membranaceus* Munro, *Millettia ovalifolia* Kurz	2017-02-11 7:40:58AM	94.280422	23.452346
	319	APC-64				*Dendrocalamus membranaceus Munro, Holarrhena pubescens Wall. ex G. Don,*	2017-02-11 7:52:02AM	94.279388	23.451681
	343	APC-65				*Dendrocalamus membranaceus Munro, Holarrhena pubescens Wall. ex G. Don, Millettia ovalifolia Kurz*	2017-02-11 8:01:25AM	94.279008	23.450720

PLANT ASSSOCIATION	ELEVATION(m)	NAME	BAMBOO SPECIES	DOMINANT TREE SPECIES	VEGETATION TYPE	IUCN redlist Species	Comment	POINT_X	POINT_Y
	366	APC-66				*Dendrocalamus membranaceus* Munro, *Millettia ovalifolia* Kurz	2017-02-11 8:08:37AM	94.278704	23.449686
	380	APC-67				*Dendrocalamus membranaceus* Munro, *Millettia ovalifolia* Kurz, *Shorea siamensis* (Kurz) Miq.	2017-02-11 8:13:16AM	94.278393	23.448658
	397	APC-68				*Dendrocalamus membranaceus* Munro, *Millettia ovalifolia* Kurz, *Dalbergia cultrata Grah.*	2017-02-11 8:21:22AM	94.278228	23.447616
	390	APC-69				*Dendrocalamus membranaceus* Munro, *Millettia ovalifolia* Kurz, *Holarrhena pubescens* Wall. ex G. Don	2017-02-11 8:28:30AM	94.277484	23.446742
	398	APC-70				*Dendrocalamus membranaceus* Munro, *Millettia ovalifolia* Kurz, *Holarrhena pubescens* Wall. ex G. Don, *Shorea siamensis* (Kurz) Miq.	2017-02-11 8:33:44AM	94.277052	23.445899
	417	APC-71				*Dendrocalamus membranaceus* Munro, *Holarrhena pubescens* Wall. ex G. Don,	2017-02-11 8:56:21AM	94.276585	23.445084
	412	APC-72				*Dendrocalamus membranaceus Munro, Millettia ovalifolia Kurz,*	2017-02-11 9:00:52AM	94.275952	23.444020

PLANT ASSSOCIATION	ELEVATION(m)	NAME	BAMBOO SPECIES	DOMINANT TREE SPECIES	VEGETATION TYPE	IUCN redlist Species	Comment	POINT_X	POINT_Y
Association VII. *Tectona grandis* L. f., *Xylia xylocarpa* (Roxb.)Taub. and *Dendrocalamus membranaceus* Munro	412	APC-73	*Dendrocalamus membranaceus* Munro, *Bambusa tulda* Roxb.	*Tectona grandis* L. f., *Xylia xylocarpa* (Roxb.)Taub., *Terminalia alata* (Heyne) Roth, *Millettia ovalifolia* Kurz, *Schleichera oleosa* (Lour.) Oken, *Adina cordifolia* Hook. f., *Shorea siamensis* (Kurz) Miq., *Cassia fistula* L., *Dalbergia paniculata* Roxb., *Dillenia pentagyna* Roxb., *Mitragyna rotundifolia* (Roxb.) Kuntze	Mixed Broad-leaved Deciduous Forest	*Dendrocalamus membranaceus* Munro, *Millettia ovalifolia* Kurz,	2017-02-11 9:04:24AM	94.275463	23.443156
	430	APC-74				*Dendrocalamus membranaceus* Munro, *Millettia ovalifolia* Kurz, *Shorea siamensis* (Kurz) Miq.	2017-02-11 9:08:27AM	94.275370	23.442088
	445	APC-75				*Dalbergia cultrata Grah., Shorea siamensis (Kurz) Miq., Dendrocalamus membranaceus Munro, Millettia ovalifolia Kurz*	2017-02-11 9:12:17AM	94.274659	23.441289
	458	APC-76				*Dendrocalamus membranaceus* Munro, *Millettia ovalifolia* Kurz, *Holarrhena pubescens* Wall. ex G. Don, *Shorea siamensis* (Kurz) Miq., *Dalbergia cultrata* Grah.,	2017-02-11 9:17:29AM	94.274324	23.440253
	470	APC-77				*Dendrocalamus membranaceus* Munro, *Millettia ovalifolia* Kurz	2017-02-11 9:39:41AM	94.274765	23.439297
	458	APC-78				*Dendrocalamus membranaceus* Munro, *Millettia ovalifolia* Kurz *Shorea siamensis* (Kurz) Miq.,	2017-02-11 9:51:08AM	94.275226	23.438359

PLANT ASSSOCIATION	ELEVATION(m)	NAME	BAMBOO SPECIES	DOMINANT TREE SPECIES	VEGETATION TYPE	IUCN redlist Species	Comment	POINT_X	POINT_Y
	446	APC-79				*Dendrocalamus membranaceus* Munro, *Millettia ovalifolia* Kurz, *Holarrhena pubescens* Wall. ex G. Don	2017-02-11 9:57:00AM	94.275722	23.437379
	430	APC-80				*Dendrocalamus membranaceus* Munro, *Millettia ovalifolia* Kurz	2017-02-11 10:01:50AM	94.276024	23.436427
	396	APC-81				*Dendrocalamus membranaceus* Munro, *Millettia ovalifolia* Kurz,	2017-02-11 10:09:05AM	94.276060	23.435388
	361	APC-82				*Dendrocalamus membranaceus* Munro, *Millettia ovalifolia* Kurz, *Alstonia scholaris*(L.) R. Br.	2017-02-11 10:15:49AM	94.276328	23.434488
	338	APC-83				*Dendrocalamus membranaceus* Munro, *Millettia ovalifolia* Kurz,	2017-02-11 10:22:34AM	94.276977	23.433640
	316	APC-84				*Dendrocalamus membranaceus* Munro, *Millettia ovalifolia* Kurz,	2017-02-11 10:30:38AM	94.277363	23.432698
Association VIII. *Tectona grandis* L. f., *Terminalia alata* (Heyne) Roth and *Dendrocalamus membranaceus*	294	APC-85	*Dendrocalamus membranaceus Munro, Cephalostachyum pergracile* Munro, *Dendrocalamus*	*Tectona grandis* L. f., *Terminalia alata* (Heyne) Roth, *Xylia xylocarpa* (Roxb.)Taub., *Mitragyna rotundifolia* (Roxb.) Kuntze, *Tetrameles nudiflora* R.Br.,	Mixed Broad-leaved Deciduous Forest	*Dendrocalamus membranaceus* Munro, *Millettia ovalifolia* Kurz, *Tetrameles nudiflora* R.Br., *Alstonia scholaris*(L.) R. Br.	2017-02-11 10:35:53AM	94.278235	23.432177

PLANT ASSSOCIATION	ELEVATION(m)	NAME	BAMBOO SPECIES	DOMINANT TREE SPECIES	VEGETATION TYPE	IUCN redlist Species	Comment	POINT_X	POINT_Y
Munro	261	APC-86	*calostachyus* (Kurz)Kurz, *Bambusa tulda* Roxb.	*Adina cordifolia* Hook. f., *Anthocephalus morindaefolius* Korth., *Shorea siamensis* (Kurz) Miq., *Duabanga grandiflora, Heterophragma adenophyllum* Seem., *Millettia ovalifolia* Kurz, *Lagerstroemia parviflora* Roxb.		*Equisetum hyemale, Dendrocalamus membranaceus Munro, Millettia ovalifolia Kurz, Tetrameles nudiflora R.Br.,Homonoia riparia* Lour.	2017-02-11 10:44:31AM	94.278382	23.431225
	243	APC-87				*Homonoia riparia* Lour., *Dendrocalamus membranaceus Munro, Millettia ovalifolia* , *Holarrhena pubescens* Wall. ex G. Don	2017-02-11 10:54:41AM	94.279159	23.430579
	228	APC-88				*Millettia ovalifolia Kurz, Tetrameles nudiflora R.Br., Alstonia scholaris(L.) R. Br.*	2017-02-11 10:59:59AM	94.280786	23.430127
	226	APC-89				*Tetrameles nudiflora R.Br., Alstonia scholaris(L.) R. Br*	2017-02-11 11:04:07AM	94.281520	23.428978
	217	APC-90					2017-02-11 11:06:46AM	94.281920	23.428109
	362	APC-91					2017-02-11 12:13:50PM	94.277351	23.388087
	358	APC-92				*Millettia ovalifolia Kurz,*	2017-02-11 12:18:01PM	94.277566	23.389591
	350	APC-93					2017-02-11 12:20:16PM	94.277130	23.390528

PLANT ASSSOCIATION	ELEVATION(m)	NAME	BAMBOO SPECIES	DOMINANT TREE SPECIES	VEGETATION TYPE	IUCN redlist Species	Comment	POINT_X	POINT_Y
	333	APC-94				*Alstonia scholaris(L.) R. Br., Shorea siamensis (Kurz) Miq.Dendrocalamus membranaceus Munro, Tetrameles nudiflora R.Br.,*	2017-02-11 12:23:42PM	94.278001	23.391640
	316	APC-95				*Dendrocalamus membranaceus* Munro, *Millettia ovalifolia* Kurz,	2017-02-11 12:26:56PM	94.279034	23.392684
	297	APC-96				*Dendrocalamus membranaceus* Munro, *Millettia ovalifolia* Kurz,	2017-02-11 12:29:51PM	94.279598	23.393692
Association IX. *Terminalia alata* (Heyne) Roth, *Xylia xylocarpa* (Roxb.)Taub. and *Dendrocalamus membranaceus* Munro	267	APC-97	*Dendrocalamus membranaceus* Munro,	*Terminalia alata* (Heyne) Roth, *Xylia xylocarpa* (Roxb.)Taub., *Mitragyna rotundifolia* (Roxb.) Kuntze, *Anthocephalus morindaefolius* Korth., *Adina cordifolia* Hook. f., *Hymenodictyon flaccidum* Wall., *Tetrameles nudiflora* R.Br., *Tectona grandis* L. f., *Nauclea orientalis* L., *Millettia ovalifolia* Kurz, *Trema orientalis* (L.) Blume	Deciduous Forest	*Dendrocalamus membranaceus* Munro	2017-02-11 12:32:50PM	94.280326	23.394656
	243	APC-98				*Dendrocalamus membranaceus* Munro	2017-02-11 12:35:41PM	94.280899	23.395606
	225	APC-99				*Holarrhena pubescens Wall. ex G. Don, Dendrocalamus membranaceus Munro, Homonoia riparia Lour.*	2017-02-11 12:38:58PM	94.281431	23.396370
	239	APC-100				*Dendrocalamus membranaceus* Munro, *Millettia ovalifolia* Kurz,	2017-02-11 12:43:24PM	94.279971	23.396284
	249	APC-101				*Dendrocalamus membranaceus* Munro, *Millettia ovalifolia* Kurz,	2017-02-11 12:51:00PM	94.279965	23.397398
	267	APC-102				*Dendrocalamus membranaceus* Munro, *Millettia ovalifolia* Kurz, *Tetrameles nudiflora* R.Br.	2017-02-11 12:55:25PM	94.279690	23.398330
	280	APC-103					2017-02-11 12:58:42PM	94.278536	23.399296

PLANT ASSSOCIATION	ELEVATION(m)	NAME	BAMBOO SPECIES	DOMINANT TREE SPECIES	VEGETATION TYPE	IUCN redlist Species	Comment	POINT_X	POINT_Y
	298	APC-104					2017-02-11 1:02:15PM	94.278800	23.400900
	313	APC-105					2017-02-11 1:05:42PM	94.278427	23.401907
	313	APC-106					2017-02-11 1:08:29PM	94.278550	23.403294
Association X. *Tectona grandis* L. f., *Terminalia alata* (Heyne) Roth, *Xylia xylocarpa* (Roxb.)Taub. and *Dendrocalamus membranaceus* Munro	311	APC-107	*Dendrocalamus membranaceus* Munro,	*Tectona grandis* L. f., *Terminalia alata* (Heyne) Roth, *Xylia xylocarpa* (Roxb.)Taub., *Homalium tomentosum* Benth, *Mitragyna rotundifolia* (Roxb.) Kuntze, *Adina cordifolia* Hook. f., *Strychnos nux-blanda* A.W.Hill, *Hymenodictyon flaccidum* Wall., *Anthocephalus morindaefolius* Korth., *Millettia ovalifolia* Kurz, *Chukrasia velutina* Roem.	Mixed Broad-leaved Deciduous Forest		2017-02-11 1:11:04PM	94.278537	23.404624
	311	APC-108				*Pterocarpus indicus*Willd.	2017-02-11 1:15:07PM	94.278745	23.406808
	321	APC-109				*Millettia ovalifolia* Kurz	2017-02-11 1:17:48PM	94.278691	23.408205
	336	APC-110				*Millettia ovalifolia* Kurz	2017-02-11 1:31:34PM	94.278849	23.409362
	343	APC-111				*Dendrocalamus membranaceus* Munro, *Millettia ovalifolia* Kurz,	2017-02-11 1:34:00PM	94.278526	23.410479
	358	APC-112				*Dendrocalamus membranaceus* Munro, *Millettia ovalifolia* Kurz,	2017-02-11 1:36:29PM	94.278243	23.411560
	387	APC-113				*Dendrocalamus membranaceus* Munro, *Millettia ovalifolia* Kurz, *Holarrhena pubescens* Wall. ex G. Don	2017-02-11 1:44:22PM	94.277860	23.412158
	394	APC-114				*Dendrocalamus membranaceus* Munro,	2017-02-11 1:52:58PM	94.277562	23.413186

PLANT ASSSOCIATION	ELEVATION(m)	NAME	BAMBOO SPECIES	DOMINANT TREE SPECIES	VEGETATION TYPE	IUCN redlist Species	Comment	POINT_X	POINT_Y
	386	APC-115				*Dendrocalamus membranaceus* Munro, *Millettia ovalifolia* Kurz, *Holarrhena pubescens* Wall. ex G. Don, *Shorea siamensis* (Kurz) Miq.	2017-02-11 1:57:34PM	94.278071	23.414023
	391	APC-116				*Dendrocalamus membranaceus* Munro, *Holarrhena pubescens* Wall. ex G. Don	2017-02-11 2:03:17PM	94.278940	23.414551
Association XI. *Xylia xylocarpa* (Roxb.)Taub., *Tectona grandis* L. f. and *Dendrocalamus membranaceus* Munro	354	APC-117	*Dendrocalamus membranaceus* Munro, *Dendrocalamus calostachyus* (Kurz)Kurz.	*Xylia xylocarpa* (Roxb.)Taub., *Tectona grandis* L. f., *Terminalia alata* (Heyne) Roth, *Anthocephalus morindaefolius* Korth., *Prema pyramidata* Wall., *Trema orientalis* (L.) Blume, *Gardenia coronaria* Buch.-Ham., *Careya arborea* Roxb., *Mitragyna rotundifolia* (Roxb.) Kuntze, *Adina cordifolia* Hook. f., *Zanthoxylum budrunga* Wall.	Mixed Broad-leaved Deciduous Forest	*Dendrocalamus membranaceus* Munro, *Millettia ovalifolia* Kurz, *Holarrhena pubescens* Wall. ex G. Don,	2017-02-11 2:15:52PM	94.278627	23.415403
	335	APC-118				*Dendrocalamus membranaceus* Munro, *Millettia ovalifolia* Kurz, *Holarrhena pubescens* Wall. ex G. Don,	2017-02-11 2:28:25PM	94.278955	23.416319
	318	APC-119				*Dendrocalamus membranaceus* Munro, *Tetrameles nudiflora* R.Br.	2017-02-11 3:01:56PM	94.278567	23.417029
	287	APC-120					2017-02-11 3:09:16PM	94.278353	23.417993
	265	APC-121				*Tetrameles nudiflora* R.Br., *Homonoia riparia* Lour.	2017-02-11 3:16:12PM	94.279209	23.418661

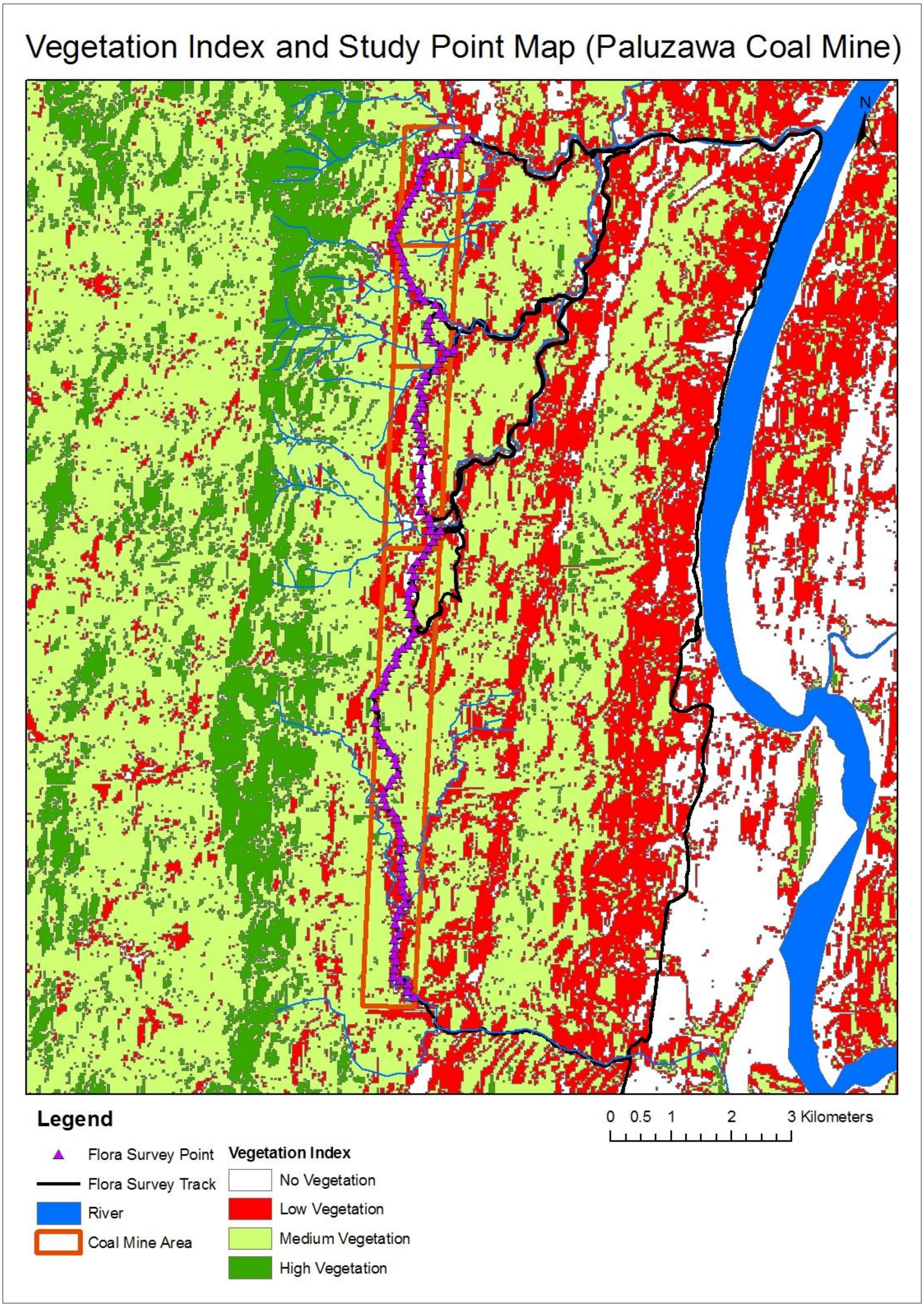
PLANT ASSSOCIATION	ELEVATION(m)	NAME	BAMBOO SPECIES	DOMINANT TREE SPECIES	VEGETATION TYPE	IUCN redlist Species	Comment	POINT_X	POINT_Y
	229	APC-122				*Homonoia riparia* Lour., *Mangifera sylvatica* Roxb., *Millettia ovalifolia Kurz,*	2017-02-11 3:38:09PM	94.279218	23.419650
	216	APC-123				*Dendrocalamus membranaceus* Munro, *Homonoia riparia* Lour.	2017-02-11 3:49:51PM	94.280727	23.420306
	219	APC-124				*Dendrocalamus membranaceus Munro, Millettia ovalifolia* Kurz,	2017-02-11 3:56:04PM	94.281144	23.421239
	210	APC-125				*Equisetum hyemale, Dendrocalamus membranaceus Munro,Homonoia riparia* Lour., *Millettia ovalifolia* Kurz,	2017-02-11 4:00:53PM	94.281848	23.422086
	201	APC-126				*Dendrocalamus membranaceus* Munro, *Homonoia riparia* Lour.	2017-02-11 4:08:50PM	94.283182	23.422809
	202	APC-127					2017-02-11 4:12:16PM	94.283598	23.423386
Association XII. *Terminalia alata* (Heyne) Roth, *Tectona grandis* L. f. and *Dendrocalamus membranaceus* Munro	214	APC-128	*Dendrocalamus membranaceus* Munro, *Cephalostachyum pergracile* Munro,	*Terminalia alata* (Heyne) Roth, *Tectona grandis* L. f., *Mitragyna rotundifolia* (Roxb.) Kuntze, *Pterocarpus indicus*Willd., *Xylia xylocarpa* (Roxb.)Taub., *Holarrhena pubescens* Wall. ex G. Don, *Phyllanthus albizzioides* (Kurz)Hook.f., *Tetrameles nudiflora* R.Br., *Adina*	Deciduous Forest	*Dendrocalamus membranaceus* Munro, *Millettia ovalifolia* Kurz,	2017-02-13 7:16:14AM	94.282472	23.422939
	248	APC-129				*Dendrocalamus membranaceus* Munro, *Millettia ovalifolia* Kurz,	2017-02-13 7:30:26AM	94.281648	23.423808
	269	APC-130				*Dendrocalamus membranaceus* Munro, *Millettia ovalifolia* Kurz, *Acacia pennata* (L.) Willd.	2017-02-13 7:37:41AM	94.280475	23.424470

PLANT ASSSOCIATION	ELEVATION(m)	NAME	BAMBOO SPECIES	DOMINANT TREE SPECIES	VEGETATION TYPE	IUCN redlist Species	Comment	POINT_X	POINT_Y
	298	APC-131		*cordifolia* Hook. f., *Shorea siamensis* (Kurz) Miq., *Zanthoxylum budrunga* Wall., *Homalium tomentosum* Benth , *Dalbergia stipulacea* Roxb., *Cordia myxa* L., *Dillenia pentagyna* Roxb.		*Dendrocalamus membranaceus* Munro, *Millettia ovalifolia* Kurz,	2017-02-13 7:44:02AM	94.279514	23.424895
	268	APC-132				*Millettia ovalifolia* Kurz, *Tetrameles nudiflora* R.Br.	2017-02-13 7:57:17AM	94.279847	23.426038
	282	APC-133				*Dendrocalamus membranaceus* Munro, *Millettia ovalifolia* Kurz, *Pterocarpus indicus*Willd.	2017-02-13 8:05:28AM	94.279483	23.426964
	280	APC-134				*Millettia ovalifolia* Kurz, *Pterocarpus indicus*Willd.	2017-02-13 8:18:50AM	94.279863	23.427932
	227	APC-135					2017-02-13 8:36:41AM	94.281168	23.428580
	358	APC-136				*Tetrameles nudiflora* R.Br.	2017-02-13 9:44:06AM	94.277358	23.387753
	329	APC-137				*Dendrocalamus membranaceus* Munro, *Millettia ovalifolia* Kurz, *Tetrameles nudiflora* R.Br.	2017-02-13 9:53:20AM	94.276715	23.387059
	323	APC-138				*Dendrocalamus membranaceus* Munro, *Millettia ovalifolia* Kurz, *Pterocarpus indicus*Willd.	2017-02-13 10:04:24AM	94.276664	23.386045
	324	APC-139				*Dendrocalamus membranaceus* Munro, *Millettia ovalifolia* Kurz,	2017-02-13 10:14:11AM	94.276854	23.385002

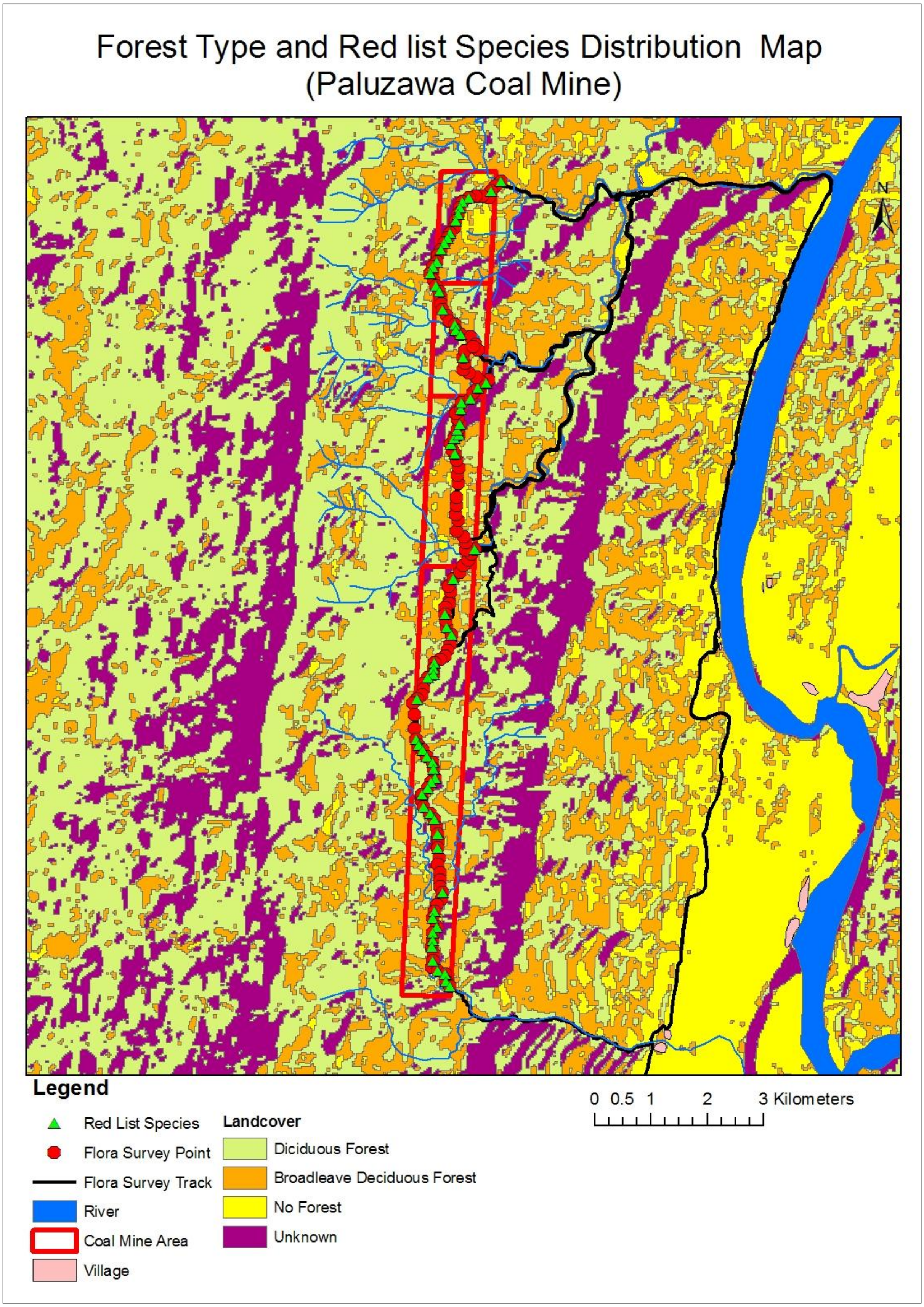
PLANT ASSSOCIATION	ELEVATION(m)	NAME	BAMBOO SPECIES	DOMINANT TREE SPECIES	VEGETATION TYPE	IUCN redlist Species	Comment	POINT_X	POINT_Y
	317	APC-140				*Dendrocalamus membranaceus* Munro, *Millettia ovalifolia* Kurz, *Pterocarpus indicus*Willd., *Holarrhena pubescens* Wall. ex G. Don, *Tetrameles nudiflora* R.Br.	2017-02-13 10:20:39AM	94.276883	23.383889
	315	APC-141				*Dendrocalamus membranaceus* Munro, *Millettia ovalifolia* Kurz, *Holarrhena pubescens* Wall. ex G. Don, *Shorea siamensis* (Kurz) Miq.	2017-02-13 10:29:10AM	94.277760	23.382737

APC=Apache Coal Mine

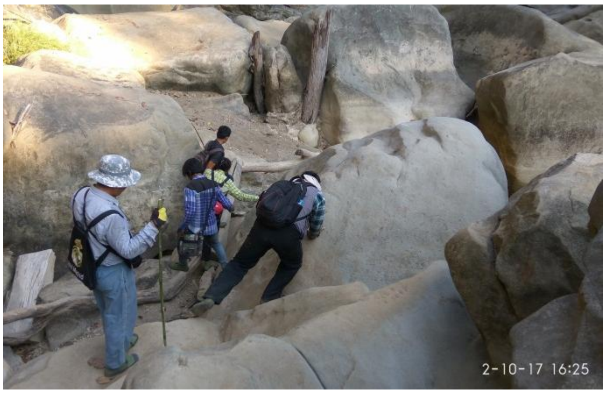
Map.I. Vegetation Index and Study Point Map



Map. II. Forest Type and Red List Species Distribution



Plant Survey Documentorty of survey Area



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Annex E2

Critical Habitat Screening Assessment

1 CRITICAL HABITAT SCREENING ASSESSMENT

1.1 *DISCRETE MANAGEMENT UNIT*

Based on IFC PS 6 Guidance Note 6, the Project is required to "determine a sensible ecological or political boundary that defines the area of habitat to be considered for the Critical Habitat assessment". Termed as a Discrete Management Unit (DMU), this is an area with a 'definable boundary within which the biological communities and/or management issues have more in common with each other than they do with those in adjacent areas'. DMUs may hence be defined using ecological boundaries such as rivers and mountain ridges/valleys where wildlife is determined to be unable to cross, management boundaries such as a Protected Area, or an artificial barriers to movement such as roads and urban areas.

Cement Plant

The DMU identified at the cement plant includes three main components:

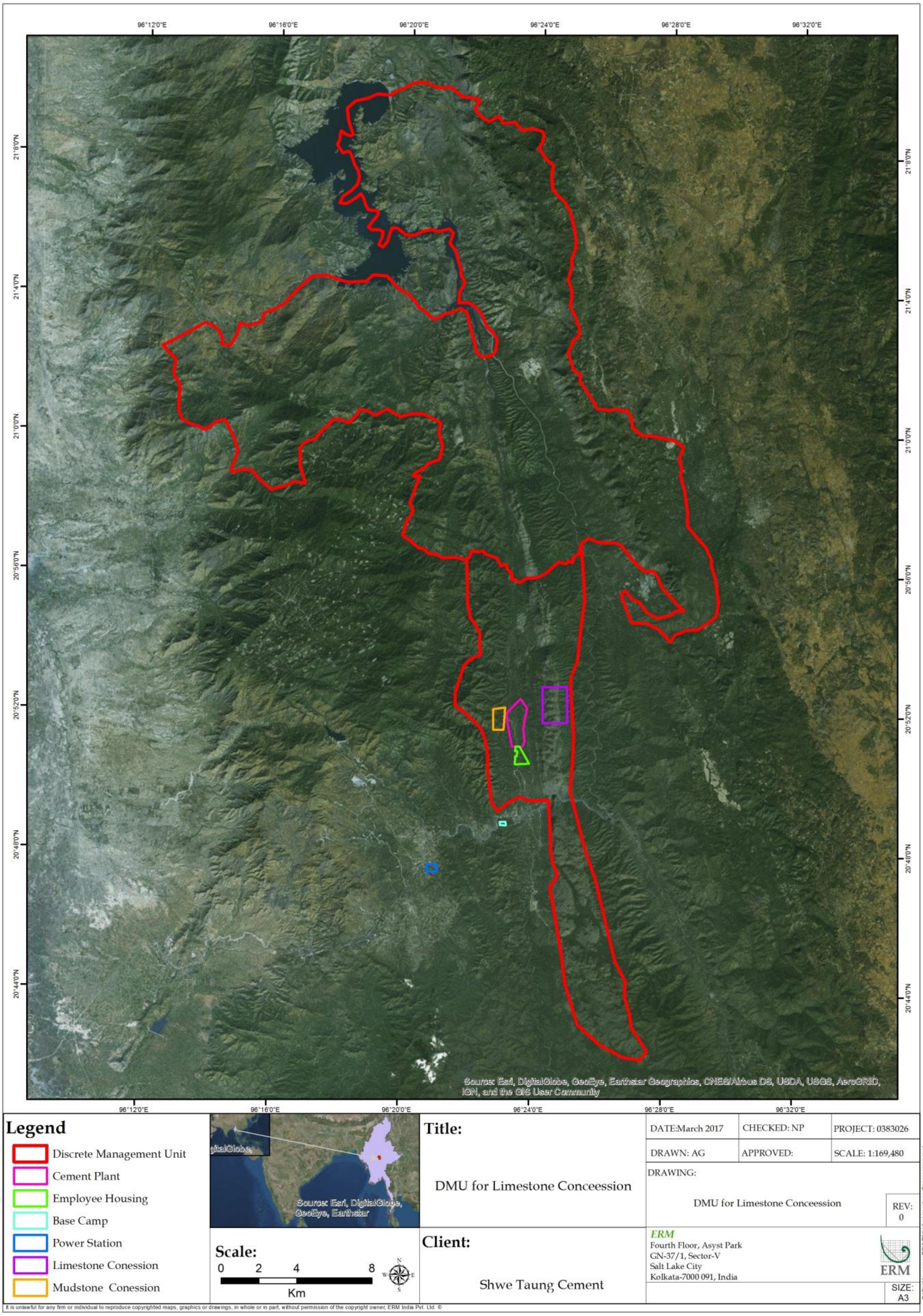
- The limestone outcrop spanning north of the limestone quarry to south of Pyi Nyaung town;
- Contiguous vegetation within and around the Project area, up to the ridge to the west of the Project; and
- Panlaung-Pyadalin Cave wildlife sanctuary, 6 km north of the cement plant.

Although the limestone outcrop is bisected by a road at Pyi Nyaung, the two sections maintain a common geological and geomorphological history. As a result, they are likely to share the same local-endemics and ecosystem types. The sections are essentially part of the same limestone cluster within the Shan plateau. The limestone outcrop in its entirety was thus used to define the DMU.

Based on a review of satellite imagery, it was observed that vegetation within and around the Project area was contiguous with Panlaung-Pyadalin Cave wildlife sanctuary. This indicates a possibility that there is movement of wildlife between Panlaung-Pyadalin and the Project area, hence warranting the inclusion of the Protected area into the project DMU.

The DMU for the cement plant occupies a total area of 45,000 hectares. The DMU for the cement plant is presented in *Figure 1.1*. As the base camp and power stations will be established within built up areas and do not share a contiguous forest with the main project components, they are not included in the DMU delineation.

Figure 1.1 Discrete Management Unit (DMU), Cement Plant



Coal Mine

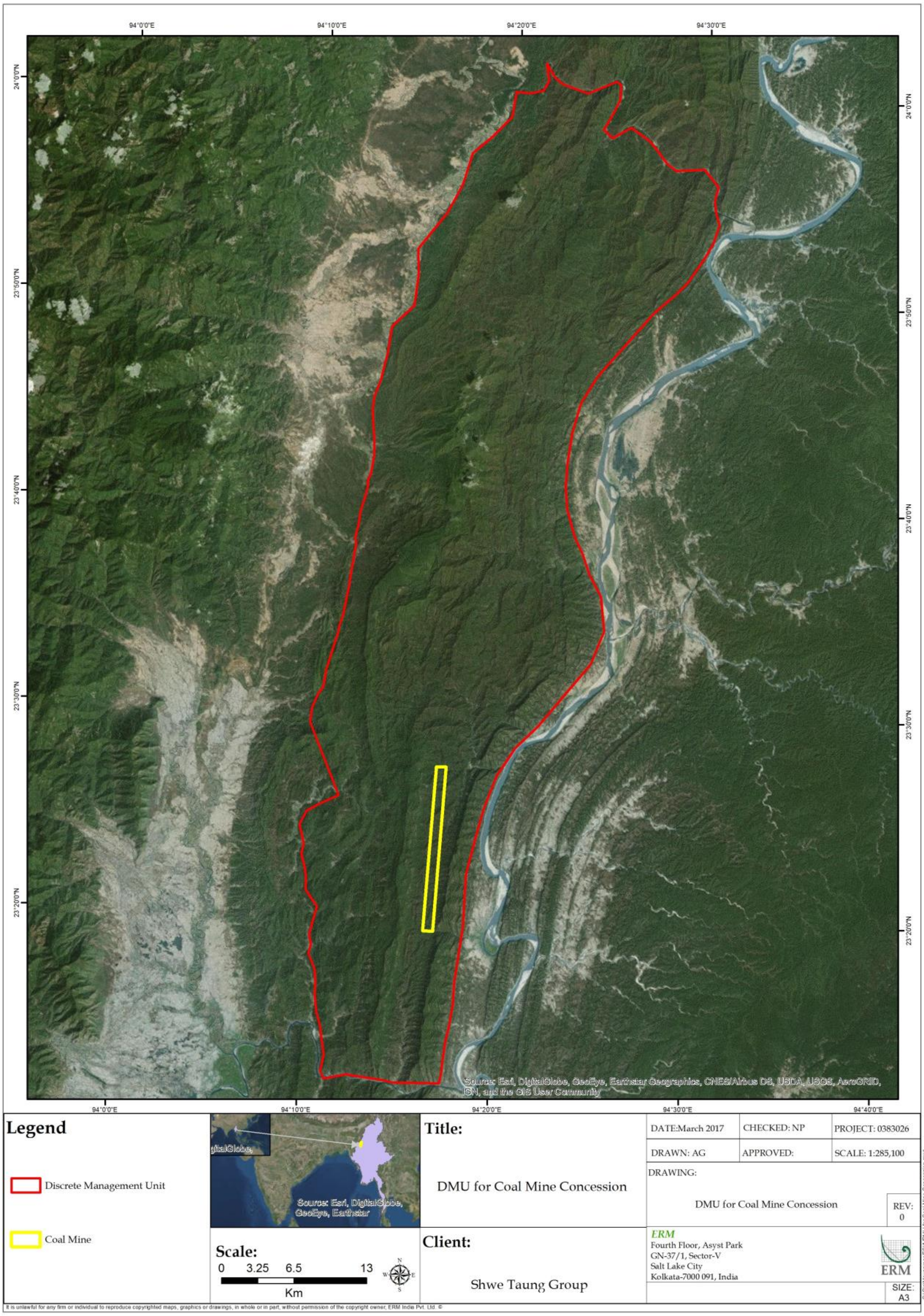
The DMU identified at the coal mine is bounded by:

- A river channel to the north;
- River valley and human-modified landscapes to the west;
- A river channel to the south; and
- The Chindwin River and human-modified landscapes to the east.

There are varying levels of logging and road construction within the DMU leading to forest loss and habitat fragmentation. However, based on a review of satellite imagery and field observations, these are not at a scale to form significant barriers to movement within the DMU. Vegetation within the DMU was thus considered to be fairly contiguous and more significant barriers to movement were considered such as river valleys, channels and tracts of urban landscapes to inform the boundaries of the DMU.

The DMU for the coal mine occupies a total area of 160,000 hectares. The DMU for the coal mine is presented in *Figure 1.2*.

Figure 1.2   Discrete Management Unit (DMU), Coal Mine



1.2 CRITERION FOR CRITICAL HABITAT

Critical Habitat criteria as defined in PS6 Guidance Note 6 (GN6) Paragraphs GN69 – GN97 (*IFC 2012b*), and shown in *Table 1*. This table provides detail of the qualifying requirements for Criteria 1-3 while details of the likely qualifying interests are given for Criterion 4 and 5 which will be defined based on research and expert opinion (as will those for Criteria 1-3 where data is lacking). The criteria listed have been used to complete this assessment.

Table 1 Critical Habitat Criteria

Criteria	Tier 1(1)	Tier 2(1)
Criterion 1: Critically Endangered (CR) / Endangered (EN) species:	a) Habitat required to sustain ≥ 10 % of the global population of a CR or EN species /sub /species and where there known regular occurrences of the species and where habitat could be considered a discrete management unit for the species. b) Habitat with known, regular occurrences of CR or EN species where that habitat is one of 10 or fewer discrete management sites globally for that species.	c) Habitat that supports the regular occurrence of a single individual of a CR species and/or habitat containing regionally- important concentrations of Red-listed EN species where that habitat could be considered as a discrete management unit for the species/subspecies. d) Habitat of significant importance to CR/EN species that are wide-ranging and/or whose population distribution is not well understood and where the loss of such a habitat could potentially impact the long-term survivability of the species. e) As appropriate, habitat containing nationally/regionally important concentrations of an EN, CR or equivalent national/regional listing.
Criterion 2: Habitat of significant importance to endemic and/or restricted-range species;	a) Habitat known to sustain ≥ 95 % of the global population of an endemic or restricted-range species where that habitat could be considered a discrete management unit for that species.	b) Habitat known to sustain ≥ 1 % but < 95 % of the global population of an endemic or restricted-range species where that habitat could be considered a discrete management unit for that species, where data are available and/or based on expert judgment.
Criterion 3: Habitat supporting globally significant concentrations of migratory species and/or congregatory species;	(a) Habitat known to sustain, on a cyclical or otherwise regular basis, ≥ 95 % of the global population of a migratory or congregatory species at any point of the species' lifecycle where that habitat could be considered a discrete management unit for that species.	(b) Habitat known to sustain, on a cyclical or otherwise regular basis, ≥ 1 % but < 95 % of the global population of a migratory or congregatory species at any point of the species' lifecycle and where that habitat could be considered a discrete management unit for that species, where data are available and/or based on expert judgment. (c) For birds, habitat that meets BirdLife International's Criterion A4 for congregations and/or Ramsar Criteria 5 or 6 for Identifying Wetlands of International Importance. (d) For species with large but clumped distributions, a provisional threshold is set at ≥ 5 % of the global population for both terrestrial and marine species. (e) Source sites that contribute ≥ 1 % of the global population of recruits.
Criterion 4: Highly threatened and/or unique ecosystems;	Criterion 4 has no tiered system although recent publication (Keith et al, 2013) may introduce this. This criterion must include one of the following a) the ecosystem is at risk of significantly decreasing in area or quality;	

Criteria	Tier 1[1]	Tier 2[1]
and/or	b) has a small spatial extent; and /or c) contains unique assemblages of species including assemblages or concentrations of biome-restricted species. Highly threatened or unique ecosystems are defined by a combination of factors which may include long-term trend, rarity, ecological condition, and threat.	
Criterion 5: Areas associated with key evolutionary processes	The criterion is defined by: a) the physical features of a landscape that might be associated with particular evolutionary processes; and/or b) subpopulations of species that are phylogenetically or morphogenetically distinct and may be of special conservation concern given their distinct evolutionary history. The latter includes evolutionarily significant units and evolutionarily distinct and globally endangered species.	

Note: [1] No Tier system is in place for Criterion 4 and Criterion 5.

Restricted range species for terrestrial vertebrates, species which have an extent of occurrence of 50,000km.

1.3 CRITICAL HABITAT TRIGGERS (CRITERION 1-3)

The five criteria are 'triggers' in that if an area of habitat meets any one of the criteria then it is considered to be Critical Habitat, irrespective of any other criterion (*TBC, 2012*). Hence Critical Habitat can be determined through a single criterion or where a habitat area holds biodiversity meeting all five criteria. This approach is generally more cautious but is used more widely in conservation (*McDonald-Madden et al, 2009*). Critical Habitat criteria therefore have two distinctive characteristics. First, components of biodiversity are essentially assigned to only two levels of conservation significance, those that trigger Critical Habitat and those that do not (Tier considerations being secondary to this primary Critical Habitat determination). Second, each criterion is applied separately, not in combination, meaning that the scores are not cumulative (*TBC, 2012*).

1.4 CRITICAL HABITAT CANDIDATE SPECIES

For Criterion 1-3 this exercise has used species identified as threatened species. Threatened species were evaluated as threatened based on IUCN status (CR or EN), restricted range and habitat requirements.

Further desktop assessment and consultation did not identify any additional data sources for threatened species that may be considered CH candidates within both Project sites.

Table 2 outlines the CH triggers for Criterion 1-3 within the Kalimantan and Papua Project sites.

Table 2 Critical Habitat Candidate Species (Criterion 1-3) within the Project Sites

SN	Species	Common Name	IUCN Listing/Endemism
Cement Plant Site			
1	*Manis pentadactyla*	Chinese Pangolin	CR
2	*Dalbergia oliveri*	Burma Rosewood	EN

SN	Species	Common Name	IUCN Listing/Endemism
3	*Trachypithecus phayrei* spp. *shanicus*	Shan State Langur	EN
4	*Diplommatina* sp. 3, new sp.	-	Local endemic
5	*Diplommatina* sp. 4, new sp.	-	Local endemic
6	*Diplommatina* sp. 5, aff. *Crispate*	-	Local endemic
7	*Anauchen* new sp.	-	Local endemic
Coal Mine Site			
1	*Manis pentadactyla*	Chinese Pangolin	CR
2	*Trachypithecus phayrei*	Phayre's Langur	EN
3	*Hoolock hoolock*	Hoolock Gibbon	EN
4	*Cuon alpinus*	Dhole	EN
5	*Dalbergia oliveri*	Burma Rosewood	EN
6	*Dipterocarpus baudii*	-	CR
7	*Dipterocarpus costatus*	-	EN
8	*Gastrochilus calceolaris*	-	CR

ON HOLD: The findings from karst reptile and flora surveys are currently pending. The CH assessments for these groups will be placed on hold until more information is available.

It is likely that endemic fauna and flora will be identified along the limestone range. Given that Critical Habitat has been triggered for the limestone area, the risk status of the associated Project area at the STC Limestone Concession will not likely change. Site endemic species associated with the quarry concession may pose a risk if identified however.

1.5 *POTENTIAL CRITICAL HABITAT SPECIES (CRITERION 1-3)*

The CH Screening Assessment identified three (3) species and eight (8) species that are potential CH species for Criterion 1-3 for the cement plant and coal mine sites respectively. *Table 3* below provides further information on these species and assessment outcomes.

Table 3 Summary of Potential Critical Habitat Species

SN	Species	Common Name	IUCN Listing	Criteria 1	Criteria 2	Criteria 3	Observation Type and Locations	Species Information	Criterion Rationale
Cement Plant Site									
1	*Dalbergia oliveri*	Burma Rosewood	EN				Flora Survey (2017); Flora Survey (2015)	Species occurs within a restricted distribution in Myanmar, Thailand and Vietnam. It is found scattered in dense evergreen and semi-deciduous forest up to 1,200 m. It suffers from overexploitation.	The total size of project components of the cement plant is 618 hectares which is likely to occupy less than 1% of the global range of *Dalbergia oliveri*. Although there were 30 individuals of *Dalbergia oliveri* recorded from the project area, this is unlikely to be a globally significant number of individuals. The concession does not exceed 500 m in elevation, whereas the species can be found up to 1,200 m. As such, it is unlikely that habitats within the concession will support 10% or more of the global population of *Dalbergia oliveri* and is also unlikely to contain nationally-important concentrations of the species. Therefore, the habitat does not qualify as Critical Habitat under Criterion 1.
2	*Manis pentadactyla*	Chinese Pangolin	CR				Interview Confirmed Presence within and adjacent to the concession	The species suffers from high levels of poaching for meat and scales. It is likely extirpated from parts of its current range. In Myanmar, the species is plausibly widespread in the northern region. However there are few records and its exact distribution is not known. There are predicted continuing declines of ≤ 90% over the next 21 years or three generations.	Pangolin sightings in and around the cement plant project area were all recorded from a year ago. Field observations noted that the forests around the project area were heavily degraded and there was limited remaining use for wildlife. Given the huge reduction in wildlife, hunting activities have declined. It is noted that habitats at the cement factory are connected with the Panlaung-Pyadalin Wildlife Sanctuary to the north; the wildlife sanctuary may serve as a refuge for

SN	Species	Common Name	IUCN Listing	Criteria 1	Criteria 2	Criteria 3	Observation Type and Locations	Species Information	Criterion Rationale
								The species is found in a wide range of habitats, including primary and secondary tropical forests, limestone forests, bamboo forests, broad-leaf and coniferous forests, grasslands and agricultural fields. In Myanmar, this species is listed as a completely protected animal under the Protection of Wildlife and Wild Plants and Conservation of Natural Areas Law.	pangolins and any sightings at the project could be due to individuals originating from there. Critical Habitat is likely triggered for the species under Criterion 1, Tier 2 in relation to the regular occurrence of a CR listed species within the DMU.
3	*Trachypithecus phayrei* ssp. *shanicus*	Shan State Langur	EN	X			Interview Confirmed Presence adjacent to concession	The eastern subspecies of the endangered Phayre's langur, known only from a few protected areas in Myanmar.	The global population size is estimated to number fewer than 2,500 mature individuals and is experiencing continuing decline that can be attributed to the same threats as its broader species complex is facing. Interviews indicate that the species is possible inside the cement plant project areas but they are more likely to be found on adjacent mountains. A group of 5-7 individuals had been sighted previously. The habitats in the project area are connected to Panlaung-Pyadalin Wildlife Sanctuary which is believed to support populations of the Shan State langur. Considering the (i) restricted distribution of the subspecies to southwestern China and northern and eastern Myanmar and (ii) low global population number, the DMU habitat could be of significant importance to the long term survivability of the Shan State langur.

SN	Species	Common Name	IUCN Listing	Criteria 1	Criteria 2	Criteria 3	Observation Type and Locations	Species Information	Criterion Rationale
									Hence, the habitat qualifies as Critical Habitat under Criterion 1, Tier 2.
4	*Diplommatina* sp. 3, new sp.	-	-		X		North, within and south of the limestone concession	Likely to be a local-endemic species to the limestone range and potentially new to science	Preliminary findings suggest that it could occupy a restricted range on the limestone outcrop such that the habitat may sustain ≥1% < 95% of the global population of this species. Therefore, the habitat qualifies as Critical Habitat under Criterion 2.
5	*Diplommatina* sp. 4, new sp.	-	-		X		North of the limestone concession	Likely to be a local-endemic species to the limestone range and potentially new to science	Preliminary findings suggest that it could occupy a restricted range on the limestone outcrop such that the habitat may sustain ≥1% < 95% of the global population of this species. Therefore, the habitat qualifies as Critical Habitat under Criterion 2.
6	*Diplommatina* sp. 5, aff. *Crispate*	-	-		X		North, within and south of the limestone concession	Likely to be a local-endemic species to the limestone range	Preliminary findings suggest that it could occupy a restricted range on the limestone outcrop such that the habitat may sustain ≥1% < 95% of the global population of this species. Therefore, the habitat qualifies as Critical Habitat under Criterion 2.
7	*Anauchen* new sp.	-	Potential EN/CR	X	X		Within and south of the limestone concession	Likely to be a local-endemic species to the limestone range and potentially new to science. The species is currently only identified within the Concession however	Preliminary findings suggest that it could occupy a restricted range on the limestone outcrop such that the habitat may sustain ≥1% < 95% of the global population of this species.

SN	Species	Common Name	IUCN Listing	Criteria 1	Criteria 2	Criteria 3	Observation Type and Locations	Species Information	Criterion Rationale
								additional sampling will occur in adjacent areas to determine its distribution during the wet season surveys.	Expert evaluation has also indicated that quarrying the project limestone concession, leading to a loss of habitat for this species, could trigger EN or CR status for it. Given its restricted range, the habitat qualifies as of significant importance to a potential CR/EN species whose distribution is still not clearly understood. The loss of this habitat could impact the long-term survivability of this species. Therefore, the habitat qualifies as Critical Habitat under Criterion 2.
Coal Mine Site									
1	*Manis pentadactyla*	Chinese Pangolin	CR	X			Interview Confirmed Presence within and adjacent to the concession	The species suffers from high levels of poaching for meat and scales. It is likely extirpated from parts of its current range. In Myanmar, the species is plausibly widespread in the northern region. However there are few records and its exact distribution is not known. There are predicted continuing declines of ≤ 90% over the next 21 years or three generations. The species is found in a wide range of habitats, including primary and secondary tropical forests, limestone forests, bamboo forests, broad-leaf and coniferous forests, grasslands and agricultural fields.	Interviews with villages and workers from neighbouring coal mine sites have confirmed the presence of the Chinese Pangolin in habitats within and around the coal mine concession. As with other areas within its range, the Chinese Pangolin faces high hunting pressure in the project locality. There were 3 sightings of pangolins in 2 weeks prior to the interviews, suggesting that there are still regular occurrences of the species within the concession although the populations have been declining. Field observations have also identified areas of good quality forest throughout the concession and there are few proper trails granting easy access into these areas. Given the habitat plasticity of the pangolin, it is likely that there are small populations of

SN	Species	Common Name	IUCN Listing	Criteria 1	Criteria 2	Criteria 3	Observation Type and Locations	Species Information	Criterion Rationale
								In Myanmar, this species is listed as a completely protected animal under the Protection of Wildlife and Wild Plants and Conservation of Natural Areas Law.	pangolins persisting within and around the concession in these forest areas. Therefore, habitats within the concession support the regular occurrence of an IUCN Red-listed CR species. Habitats at the concession can be considered part of a larger DMU as indicated in *Figure 6.29* of the ESIA Report. Therefore, habitats in the concession are considered Critical Habitat, Tier 2 with the Chinese Pangolin as a trigger.
2	*Trachypithecus phayrei*	Phayre's Langur	EN	X			Sighted (2015 Survey) Interview Confirmed Presence adjacent to concession	Species is listed as EN as it is believed to have undergone a decline of more than 50% over the last 3 generations due to a combination of habitat loss and hunting. One generation length is estimated at 12 years. According to IUCN, there is little information available concerning the species' status in Myanmar. The species prefers primary and secondary evergreen and semi-evergreen forest, mixed moist deciduous forest. It can also be found in bamboo-dominated areas and some human-cultivated landscapes. It is a predominantly arboreal, diurnal and folivorous species. In several parts of its range, this species suffers from habitat disturbance, fragmentation and hunting.	Presence of this species was confirmed in all interviews and surveys in 2015 had a sighting. Individuals face hunting pressure and all interviewed persons had commented that langurs have undergone a substantial decline in the region. There were unconfirmed claims of regular sightings of langur groups around the concession. Phayre's langurs have an estimated home range of 10 to 100 ha with little overlap amongst groups. Given the coal mine concession itself is 1,450 ha and the DMU is 160,000 ha. Field observations have noted the presence of good quality forests in several parts within and around the concession. This combined with the size of the concession and DMU suggest that habitats have the capacity to support more groups of langurs than reported. According to the IUCN Red List, the status of Phayre's langurs in Myanmar is currently unknown however there is a general

SN	Species	Common Name	IUCN Listing	Criteria 1	Criteria 2	Criteria 3	Observation Type and Locations	Species Information	Criterion Rationale
									population decline within its range due to habitat conversion, fragmentation and hunting. The species' population distribution in Myanmar is not well understood and is fairly wide-ranging. , The DMU identified for the coal mine is unlikely to constitute a significant habitat for the Phayre's langur in Myanmar. Habitats thus qualify is not triggered as Critical Habitat under Criterion 1 Tier 2.
3	*Hoolock hoolock*	Hoolock Gibbon	EN	X			Interview; Acoustic record Confirmed Presence adjacent to concession	Main threats to this species are hunting and habitat loss. It is believed that the species has declined by at least 50% over the past 40 years. In Myanmar, the dominant threats are shifting cultivation, hunting and logging. The largest and most viable populations are believed to be found west of the Chindwin River. However, there is a lack of information regarding the population sizes and distribution of Hoolock Gibbons in these forests. The species is a forest dweller and feeds on fruits and leaves. Home ranges range from 8-63 ha but large home ranges of 200-400 ha were reported from populations in India.	Gibbons were heard calling adjacent to the concession. However, due to large home range sizes reported from other populations (8 - 63 ha, and 200 - 400 ha), it is likely that the gibbons found in the Paluzawa area would utilise habitats within the concession. The Hoolock Gibbon has been declining within its range due to habitat fragmentation and hunting. According to the IUCN Red List, the largest and most viable populations of the gibbon could be found west of the Chindwin river, where the project is located. There are remaining good quality patches of forest within the DMU defined around the coal concession that support the belief that more gibbons are likely to dwell within the area. The DMU could hence contain habitats of significant importance to Hoolock gibbons and a loss could potentially impact the long term survival of the species. Habitats thus qualify as Critical Habitat under Criterion 1 Tier 2.

SN	Species	Common Name	IUCN Listing	Criteria 1	Criteria 2	Criteria 3	Observation Type and Locations	Species Information	Criterion Rationale
4	*Cuon alpinus*	Dhole	EN	X			Interview; Canine tooth Confirmed Presence within concession	Dholes have disappeared from most of their historical range, and populations are still declining due to depletion of prey base, habitat loss, persecution, disease and potential interspecific competition. Based on IUCN RedList, there is an estimated 4,500 - 10,500 individuals remaining of which only 949 - 2,215 are mature. The current distribution of Dholes in Myanmar is uncertain; they have been recorded from several protected areas in Myanmar and could potentially occur throughout these regions. Myanmar has been classified as having medium numbers of Dholes (750-1,500). Dholes have been recorded from several protected areas including Mahamyaing Wildlife Sanctuary east of the Project. The Dhole is a habitat generalist and can occur in a wide variety of vegetation types including degraded forms of tropical dry and moist deciduous forests. Home range studies have estimated 23-199 km^2 and 60-80 km^2 in India and Thailand respectively.	The presence of the Dhole was confirmed in habitats within the concession. As dholes are typically found in a pack, the presence of one individual may signal the presence of a larger group of individuals. With the coal concession spanning 1,450 ha (14.5 km2), it is likely to overlap with the home range of a pack of Dholes in the locality. The distribution of Dholes in Myanmar is still poorly known, with records from the northern, western and central parts of the country. There are records from Maharmyaing Wildlife Sanctuary but the habitats there are not contiguous with the coal mine DMU due to separation by the Chindwin River. This suggests the population of dholes around the project area is distinct from the wildlife sanctuaries. With a poorly understood distribution, and continuing declines, the potential presence of a population of dholes within the DMU is of interest. The habitat within the DMU is unlikely to be of importance for the conservation of the species. Therefore, the habitat does not qualifyas Critical Habitat under Criterion 1, Tier 2.
5	*Dalbergia oliveri*	Burma Rosewood	EN				Flora Survey (2017); Flora Survey	Sepcies occurs within a restricted distribution in Myanmar, Thailand and Vietnam. It is found scattered	The coal mine concession spans 1,450 ha which is likely to occupy less than 1% of the global range of *Dalbergia oliveri*. The

SN	Species	Common Name	IUCN Listing	Criteria 1	Criteria 2	Criteria 3	Observation Type and Locations	Species Information	Criterion Rationale
							(2015)	in dense evergreen and semi-deciduous forest up to 1,200 m. It suffers from overexploitation.	concession does not exceed 500 m in elevation, whereas the species can be found up to 1,200 m. As such, it is unlikely that habitats within the concession will support 10% or more of the global population of *Dalbergia oliveri* and is also unlikely to contain nationally-important concentrations of the species. Therefore, the habitat does not qualify as Critical Habitat under Criterion 1.
6	*Dipterocarpus baudii*	-	CR				Flora Survey (2015)	This species is found scattered in the greatly reduced lowland evergreen forests of South East Asia. Main threat is habitat destruction. It is rather rare and scattered in low-lying, well-drained or semi-swampy forests or on low hills. It can be found at elevations up to 800 m.	The coal mine concession spans 1,450 ha which is likely to occupy less than 1% of the global range of *Dipterocarpus baudii* which occurs over Cambodia, Indonesia (Sumatra), Malaysia, Myanmar, Thailand and Vietnam. The concession does not exceed 500 m in elevation, whereas the species can be found up to 800 m. The concession also supports deciduous forest vegetation and does not contain semi-swampy forests. As such, it is unlikely that habitats within the concession will support 10% or more of the global population of *Dipterocarpus baudii* and is also unlikely to contain nationally-important concentrations of the species. However, Critical Habitat is likely triggered for the species under Criterion 1, Tier 2 in relation to the regular occurrence of a CR listed species within the DMU.
7	*Dipterocarpus costatus*	-	EN				Flora Survey (2015)	This species is found scattered in lowland, hill and upper dipterocarp forest. There are	The coal mine concession spans 1,450 ha which is likely to occupy less than 1% of the global range of *Dipterocarpus costatus* which

SN	Species	Common Name	IUCN Listing	Criteria 1	Criteria 2	Criteria 3	Observation Type and Locations	Species Information	Criterion Rationale
								populations found within reserves.	occurs over most of Southeast Asia and Bangladesh. The dominant vegetation types of the coal mine comprises deciduous forests, therefore *Dipterocarpus costatus* is unlikely to form the dominant group in project habitats. As such, it is unlikely that habitats within the concession will support 10% or more of the global population of *Dipterocarpus costatus* and is also unlikely to contain nationally-important concentrations of the species. Therefore, the habitat does not qualify as Critical Habitat under Criterion 1.
8	*Gastrochilus calceolaris*	-	CR				Flora Survey (2015)	Rare species that is only found in Benguet Province, Luzon. The species account on IUCN Red List is potentially confusing, as it lists its range to include the Himalayas, Indochina, Malaysia and Taiwan but indicates that the population is localised in the Philippines. Only found at high altitudes.	It is highly likely that this is a misidentification. However, assuming the species was correctly identified, it is found only at high altitudes. This thus excludes the project from containing high enough numbers of individuals to meet the population threshold of 10% to qualify it as a Critical Habitat. Therefore, the habitat does not qualify as Critical Habitat under Criterion 1.

ON HOLD: The findings from karst reptile and flora surveys are currently pending. The CH assessments for these groups will be placed on hold until more information is available following the completion of additional surveys.

1.6 *CRITERION 4) HIGHLY THREATENED AND/OR UNIQUE ECOSYSTEMS*

Highly threatened and unique ecosystems as defined by the IFC are those that are a) under significant threat; b) small in size; and/or c) have unique species assemblages. An assessment of the presence of habitats within the concessions at the Cement Plant and Coal Mine which meet these criteria and relevant discussions are provided below.

1.6.1 *Ecosystems at Risk of Significantly Decreasing In Area or Quality*

Myanmar's accessible forests are decreasing rapidly in extent and quality. Forest cover has reduced by approximately 58% in 1990 to 45% in 2015 (1). Further studies have shown that areas subjected to extremely high rates of deforestation occur in the mangroves in the Ayeyarwady Delta and the dry deciduous forests in the northern edge of the Central Dry Zone. The largest remaining areas of intact forests can be found in northern Sagaing region, Kachin State and Taninthayi Region. However, the Sagaing region also possesses high rates of forest conversion to plantations and mining (2). Based on Global Forest Watch Data, Myanmar has lost an estimated 2,030,101 ha of tree cover in the years of 2001-2014.

Cement Plant – Karst Ecosystem

As outlined in *Section 6.3.2 – Karst/Limestone Ecosystems* of the ESIA Report, karsts in Southeast Asia face a number of threats and lack adequate levels of protection. Poorly planned quarrying operations may destroy whole karst landforms, wiping out site-endemics and greatly reducing the populations of regional-endemics. There is also a lack of representation of karst ecosystems in Protected Area networks in Southeast Asia, with the percentage of protected karst areas ranging from 0 – 45% of total karst areas depending on the country. An assessment of protected karst areas in Southeast Asia reported that only 1 % of karst areas in Myanmar is protected (within Shwe u Daung and Shwesettaw Game Reserves, and Pindaya Cave) (5).

While there is no reported data on the decrease of karst ecosystems in Southeast Asia and Myanmar in particular, the under-representation of karsts in Protected Areas and the country's burgeoning economic growth suggests that resource extraction will continue to threaten this ecosystem. In the context of the DMU, an estimated quarter of the limestone range is within the project concession and will be removed entirely from quarrying. However, the same limestone range exists further south and other geologically and geomorphologically related outcrops are distributed across the Shan Plateau.

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(1) Myanmar National Biodiversity Strategy and Action Plan (2015)

(2) Myanmar National Biodiversity Strategy and Action Plan (2015)

(5) Day M & Urich P (2000) An Assessment of Protected Karst Landscapes in Southeast Asia. Cave and Karst Science. Volume 27, No.2

Whilst karst ecosystems are not well represented in the protected area system, there is insufficient data available to suggest that they are currently highly threatened in Myanmar. Therefore, it is not likely that karst ecosystems in Myanmar qualify as Critical Habitat under Criterion 4.

Coal Mine

Evidence collected from the field studies suggest that habitats in the DMU are not decreasing rapidly in area; however the quality of habitats is at risk from logging, conversion and fragmentation. Field observations note that there is still remaining good quality forest adjacent to the concession. The forest habitats therefore are not currently threatened in area; however they are currently impacted by threats in relation to habitat quality. Illegal logging in Myanmar is currently a major threat to forest ecosystems. In relation to the DMU, whilst this threat is present, it is not determined to be a significant threat to the persistence of the forest ecosystem in terms of area. A visual assessment of satellite imagery for the DMU indicates that stands of mature forests exist within the DMU and that logging has occurred only where access has enabled this threat to occurin the landscape. Therefore, the forest ecosystem within the DMU is unlikely to qualify as Critical Habitat under Criterion 4.

1.6.2 *Ecosystems with a Small Spatial Extent*

The limestone ecosystems within the DMU were considered in the context of the Shan plateau – an extensive karst occurring over an area of 500 km by 300 km. The limestone outcrops within the Shan Plateau are assumed to be geologically and geomorphologically related. As limestone outcrops can differ significantly from each other in terms of habitat, a review of the findings of the karst survey was also conducted. This was to understand if the karst ecosystem present on the limestone within the concession was replicated elsewhere across the range.

No site endemics were recorded from the limestone within the project concession and preliminary findings indicate that local-endemic species are likely to occur across the limestone range and its extensions further south. This suggests that the limestone ecosystem within the DMU does not occur within a small spatial extent, and hence is unlikely to trigger Critical Habitat under this Criterion.

Coal Mine

The ecosystem found within the DMU is likely to be an extension of the deciduous forest ecosystem within the coal mine concession. In the context of the DMU (160,000 hectares), the coal mine concession occupies less than 1% of the total area. The forest ecosystem is representative of a larger forest complex that extends into Northern Myanmar and into North Eastern India.

The ecosystem does not have a small spatial extent and hence is unlikely that Critical Habitat could be triggered under this Criterion.

1.6.3 *Ecosystems Containing Unique Assemblages of Species Including Assemblages or Concentrations of Biome-Restricted Species*

Cement Plant

The forests around the project were also observed to be highly degraded. These suggest that the forest ecosystem around the project area has a low capacity for an assemblage of species that can be deemed unique. Therefore, forest ecosystems at the project do not qualify as Critical Habitat under Criterion 5.
Surveys of the limestone range indicate an absence of site-endemics in the project concession but a presence of local-endemics across the range. Limestone areas are typically known for containing limestone-restricted species and display high levels of endemism. The limestone range in the DMU thus qualifies as Critical Habitat under Criterion 5.

Coal Mine

Given the general inaccessibility to parts of good forest in the site, it is likely that there may be more sensitive and elusive species within the DMU. The Project site is within a Tiger Conservation Landscape, and although this species was not determined to be present during surveys conducted for this Project, suitable prey species exists within the landscape. Insufficient evidence currently exists to evaluate the coal mine site as containing a unique assemblage of species or biome restricted species. Whilst a number of different species were identified, the species mix is not unique as it is representative of the fauna that are normally associated with this habitat type in SE Asia. The number of species detected though is generally higher than equivalent habitat types sampled in adjacent countries. Therefore, the ecosystems within the DMU are not evaluated as Critical Habitat under this Criterion.

1.7 *CRITERION 5) KEY EVOLUTIONARY PROCESSES*

Criterion 5 recognises the attributes of a region that that can influence evolutionary processes and give rise to regional configuration of species and ecological properties. Examples can include isolated areas where populations are phylogenetically distinct, areas of high endemism, environment gradients or ecotones and biological corridors.

While no site endemic species were recorded within the limestone concession, several local-endemic species were found throughout the limestone range, including within the project concession. Most of the unidentified species (constituting a third of all recorded species) are also potentially new to science. Two limestone restricted flora species were recorded. It is likely that there are more local-endemic and limestone restricted species within the range as the surveyors could only access sites that were severely degraded. While results are preliminary and no quantitative findings have been reported, the initial findings reflect the richness limestone-restricted species within the range. This is testament to the evolutionary significance of limestone ecosystems; hence the limestone range within the DMU qualifies as Critical Habitat under Criterion 5.

Criterion 5 assessment will be updated upon review of Final Karst Survey Report

Annex E3

Ecosystem Services Assessment

1.1 *ECOSYSTEM SERVICES ASSESSMENT*

1.1.1 *Defining Ecosystem Services*

Ecosystem services are defined as the benefits that people, including businesses, derive from ecosystems (IFC 2012). These services are substantial and varied, underpinning basic human health and survival needs as well as supporting economics activities, the fulfillment of people's potential, and enjoyment of life.

In order to provide a uniform basis to assess the status of all major global habitat across all of the word's bioregions, the United Nation's Millennium Ecosystem Assessment (UN 2005) combine diverse Ecosystem Services typologies into a consistent classification scheme.

There are four categories of ecosystem services defined in Millennium Ecosystem Assessment as outlined in IFC Performance Standard 6:

- **Provisioning Services**; these services that can be extracted from ecosystem to support human needs. This term is more or less synonymous with the term " **Ecosystem Goods**" that was used in some prior classification schemes, including such tangible assets as fresh water, food, fiber, timber and medicinal plants,

- **Regulating Services**; the benefit obtained from an ecosystem's control of the natural environment, including of the regulation of surface water purification, carbon storage, and sequestration, climate regulation, protection from natural hazard, air quality, erosion and pests,

- **Cultural Services**; non-material benefits including diverse aspect of aesthetic, spiritual, recreational, and others cultural value,

- **Supporting services**; the natural process essential to the maintenance of the integrity, resilience, and functioning of ecosystem, thereby supporting the delivery of all other benefits. They include soil formation, nutrient cycling, and primary production.

1.1.2 *IFC Performance Standard Requirements*

The International Finance Corporation's (IFC) performance standards require projects to assess and preserve the benefits from ecosystem services. The IFC also requires that the environmental and social risks and impacts identification process considers a project's dependence on ecosystem services. A fundamental component is to apply the mitigation hierarchy to determine measures to limit impacts on ecosystem services.

ERM has utilized the World Resources Institute (WRI) Guidelines: *Weaving Ecosystem Service into Impact Assessment* to guide the approach used to assess ecosystem services in relation to the project.

The Ecosystem Services Review was undertaken following a five-stage approach (WRI 2014):

- ***Screening assessment*** to Identify Ecosystem Services that may occur within the study area;
- ***Data Collection and prioritization*** for 'screened in' Ecosystem Services;
- ***Scoping***; to refine the list of ecosystem services based on those identify in the study area and potentially impacted by the project;
- ***Prioritization*** to identify Ecosystem services importance to beneficiaries; and
- ***Impact Assessment*** to identify the impacts to ecosystem services and their human beneficiaries as a result of the project

1.1.3 Ecosystem Services Screening Assessment

An ecosystem services screening assessment was undertaken to determine the likely ecosystem service values that could be potentially important to affected communities. This assessment was done using existing sources of data, including information gleaned during the initial scoping visit. This visit was held in October 2016 and consisted of initial management interviews with STC representatives at the cement plant on 14 November 2016 site visit.

The scoping exercise was undertaken in order to refine the list of Ecosystem Services that:

- **Potential Beneficiaries**: Known and potential beneficiaries for a service were identified and where possible identifying people at the local, national, and / or global level.
- **Sources of Impact**: Potential sources of impact were considered based on the project description (See *Section 2* of the ESIA Report);
- **Project Dependence:** IFC PS-6 requires that the Ecosystem Services assessment take into consideration any services that the Project may rely upon during construction, operation and/or decommissioning. Therefore all services for which there is a potential project dependency were scoped into the prioritisation stage.

The goal of the scoping exercise was to identify a list of Ecosystem Services to be assessed during through the surveys.

The results of the scoping assessment are contained in *Table 1*

Table 1 Ecosystem service screening assessment

Ecosystem Service Type	Description, Examples	Current Known Ecosystem Services	Screened in?
Provisioning Services			
Food: wild-caught fish and shellfish & aquaculture	Fish caught for subsistence or commercial sale; Fish, shellfish, and/or plants that are bred and reared in ponds, enclosures, and other forms of fresh- or salt-water confinement for harvesting	Evidence suggests that there is limited fishing at both Project areas. Fishing undertaken is limited to areas outside of the Project area but within the AoI. The project is unlikely to have a significant impact on this service.	No
Food: wild meat	Animals hunted for primarily for food (recreational hunting covered under cultural services)	Evidence suggests that there is currently hunting by local people for wild meat within the Project Area and AoI.	Yes
Food: cultivated crops	Annual and permanent crops grown for subsistence use and commercial sale	Evidence suggests that cultivated crops occur within the Project Area and AoI. There is potential for impacts to cultivated crops from air emissions.	Yes
Food: herbs and plants	Herbs and plants collected for food by local people	Evidence suggests that herbs and plants are collected by local people. The project may restrict or reduce the availability of this service.	Yes
Livestock farming	Sedentary and nomadic livestock farming	Evidence suggests that local people undertake livestock farming within the Project Area and AoI. The project may restrict this practice.	Yes
Biomass fuel	Wood, dung and plant matter collected for charcoal, fuel	Evidence suggests that there is limited collection of wood, dung and plant matter for the production of charcoal and fuel	No
Timber and wood products	Wood collected for local use or for sale as timber, wood pulp and paper	Evidence suggests that wood is harvested from within the Project Area and AoI for use by local people. The project may restrict this activity.	Yes
Non- Timber Forest Products (NTFP)	Non-timber products collected from the forest. For example, cane, palm, straw, cotton, hemp, twine and rope, natural rubber	Evidence suggests that NTFP is harvested from within the Project Area and AoI for use by local people. The project may restrict this activity.	Yes
Regulating services			
Freshwater	Freshwater for bathing, drinking, irrigation, laundry, household and industrial use	Evidence suggests that freshwater is used by local people from within the Project Area and AoI. The project may restrict or impact this activity.	Yes
Biochemical, natural medicines, pharmaceuticals	Natural medicines, biocides, food additives, pharmaceuticals and other biological material for commercial or domestic use. For example, pelts, carved or decorative animal products, live animal trade	Evidence suggests that there is little use of natural medicines biocides, food additives, pharmaceuticals and other biological material for commercial or domestic use.	No
	Genes and genetic information used for animal breeding, plant improvement, and biotechnology	Evidence suggests that there is no current use of genes and genetic information used for animal breeding, plant improvement, and biotechnology.	No

Ecosystem Service Type	Description, Examples	Current Known Ecosystem Services	Screened in?
Ecosystem functions	The influence ecosystems have on air quality by extracting chemicals from the atmosphere (i.e., serving as a "sink") or emitting chemicals to the atmosphere (i.e., serving as a "source")	Evidence suggests that the Project area of AoI has no major influence on air quality in the vicinity.	No
	Carbon sequestration (impacts on global climate change) regulation of temperature, shade air quality by vegetated areas	Evidence suggests that the Project area of AoI has no major influence on Carbon sequestration in the vicinity.	No
	Influence ecosystems have on the timing and magnitude of water runoff, flooding, and aquifer recharge	Evidence suggests that the Project area of AoI has no major influence on water runoff, flooding, and aquifer recharge in the vicinity.	No
	Role played by vegetation and bacteria in the filtration and decomposition of organic wastes and pollutants and the assimilation and detoxification of compounds.	Evidence suggests that the Project area of AoI has no major influence on filtration and decomposition of organic wastes and pollutants in the vicinity.	No
	Role of natural habitats (e.g. wetlands, beaches, reefs) in protecting crops, buildings, recreation areas from waves, wind and flooding from coastal storms.	Evidence suggests that the Project area of AoI has no major influence on protecting crops, buildings, recreation areas from waves, wind and flooding from coastal storms in the vicinity.	No
	Regulation of fire frequency and intensity (e.g. dense forest can provide firebreaks)	Evidence suggests that the Project area of AoI has no major influence on regulation of fire frequency and intensity in the vicinity.	No
	Predators from forests, grassland areas, etc. may control pests attacking crops or livestock	Evidence suggests that the Project area of AoI has no major influence on Predators from forests, grassland areas, etc. may control pests attacking crops or livestock in the vicinity.	No
	Influence ecosystems have on the incidence and abundance of human pathogens	Evidence suggests that the Project area of AoI has no major influence on incidence and abundance of human pathogens in the vicinity.	No
	Role of vegetation in regulating erosion on slopes and riparian areas	Evidence suggests that the Project area of AoI for the coal mine site has regulating erosion on slopes and riparian areas in the vicinity.	Yes
	Birds, insects and some small mammals pollinate certain flora species, including some agricultural crops	Evidence suggests that the Project area of AoI has no major influence on birds, insects and some small mammals pollinate certain flora species, including some agricultural crops in the vicinity.	No
Cultural Services			
Spiritual, religious or cultural value	Natural spaces or species with spiritual, cultural or religious importance	Evidence suggests that the Project area of AoI is considered as important natural spaces or species with spiritual, cultural or religious importance.	No
	Cultural value placed on traditional practices such as hunting, fishing, crafts and use of natural resources.	Evidence suggests that the Project area of AoI is not considered important areas for cultural value on traditional practices.	No
	Use of natural spaces and resources for tourism and recreation (e.g. swimming, boating, hunting, bird-watching, fishing)	Evidence suggests that the Project area of AoI is not considered important natural spaces and resources for tourism and recreation.	No
	Cultural value placed on the aesthetic value provided by landscapes, natural landmarks	Evidence suggests that the Project area of AoI is not considered as important aesthetic value provided by landscapes, natural landmarks.	No

Ecosystem Service Type	Description, Examples	Current Known Ecosystem Services	Screened in?
	Information derived from ecosystems used for intellectual development, culture, art, design, and innovation.	Evidence suggests that the Project area of AoI is not considered important for information derived from ecosystems used for intellectual development, culture, art, design, and innovation.	No
Supporting Services			
Non-use value of biodiversity (e.g. existence, bequest value)	Species and areas valued globally as of high conservation value	Evidence suggests that the Project area of AoI may contain species that are considered as being a high conservation value.	Yes
	Formation of biological material by plants through photosynthesis and nutrient assimilation.	Evidence suggests that the Project area of AoI is not considered important regarding biological material by plants through photosynthesis and nutrient assimilation.	No
	Flow of nutrients (e.g., nitrogen, sulfur, phosphorus, carbon) through ecosystems.	Evidence suggests that the Project area of AoI is not considered important for the flow of nutrients.	No
	Flow of water through ecosystems in its solid, liquid, or gaseous forms.	Evidence suggests that the Project area of AoI is not considered important for the flow of water through ecosystems.	No
	Natural soil-forming processes throughout vegetated areas.	Evidence suggests that the Project area of AoI is not considered important for natural soil forming processes.	No
	Natural spaces that maintain species populations and protect the capacity of ecological communities to recover from disturbances.	Evidence suggests that the Project area of AoI is not consider important to maintain species populations and the capacity to assist ecological communities recover from disturbances.	No

1.1.4 *Ecosystem service Data Collection and Prioritization*

Standard approaches to collect ecosystem service data through community consultation and market survey was conducted during the supplementary social baseline surveys undertaken for the ESHIA Addendum assessment to comply with IFC PS during April 2015. The methods used and results identified are outlined below.

Biodiversity surveys in the project area and area of influence were conducted from March 2015 until August 2015. A summary of the methodology and results are outlined below.

1.1.4.1 *Community Surveys*

ERM visited the two project sites in January 2017 to consult with the Project stakeholders explaining the concept of the project and administering questionnaires to individuals and groups. The stakeholder engagement included specific discussions regarding ecosystem services.

ERM undertook the following consultation as part of ESIA:

- Consultation with 100 households living in close proximity to the cement plant and coal mine from selected communities (5 villages); and
- Consultation meetings with government authorities, NGOs, PAPs and other interested people.

Household survey questionnaires were used to gather data from the communities around the cement plant and coal mine to solicit their opinions on both the positive and negative aspects of the Project development to inform the ESIA. The data is relevant to understanding current socio-economic conditions in the Area of Influence of the Project, historical impacts associated with the construction of the cement plant and coal mine as well as potential issues associated with the on-going operation of the Project.

The topics addressed in the household surveys included:

- basic household information (Individual);
- socio-economic surveys with village leaders;
- group discussions focussed on the livelihoods women and farmers; and
- socio-economic system survey as a quantitative assessment of the level of reliance on natural resources by affected communities and the linkage between the subsistence economy and the livelihoods of affected communities.

Prior to conducting household surveys, an introductory meeting was convened in the host community to introduce the purpose of the consultation.

1.1.4.2 Data Collection

Data was collected through community meetings, household surveys and face to face discussions with stakeholders. Community meetings were arranged by STC in collaboration with the Township General Administration Department Authorities and Village leaders. These meetings provided an opportunity to update stakeholders on the Project as well as gather feedback.

A total of 100 useable household surveys, five (5) Socio-Economic surveys to Village leaders, and 15 group discussions for socio-economic systems were completed across all five (5) villages with particular focus on the livelihoods of women and farmers. The details the surveys conducted are in *Table 2**Table* .

Table 2 The details of the surveys conducted in project area.

Date	Village	Village Tract	Township	Region	No. of HH Consulted by Village Tract
Limestone Concession					
17-1-17	Kyubin & Pyinaung	Pyinaung	Tharsi	Mandalay	Meeting with Village leaders and 2 Socio-economic Surveys
18-1-17	Kyubin	Pyinaung	Tharsi	Mandalay	25 HH Survey
19-1-17	Pyinaung	Pyinaung	Tharsi	Mandalay	25 HH Survey
20-1-17	Kyubin & Pyinaung	Pyinaung	Tharsi	Mandalay	2 Townhall Meetings, 6 Groups Discussion
Coal Mine Concession					
22-1-17	Pluzawa	Ywarthar	Kalaywa	Sagaing	Townhall Meeting, 11HH Surveys, Socio-economic survey and 3 Group Discussion
23-1-17	Nanmawke	Ma Sein	Kalaywa	Sagaing	Townhall Meeting, 19HH Surveys, Socio-economic survey
24-1-17	ChaungSone	Ma Sein	Kalaywa	Sagaing	Townhall Meeting, 20HH Surveys and Socio-economic survey
25-1-17	Nanmawke & Chaungsone	Ma Sein	Kalaywa	Sagaing	6 Groups Discussion
Total Surveys	**100 HH Surveys, 5 Socio-economic survey and 15 Groups discussion**				

The questionnaire used to collect data on ecosystem services is shown in *Figure 1*. Data was collected on screened in ecosystem services relevant to the community. Information was collated on:

- Type of ecosystem services used by the local community;
- Sources (locations), amounts utilised and availability of alternatives; and
- Condition and trends in resource availability.

Information collected on cultural, and supporting ecosystem services was collected from social surveys and biodiversity surveys. Screened ecosystem services for erosion and non-use value of biodiversity (e.g. existence, bequest value) have been determined based on data collected on soil, water and biodiversity for this ESIA.

Figure 1 Ecosystem Services Questionnaire

ES Screened in	Questions
Food: wild meat	• Does the local community hunt for animal to supply wild meet in the forest? (e.g. Deer). Record the type and amounts. • Discuss what other sources of protein are used by households. Record the type and amounts. • Record the type and trend (increasing or decreasing)
Food: cultivated crops	• Discuss the crops that are cultivated in the forest by the household. Record the number and area of plots. • Discuss what other crops are used by households. Record the type and amounts. • Discuss any trends in quality or quantity. Record the type and trend (increasing or decreasing)
Food: herbs, mushrooms and plants	• Discuss what herbs, mushrooms and plants are collected from the forest. Record the species, places where they are collected, their use and frequency of collection. • Discuss what other plants, mushrooms or herbs are used by households. Record the type and amounts. • Discuss the type of plants and herbs consumed and whether there is a trend in quality or quantity. Record the type and trend (increasing or decreasing)
Livestock farming	• Discuss the livestock used and the location of grazing areas. Not if grazing areas are within natural forest areas • Discuss what other livestock are used by households. Record the type and amounts. • Discuss the type of livestock tended and whether there is a trend in quality or quantity. Record the type and trend (increasing or decreasing)
Timber and wood products	• Discuss the types of wood and timber products collected in the forest by the household and their primary uses (house building/canoe building). Record the amount and location of the collection point. • Discuss what other sources of wood are used by households. Record the type and amounts. • Discuss the yield of wood and timber products and whether there is a trend in quality or quantity. Record the type and trend (increasing or decreasing)
Non- Timber Forest Products (NTFP)	• Discuss the collection of NTFP in the forest by the household. Record the type and amount. • Discuss what other NTFP are used by households. Record the type and

ES Screened in	Questions
	amounts. • Record the type and trend (increasing or decreasing) of NTFP collected.
Freshwater	• Discuss the use of freshwater by the household. Record the location of freshwater collection and uses. Record the type of use (potable, wastewater, irrigation etc.) • Discuss alternatives locations for water collection for the household • Determine if any changes have occurred and over what time period and any trends.

1.1.5 Results

The results of the survey for screened ecosystem services are outlined below.

1.1.5.1 *Provisioning Services*

Food – Wild Meat

The results of the survey in relation to provisioning services for Food – Wild meat are outlined in *Table 3* below.

Table 3 Results of survey in relation to Food – Wild meat

Name of Village	Food- Wild Meat					
	Wild meat caught from the forest (per month)		Other sources of protein consumed (per month)		Resource condition and trends	
	Type	Amount	Type	Amount (kg)	Size	Trend
Kubin	-	-	Chicken	20 kg	Normal	Increase
	-	-	Pig	10 kg	Normal	Increase
Pyinnaung	Wild goat	1	Chicken	16 kg	Normal	Increase
			Beef	7 kg	Normal	Increase
			Pig	7.5 kg	Normal	Increase
			Goat	5 kg	Normal	Increase
Chaungsone	Wild Boar	1	Chicken	20 kg	Normal	Increase
	Barking Deer	1	Pig	10 kg	Normal	Increase
Pluzawa	Wild Boar	1	Chicken	5 kg	Normal	Increase
	Barking Deer	1	Pig	6 kg	Normal	Increase
Nanmawke	-	-	Chicken	5 kg	Normal	Increase
			Pig	5 kg	Normal	Increase

Food – Cultivated Crops

The results of the survey in relation to provisioning services for Food – Cultivated Crops are outlined in *Table 4* below.

Table 4 ***Results of survey in relation to Food – Cultivated Crops***

Name of Village	Food: Cultivated Crops						
	Crops cultivated in the forest			Crops used by Household		Resource Condition and Trends	
	Name	Plot No.	Plot area	Type	Amount	Trend	
						Quality	Quantity
Kubin	Rice	1	2 Acre	Rice	80 kg	Same	Increase
Pyinnaung	Rice	1	1 to 3 Acre	Rice	90 kg	Same	Decrease
				Long Bean	5 kg		
				Mango	25 kg		
				Banana	25 kg		
				Avocado	10 pc		
Chaungsone	Rice	1	1 to 3 Acre	Rice	90 kg	Same	Decrease
	Corn	1	1 Acre	Corn	5 kg		
Pluzawa	Rice	1	1-4 acre	Rice	90 kg	Same	Decrease
	Salad	1	1 Acre	Salad		Same	Decrease
	Bean	1	2 Acre	Bean		Same	Decrease
	Sesame	1	3 Acre	Sesame		Same	Decrease
Nanmawke	Rice	1	1-3 Acre	Rice	90 kg	Same	Decrease
	Sun-flower	1	1 Acre	Sunflower			

Food: Herbs, Mushrooms and plants

The results of the survey in relation to provisioning services for Food: Herbs, Mushrooms and plants are outlined in *Table 5* below

Table 5 ***Results of survey in relation to Food: Herbs, Mushrooms and plants***

Name of Village	Food: Herbs, Mushrooms and plants						
	Herbs, Mushroom and plants are collected from the forest			Other collected foods		Resource Condition and Trends	
	Name	Place	Frequency	Type	Amount	Trend	
						Quality	Quantity
Kubin	Bamboo Shoot	Near Forest	10	-	-	Same	Decrease
	Mushrooms	Near Forest	15			Same	Decrease
	Fetid Acacia	Near Forest	20			Same	Decrease
Pyinnaung	Bamboo Shoot	Near Forest	10	Onion	1.63 kg	Same	Decrease
	Mushrooms	Near Forest	10	Garlic	0.9 kg	Same	Decrease
Chaungsone	Bamboo Shoot	Near Forest	10	Onion	1.63 kg	Same	Decrease
	Mushrooms	Near Forest	15	Garlic	0.9 kg	Same	Decrease
	Eastern gooseberry	Near Forest	5	Black Pepper	0.002 kg	Same	Decrease
	Myrobalan	Near Forest	5			Same	Decrease
Pluzawa	Bamboo Shoot	Near Forest	10	Onion	2 kg	Same	Decrease
	Mushrooms	Near Forest	15	Garlic	0.05 kg	Same	Decrease
	Ginger	Near Forest	10	Black Pepper	0.002 kg	Same	Decrease
Nanmawke	Bamboo Shoot	Near Forest	10	Ginger	0.002 kg	Same	Decrease
	Mushrooms	Near Forest	15			Same	Decrease

Food: Livestock farming

The results of the survey in relation to provisioning services for Food: Livestock farming are outlined in *Table 6* below

Table 6 Results of survey in relation to Food: Livestock Farming

Name of Village	Livestock Farming						
	Livestock		Other Livestock		Resource Condition and Trends		
	Name	Grazing area	Type	Amount	Type	Trend	
						Quality	Quantity
Kubin	Buffalo	Around village	Pig	1 to 5	Pig	Same	Increase
			Chicken	5 to 15	Chicken	Same	Increase
Pyinnaung	-	-	Buffalo	1 to 3	Buffalo	-	Increase
			Pig	1 to 5	Pig	Same	Increase
			Goat	1 to 5	Goat	Same	Increase
			Chicken	5 to 20	Chicken	Same	Increase
Chaungsone	-	-	Buffalo	4 to 10			
			Pig	1 to 8	Pig	Same	Increase
			Chicken	12 to 60	Chicken	Same	Increase
Pluzawa	-	-	Buffalo	2 to 7	-	-	-
	-	-	Pig	3 to 4	Pig	Same	Increase
	-	-	Chicken	6 to 10	Chicken	Same	Increase
Nanmawke	-	-	Buffalo	5			
	-	-	Pig	5	Pig	Same	Increase
			Chicken	13	Chicken	Same	Increase

Timber and wood products

The results of the survey in relation to provisioning services for timber and wood products are outlined in *Table 7* below

Table 7 Results of survey in relation to Timber and Wood Products

Name of Village	Timber and wood products						
	Wood and Timber collected from the forest			Other source of wood		Resource Condition and Trends	
	Type	Amount	Location	Type	Amount	Type	Trend Quantity
Kubin	Pyinkado	0.2 ton	Forest			Pyinkado	Decrease
				Latpan	0.5 ton	Latpan	Decrease
				Wood	0.25 ton	Wood	Decrease
Pyinnaung	Pyinkado	0.3 ton	Forest	-	-	Pyinkado	Decrease
	Ingyne	0.05 ton	Forest	-	-	Ingyne	Decrease
	Latpan	0.03 ton	Forest	-	-	Latpan	Decrease
Chaungsone	Pyinkado	0.2 ton	Forest	-	-	-	-
	Ingyne	0.05 ton	Forest	-	-	-	-
	Latpan	0.05 ton	Forest	-	-	-	-
Pluzawa	Pyinkado	0.2 ton	Forest	-	-	-	-
	Ingyne	0.05 ton	Forest	-	-	-	-
	Thit yar	0.06 ton	Forest	-	-	-	-

Name of Village	Timber and wood products						
	Wood and Timber collected from the forest			Other source of wood		Resource Condition and Trends	
	Type	Amount	Location	Type	Amount	Type	Trend Quantity
Nanmawke	-	-	-	-	-	-	-

Non-Timber Forest Product (NTFP)

The results of the survey in relation to provisioning services for Non-Timber Forest Product (NTFP) are outlined in *Table 8* below

Table 8 ***Results of survey in relation to Non-Timber Forest Product (NTFP)***

Name of Village	Non-Timber Forest Product (NTFP)					
	NTFP collected from the forest			Resource Condition and Trends		
	Type	Amount	Location	Type	Trend	
					Quality	Quantity
Kubin	Bamboo	0.2 ton	Near Forest	Bamboo	Same	Decrease
Pyinnaung	Bamboo	0.5 ton	Near Forest	Bamboo	Same	Decrease
Chaungsone	Bamboo	0.3 ton	Near Forest	Bamboo	Same	Decrease
Pluzawa	Bamboo	0.5 ton	Near Forest	Bamboo	Same	Decrease
Nanmawke	Bamboo	0.5 ton	Near Forest	Bamboo	Same	Decrease

Freshwater

The results of the survey in relation to freshwater are outlined in *Table 9* below

Table 9 ***Results of survey in relation to Freshwater***

Name of Village	Freshwater						
	Location	Alternative location			Resource Condition and Trends		
	Type	Type	Location	When	How		Why
					Quality	Quantity	
Kubin	Creek	Purified drinking water	Private Company	Since Cement Project	More Turbidity	Decrease especially in Summer	Cement plant Reservoir
Pyinnaung	Creek	Purified drinking water	Private Company	2 year	Decrease	Decrease	Nearest Gold mine (Asia World)
Chaungsone	Creek	Chindwin River	Nearest	1 year	Decrease	Decrease	Coal Mine
Pluzawa	River	Chindwin River	Nearest	1 year	Decrease	Decrease	Coal Mine
Nanmawke	River	Chindwin River	Nearest	1 year	Decrease	Decrease	Coal Mine

Role of vegetation in regulating erosion on slopes and riparian areas

Vegetation plays an important role in maintaining soil cohesion along riparian areas and on steep slopes. It was observed at the coal mine site that activities had disturbed areas along the riparian zone of the creek and also on areas associated with mining activities. The vegetation had been removed, exposing soil surfaces to erosion.

Biological value: Species and areas valued globally as of high conservation value

Both project areas are candidate critical habitat areas for global high conservation species.

1.1.6 Ecosystem Services Prioritisation

IFC PS6 requires that Priority Ecosystem Services are identified, and impacts to those services are assessed (IFC 2012). The prioritization process is aimed at identifying those services for which Project impacts would be most likely to result in adverse impacts on Project Affected Communities and other beneficiaries. Using the information collected through the baseline data collection and stakeholder engagement processes, Ecosystem Services were prioritized according to a Priority matrix ranking two criteria:

- Importance of the Ecosystem Service to the beneficiary which considers the intensity of use, degree of dependence and the importance expressed by the Project Affected Communities; and
- Irreplaceability of the Ecosystem Service, which refers to the availability of alternatives, the accessibility, cost and appetite for those alternatives as discussed with the beneficiary.

After compiling baseline information on the importance and irreplaceability of each service, these ratings were combined to assign a priority rating to the service grading from Low to Mayor, as shown in the Ecosystem service Prioritization Matrix in *Figure 2*.

Ecosystem services identified as High Priority or Major Priority were considered Priority Ecosystem Services. The weight given to each of these components varied slightly depending upon the service, but stakeholder values were given precedence over other criteria where the rating was not clear.

In addition to the above, according to the IFC definition of Priority Ecosystem Services, all services for which project dependencies are identified are considered priority services. The importance and irreplaceability of services relied upon by the Project was assessed through the same prioritization process outlined above, with the Project filling the role of the beneficiary.

Figure 2 Ecosystem Service Prioritization Matrix

Importance to Beneficiaries		**Irreplaceability**		
		High	**Moderate**	**Low**
Low	The service is used and valued by parts of the community, but it is not important in maintaining quality of life or livelihoods of Project Affected Communities.	**Low Priority**	**Low Priority**	**Moderate Priority**

Importance to Beneficiaries		**Irreplaceability**		
		High	Moderate	Low
Medium	The service is readily used by some members of the Project Affected Communities for income or subsistence, but they are not dependent upon the service for their livelihoods, and not everyone utilises the service.	**Low Priority**	**Moderate Priority**	**High Priority**
High	The service is highly important in maintaining the livelihoods of the Project Affected Communities, and is used by most of the community regularly.	**Moderate Priority**	**High Priority**	**Major Priority**
Essential	The service is essential to maintain the health of the Project Affected Communities, and the service is used by all members of the community.	**High Priority**	**Major Priority**	**Major Priority**
Irreplaceability definition				
High	Many spatial alternatives exist that are readily available to the Project Affected Communities, and there are no major impediments to their usage.			
Moderate	Spatial alternatives exist but are either less accessible than the affected service, or there are other barriers to their use such as distance, cost and skills required to access the service.			
Low	There are few to no spatial alternatives available to the Project Affected Communities.			

In addition to the prioritization exercise, the baseline data collection process provided the opportunity to collect information on the status, trends and sustainability of resource use as they pertain to the habitats and species that support Ecosystem Services. This information was gathered through secondary sources and field studies by the environment team and where appropriate through engagement with local stakeholders. This information is important for the assessment of impacts on Ecosystem Services and therefore on local people as the final receptors of these changes.

Table 10 outlines the beneficiaries, potential sources of impact and project dependence for each service, and whether the service was scoped into or out of the Ecosystem Services assessment.

This *section* provides an assessment of the potential Project impact to ecosystem services using the criteria provided for the impact assessment at *Annex B* and the Project description provided in *Section 2* of the ESIA Report.

Table 10 Results of Prioritization

Ecosystem Services	Trends and Sustainability	Beneficiaries	Importance to Beneficiaries	Irreplaceability	Potential Alternatives	Priority?
Provisioning Services						
Food: wild meat	The populations of wild animals caught for meat appears to be in decline.	All villages within AoIs of both project areas	Medium	High	Both communities have ready access to alternative protein sources such as beef, chicken and pork.	Low
Food: cultivated crops	The amount of crops planted and harvested within the Project AoI is decreasing.	All villages within AoIs of both project areas	Moderate	High	Besides crops from the community agricultural land, the local people can purchase the cultivated crops in the market.	Low
Food: herbs and plants	The amount of herbs and plants available to the community from forested areas within the AoI has been decreasing	All villages within AoIs of both project areas	Medium	High	Replacements for herbs and plants collected are readily available within nearby markets.	Low
Timber and wood products	The amount of timber available to local people has been decreasing. Unsustainable harvesting of timber will lead to continued reductions in availability of timber.	All villages within AoIs of both project areas	High	Moderate	Potential alternatives exist for use by the villages such as bricks and cement; however these are likely to be at a higher price than timber sourced from nearby forests.	High
Non- Timber Forest Products (NTFP)	Bamboo availability has been decreasing at both project AoIs.	All villages within AoIs of both project areas	Low	Moderate	Potential alternatives for use by villagers such as plastic and metals poles exist however they are likely to be a higher price than native bamboo.	Low
Freshwater	Freshwater impacts were reported by all villages within both Project AoIs. Impacts from the coal mining site impacted downstream, especially during the wet season. Decreases in water flows were also reported.	All villages within AoIs of both project areas. Water quality impacts of the coal mine site affected villages downstream.	High	Moderate	Bottled water is available for drinking; however river water is used for irrigation.	High
Regulating Services						
Erosion regulation	The forest at the coal mine site provides stability to the slopes to reduce the chance of land slips and erosion. The coal mine site has had an increased incidence of erosion due to coal mine operations	Erosion impacts of the coal mine site affected villages downstream.	High	Moderate	Careful management of soil surfaces will be required to limit damage caused by erosion and mass movement.	High

Ecosystem Services	Trends and Sustainability	Beneficiaries	Importance to Beneficiaries	Irreplaceability	Potential Alternatives	Priority?
Supporting Services						

1.1.7 *Priority Ecosystem Services*

The following priority ecosystem services shown in *Table 11* have been identified and will be assessed against the impact assessment procedures.

Table 11 Priority ecosystem services

Priority Ecosystem Service	Description
Timber and wood products	Evidence suggests that wood is harvested from within the Project Area and AoI for use by local people. The project may restrict this activity. The amount of timber available to local people has been decreasing. Unsustainable harvesting of timber will lead to continued reductions in availability of timber.
Freshwater	Evidence suggests that freshwater is used by local people from within the Project Area and AoI. The project may restrict or impact this activity. Freshwater impacts were reported by all villages within both Project AoIs. Impacts from the coal mining site impacted downstream, especially during the wet season. Decreases in water flows were also reported.
Erosion regulation (Coal Mine concession only)	Evidence suggests that the Project area of AoI for the coal mine site has regulating erosion on slopes and riparian areas in the vicinity. The forest at the coal mine site provides stability to the slopes to reduce the chance of land slips and erosion. The coal mine site has had an increased incidence of erosion due to coal mine operations.

Annex E4

Biodiversity Clearance Protocol (Forested Habitats Only)

Biodiversity Clearance Protocol (Forested Habitats Only)

Competencies

Site clearance surveys must be conducted by a suitably qualified person(s) able to enable identification of relevant habitats and species. Suitably qualified personnel must also be present to rescue, relocate and/or treat fauna due to injury. The person should have a background in flora and fauna assessment and management, ecology or biology.

Site Clearance Surveys

Site level clearance surveys should be overseen and approved by site-level management.

There are two levels of survey required for biodiversity during clearing activities:

1) **Pre-clearance survey**

The pre-clearance survey is to occur at a maximum of 14 and minimum of 7 days prior to clearance. The scope of the survey is to consist of a transect survey covering key habitat features within the clearance area. A minimum of 2 hours should be spent for every 5 hectares to be cleared. The survey should commence at dawn and/or dusk for fauna surveys to allow maximum detection of the relevant species. Flora surveys may occur during the day time.

Key habitat and physical features are to be identified and demarcated within and directly adjacent to the area planned for clearing. All efforts should be taken to avoid features where possible.

Habitat Features and Flora

The following habitat features should be identified and marked by physical marker (spray paint or tape) and by GPS during the pre-clearance survey:

- Boundary of agreed clearance area;
- Living and dead trees containing hollows, nests and/or roosts;
- Ground habitats including fallen trees, rocky outcrops, nests and/or roosts;
- Critically Endangered, Endangered and Vulnerable Plant Species and conservation significant flora;
- primate significant feed trees;
- Wetlands, waterways and/or standing water; and
- Other relevant habitat features (such as salt licks).

Physical Features

The following physical features should be marked using GPS:

- Existing roads/tracks;
- Slopes greater than 30 degrees;
- Drainage features, including Strahler stream order;
- Rocky outcrops, cliffs and caves;
- Areas of active soil erosion and deposition;
- Areas of mass movement; and
- Soil characteristics, including type, soil depth, sub-soil depth

2) Clearance survey

The pre-clearance survey should identify mammals, birds and herpetofauna present on the site. The survey should be undertaken to identify tracks and traces; vocalisations; and other indicators of presence of species. Particular attention should be paid to individual species listed in the ESIA as CR and EN.

The survey should occur during clearance activities to identify any habitat features to be retained/removed; to identify and enable fauna to move; and to rescue any fauna if accidentally injured due to clearance activities.

Clearance activities should not occur during periods of high rainfall (**May to October**). Further site specific advice is to be obtained on relevant site conditions prior to clearance activities commencing.

Habitat Features

The following protocol should be observed during clearance activities:

- Clearance should occur progressively towards refugia. This will enable animals to be given the chance to move towards safe habitats through existing habitat corridors/features on the site.
- All habitat features identified during the pre-clearance survey should be inspected for species presence prior to clearance. Where an animal is identified, it should be given the opportunity to move by its own accord. Reasonable coercion can occur to encourage the individual to move. This should be carried out by the nominated qualified person and not by general clearance personnel;
- Where a bird nest and/or roost are identified, if the birds nest is occupied, the tree where the nest occurs must not be cleared (with a buffer of at least 10 metres). The tree may be cleared when the individual has moved from the nest and the nest is deemed empty.
- Where a flowering or fruiting tree is identified, the flowering or fruiting tree is to be left in situ until it has finished flowering/fruiting, including a buffer of at least 30 metres beyond the drip line of the tree. The buffer must not be breached by felling surrounding trees. The tree may be cleared when the tree has finished

fruiting/flowering (It should be noted that tree fruiting/flowering occurs generally in the period May – August annually).

Flora

For conservation significant plant species advice is to be sought from suitably qualified professionals in determining requirement for physical relocation of individuals, seed collection and/or propagation. These activities would require action prior to clearing and may require maintenance, monitoring or propagation during suitable conditions.

Fauna

The following protocol should be observed during clearance activities:

- All workers must be inducted and trained regarding clearance activities prior to commencement, including the following points:
  - All workers must comply with requirements to stop work when directed;
  - No species is to be captured or transported from the site unless authorized during the clearance survey and;
  - No individual is to be captured for consumption.
- Where an individual are identified during clearance activities, clearance should stop immediately until the individual has been given the opportunity to move to refugia. This may include leaving the area overnight;
- Where an individual does not move or is unable to move, the following steps should be used
  1) Reasonable coercion is used to encourage the individual to move;
  2) The area where the individual is located be left overnight to enable the individual to move of its own accord; **OR**
  3) The individual is captured and moved to refugia (Note that capture and movement of fauna should be undertaken by an experienced animal handler).
- Where an individual is injured due to clearance activities the individual is to be assessed as to the nature of the injuries. Where it is determined that the individual is severely injured, the individual is to be captured and taken to a veterinary for treatment.

Annex F

Biodiversity Offset Strategy

1 *BIODIVERSITY OFFSET STRATEGY*

Mitigation and management approaches have been considered to avoid, minimize and mitigate potential impacts to biodiversity as a result of Project activities. In general, many of the indirect impacts to biodiversity values can be avoided or minimized, such as behavioral disturbances, degradation of habitats, edge effects and barriers to terrestrial fauna movement. The next step of the mitigation hierarchy necessitates consideration of biodiversity offsets for residual impacts.

ERM has undertaken a biodiversity offsets assessment based on the guidance contained in the Business and Biodiversity Offset Program (BBOP) resource documents:

- *Biodiversity Offset Design Handbook* (BBOP 2012a); and
- *Resource Paper: No Net Loss and Loss-Gain Calculations in Biodiversity Offsets* (BBOP 2012b).

1.1 *BIODIVERSITY OFFSET DESIGN*

Biodiversity offsets are designed to compensate for the residual biodiversity losses due to the Project. Offset rules are used to outline the approach to govern how offsets are undertaken and to define the offset calculation methods .

IFC PS 6 requires the following biodiversity offset design steps:

1. Ensuring that the development project meets all applicable laws, regulations and policies pertaining to biodiversity offsets;
2. Establishing an effective process for Affected Communities to participate in designing and implementing the biodiversity offset;
3. Describing the project's scope and predicted impacts on biodiversity, applying and documenting the steps in the mitigation hierarchy and using defensible metrics that properly account for biodiversity to calculate residual impacts;
4. Identifying suitable opportunities (potential offset sites, activities and mechanisms) for achieving "like-for-like or better" biodiversity gains to balance the losses due to the development;
5. Quantifying the required biodiversity gains to achieve a no net loss or net gain outcome of biodiversity values and selecting the preferred locations and activities to provide these gains; and
6. Setting the specific offset activities and locations in a biodiversity offset management plan to guide implementation.

This Strategy addresses items 3 to 5 of the steps outlined above. Further consultation and assessment is required to address items 1, 2 and 6.

1.2 *RESIDUAL IMPACTS ON BIODIVERSITY VALUES*

The residual impacts to biodiversity predicted in the EIA largely relate to unavoidable habitat loss within the footprint of the Project and edge effects. s. To achieve no-net-loss of biodiversity values, a biodiversity offset will be required to compensate for this loss of habitat. Critical Habitats will require to demonstrate a net-gain. The habitat lost is outlined in *Table 1.1* below.

Table 1.1 Habitat lost due to project activities

Habitat Type	IFC Habitat Classification	Area
Limestone Concession		
Limestone Habitat	Critical Habitat	235.58ha
Forested Natural Habitat	Natural Habitat	32.59ha
Coal Mine Concession		
Forested Natural Habitat	Critical Habitat	899.95ha

The fauna species assessed will experience a loss of habitat due to Project related activities, however it is not expected that this loss is significant. The types of impacts are generally induced impacts from hunting, poaching and incidental deaths. The scale of habitat remaining within the DMU is likely to support displaced populations. Mitigation measures have been designed to reduce impacts to species in relation to Project related activities. Monitoring of species within the AoI will be required to determine if populations of species are maintained.

Loss of flora species (particularly endemic flora species) constitutes a residual loss to biodiversity values. Specific mitigation measures have been designed to reduce impacts on flora species; however specific offsets will be required to achieve no-net-loss of biodiversity values for these species. The list of Critical Habitat candidate species requiring achievement of net-gain values are shown in *Table 1.2* below.

An assessment of the requirements to achieve net-gain is outlined below (*Section 1.5.4*).

Table 1.2 Species requiring net-gain offsets

SN	Species	Common Name	IUCN Listing/Endemism
Cement Plant Site			
1	*Manis pentadactyla*	Chinese Pangolin	CR
3	*Trachypithecus phayrei* spp. *shanicus*	Shan State Langur	EN
4	*Diplommatina* sp. 3, new sp.	-	Local endemic
5	*Diplommatina* sp. 4, new sp.	-	Local endemic
6	*Diplommatina* sp. 5, aff. *Crispate*	-	Local endemic
7	*Anauchen* new sp.	-	Local endemic

SN	Species	Common Name	IUCN Listing/Endemism
Coal Mine Site			
1	*Manis pentadactyla*	Chinese Pangolin	CR
3	*Hoolock hoolock*	Hoolock Gibbon	EN
6	*Dipterocarpus baudii*	-	CR

1.3 BIODIVERSITY OFFSETS CALCULATIONS (AVERTED LOSS METRIC)

Management of offsets may avert background loss of biodiversity values either through reductions in the extent of forest clearing extent and/or reductions in species losses. This averted loss can be calculated through defining the background loss of forest extent and calculating the area to be managed that would avert that loss over the offset management period.

Global Forest Watch reports (2017) that the rate of annual forest loss in Myanmar for the period 2000–2015 is 1.35% forest cover loss per annum.

No contemporary data is currently available; however the FAO notes that forest cover reduction has accelerated in recent years (FAO 2009). ERM has used this rate of loss, however it is noted that this rate may not currently reflect the current or future rate of forest loss in Myanmar.

The offset management period proposed is 25 years (time of the concession period).

The formula to determine the averted loss based on a compound interest rate (1.35%):

$$Offset\ Area = Habitat\ Impact\ Area\ (1 + \frac{-0.0135}{1})^{25\ years}$$

The calculation of averted loss offsets are shown in *Table 1.6*.

Table 1.6 Calculation of Offsets using an Averted Loss Metric

Habitat Type	Habitat Impact Area (Ha)	Offset Area (Ha)
Limestone Concession		
Limestone Habitat	235.58	1420
Forested Natural Habitat	32.59	127
Coal Mine Concession		
Forested Natural Habitat	899.95	5420

1.4 BIODIVERSITY OFFSET OPTIONS

1.4.1 *Relevant Myanmar Conservation Projects*

Conservation activities in Myanmar are undertaken by NGOs such as Fauna and Flora International (FFI), Wildlife Conservation Society and the Rufford Foundation that may be relevant to development of the Project Offset Strategy. A summary of relevant existing conservation programs is shown in at *Annex A.*

Contributions to these programs may provide an option for STC to achieve offset requirements. Further investigation is required to determine if these programs are viable to contribute to. Specific programs may be used for critical habitat species offsets.

1.4.2 *Management of Protected Areas*

Protected areas in Myanmar currently do not receive substantive funding to support ongoing management. Instituto Oikos and BANCA (2011) report that significant underfunding of protected areas has led to a long-term decline in the management of threats. Illegal logging, poaching, hunting and overuse of natural resources have seen a decline of habitat quality. Protected areas in Myanmar however do have significant biodiversity values that would benefit from management.

Emerton *et al* (2015) report that protected area financing in Myanmar is currently limited due to budget shortfalls, narrow funding sources, uneven funding allocations and lack of capital spending. Emerton also identifies biodiversity offsets as a way to improve funding of protected areas in Myanmar.

Preliminary consultation with the Myanmar Government by STC indicates that the Ministry of Forestry is restricted in terms of receiving direct funding contributions from the private sector, however management of protected areas by specific programs run by joining government/NGOs partnerships are possible.

Two relevant protected areas for offsetting for the STC Project include: the Mahamyaing Wildlife Sanctuary and the Panlaung-Pyadalin Cave Wildlife Sanctuary.

The Mahamyaing Wildlife Sanctuary was established in 2002 and is 1180km^2 in size (111,900ha). It is an IUCN Category IV Protected Area and Important Bird Area (IBA) and is located 24km East of the Coal mine site. It has important biodiversity values, including an important population of Hoolock Gibbon, Banteng, Sambar Deer and Asiatic Wild Dog, Small Asian Mongoose, Wild Boar, Mongoose, Asian Elephant and Jungle Cat. No information is available on the Protected Areas current management regime.

The Panlaung-Pyadalin Cave Wildlife Sanctuary was established in 2002 and is 334km^2 (33,400ha) in size. It is an IUCN Category IV Protected Area and is located 6km North of the Limestone quarry site. It has important cultural values and biodiversity values including habitat for the Asian Elephant, Banteng, Gaur, Clouded Leopard and Serow. It is listed as having an annual operation plan and Management actions in place however it is significantly underfunded (Emerton L 2015). Threats identified include illegal logging and settlement encroachment.

1.4.3 Conservation of Limestone Habitats

Conservation of limestone habitats in Myanmar is generally poor with an under representation in the Protected Area system. Only 1% of karst areas in Myanmar are reported as protected (within Shwe u Daung and Shwesettaw Game Reserves, and Pindaya Cave).

The limestone range that forms part of the Tha Pyae mountain range is not currently subject to conservation measures. The ownership of the land is currently held with the Myanmar Government. Surveys undertaken for the STC project identified locally endemic species along this range (meaning that their distribution is restricted to the extent of or components of the limestone range). A component of this range would therefore be a candidate for conservation as part of the offset for the project. Addition of the Northern most component of the limestone range to the Panlaung-Pyadalin Cave Wildlife Sanctuary may ensure future protection of this area.

1.4.4 Assessment of Offsets for Critical Habitat Species

An assessment of Critical Habitat species and habitats has been undertaken to determine the requirements to achieve net-gain for these values as required by IFC PS6. The following species have been identified:

Limestone concession:

- *Manis pentadactyla* Chinese Pangolin (CR)
- *Trachypithecus phayrei spp. Shanicus* Shan State Langur (EN)
- *Diplommatina sp.* 3, new sp. - Local endemic
- *Diplommatina sp.* 4, new sp. - Local endemic
- *Diplommatina sp.* 5, aff. Crispate - Local endemic
- *Anauchen new sp.* - Local endemic

Coal Mine Concession:

- *Manis pentadactyla* Chinese Pangolin (CR)
- *Hoolock hoolock* Hoolock Gibbon (EN)
- *Dipterocarpus baudii* (CR)

The assessment has determined whether habitat offsets would be sufficient surrogates to achieve net-gains in species populations. The assessment has considered the existing threats to these species in Myanmar and additional threats posed by the project. The assessment is outlined in *Table 1.8*.

Where species have been identified that require additional measures, the scope of these measures has also been outlined. Cost estimates have also been included where necessary in *Table 1.9* below.

Further assessment and consultation is required to define management actions for these species.

Table 1.8 Critical Habitat Species Net-gain Assessment

SN	Species	Common Name	IUCN Listing/ Endemism	Assessment of Habitat Offset Suitability	IUCN Conservation Actions	Requirements to achieve net-gain	Proposed Delivery agent
Cement Plant Site							
1	*Manis pentadactyla*	Chinese Pangolin	CR	The species is threatened by hunting and poaching for the illegal wildlife trade across its range. Recent assessments (Zhang M et al 2017) between 140–168 pangolins/year are smuggled into China via three different routes from Kachin to China although this may be an underestimate given the porosity of the border with China. The species is noted to exist within the Panlaung-Pyadalin Cave Wildlife Sanctuary however its current population is unknown. Management of the species within the protected area may reduce existing threats through increased education and enforcement of wildlife poaching rules. However the species is likely to continue to suffer reductions in population within the Sanctuary and more broadly in Myanmar. It is unlikely that habitat offsets will enable a net-gain in species populations to be achieved.	This species is listed in CITES Appendix II and zero annual export quotas were established for wild-caught specimens traded for primarily commercial purposes in 2000 (CoP11). In Myanmar this species is listed as a completely protected animal under the Protection of Wildlife and Wild Plants and Conservation of Natural Areas Law (1994). Greater enforcement and management within protected areas to prevent poaching is needed as is strict enforcement along national and international trade routes, the identification and verification of strongholds where conservation efforts should be focused, and efforts to reduce consumer demand in key markets.	A specific program should be undertaken within the Panlaung-Pyadalin Cave Wildlife Sanctuary to educate local people on Pangolin conservation; undertake regular patrols for hunting and poaching; introduce a snare reduction program and undertake monitoring of species populations. It is recommended that additional financial contributions be made to a program to reduce threats to Pangolin hunting and poaching. Discussions with WCS indicate that Singapore Zoo is planning to establish a Pangolin rescue center in Myanmar. Another option will be to provide a financial contribution to TRAFFIC, an NGO focused on reducing the trade in CITES species. Further consultation is required to determine the necessary frameworks and financial obligations. Actions are to outlined in the BOP.	Further discussion and consultation required with WCS/TRAFFIC to determine cost and approach required (to be updated)
3	*Trachypithecus phayrei* spp.	Shan State	EN	The global population size is estimated to number fewer than	The species is listed on CITES Appendix II. It is listed under	It is recommended that a specific program be implemented within	Further discussion and consultation required with

SN	Species	Common Name	IUCN Listing/ Endemism	Assessment of Habitat Offset Suitability	IUCN Conservation Actions	Requirements to achieve net-gain	Proposed Delivery agent
	shanicus	Langur		2,500 mature individuals and is experiencing continuing decline that can be attributed to hunting, poaching and habitat destruction. The species is noted to exist within the Panlaung-Pyadalin Cave Wildlife Sanctuary, however current population estimates within the wildlife sanctuary are unknown. Given the small geographic distribution of the species, it is likely that specific management programs within the Sanctuary will be sufficient to manage the species.	Schedule I, part I of the Indian Wildlife (Protection) Act (amended up to 2002), completely protected species in Myanmar since 1994. No specific management actions identified.	the Panlaung-Pyadalin Cave Wildlife Sanctuary biodiversity offset site for the species. The program should be run by a reputable conservation NGO in conjunction with the Myanmar Forestry Department. The program should include the following objectives: undertake a population census within the Wildlife Sanctuary to determine current population of the species; conduct specific community education programs to determine current hunting and use rates of the species; conduct education on the species conservation status and illegal poaching activities; introduce a snare reduction program; and conduct regular monitoring of the species' population. Actions are to outlined in the BOP.	appropriate NGO (To be updated).
4	*Diplommatina* sp. 3, new sp.	-	Local endemic	Local endemic snail fauna identified within the concession are distributed along the limestone range, including new-to-science species. A gradient of species was identified during the surveys. The species identified at the Project site were however identified in the candidate offset site at the northern part of the range. Given that the same species is located at the offset	No specific IUCN recommendations. Suggest additional consultation with WCS regarding conservation options.	Species are likely adequately managed through habitat offsets consisting of protection and management of the northern portion of the limestone range. A monitoring and evaluation program is recommended to determine current species presence at the offset site, and future population trends. Actions are to be outlined in the BOP.	Species likely adequately conserved within the proposed offset site. Monitoring and evaluation measures are to be outlined in the BOP.
5	*Diplommatina* sp. 4, new sp.	-	Local endemic				
6	*Diplommatina* sp. 5, aff. *Crispate*	-	Local endemic				
7	*Anauchen* new sp.	-	Local endemic				

SN	Species	Common Name	IUCN Listing/ Endemism	Assessment of Habitat Offset Suitability	IUCN Conservation Actions	Requirements to achieve net-gain	Proposed Delivery agent
				site, management of the offset site will be sufficient to ensure the long-term survival of the species.			
Coal Mine Site							
1	*Manis pentadactyla*	Chinese Pangolin	CR	As noted above, the species suffers considerable poaching pressure for the international wildlife trade. The species is present within the Mahamyaing Wildlife Sanctuary, however the population of the Project area is likely distinct as it is on the Western side of the Chindwin River. The management of the species within the Wildlife Sanctuary is likely to alleviate some pressure on the species, however the population within the Project Area and more broadly within Myanmar are likely to suffer declines due to the hunting and poaching pressure. It is recommended that additional offset measures are applied to achieve net-gain.	See above.	As recommended above, a financial contribution to a specific program for Pangolin conservation should occur within Myanmar. A specific program should also be undertaken in the Mahamyaing Wildlife Sanctuary biodiversity offset site to reduce hunting and poaching pressure for the species. As above, the program shall consist of activities to reduce threats to the species by educating local people on Pangolin conservation; undertake regular patrols for hunting and poaching; introduce a snare reduction program and undertake monitoring of species populations. Actions are to be outlined in the BOP.	Further discussion and consultation required with appropriate NGO (To be updated).
3	*Hoolock hoolock*	Hoolock Gibbon	EN	In Myanmar, shifting cultivation is a major threat to the species as well as hunting. Logging and habitat destruction is also considered a threat for this species. The population detected on the Western side of the Chindwin River that is associated	No specific conservation actions identified by IUCN.	It is recommended that a population census be undertaken of the population on the Western side of the Chindwin River A contribution to the Mahamyaing Wildlife Sanctuary Management Plan is	Additional contributions to the Mahamyaing Wildlife Sanctuary (MWS) Management Plan. The project is run by the Rainforest Trust and Friends of Wildlife (FOW).

SN	Species	Common Name	IUCN Listing/ Endemism	Assessment of Habitat Offset Suitability	IUCN Conservation Actions	Requirements to achieve net-gain	Proposed Delivery agent
				with the Project area of the coal mine is likely to be distinct from the population contained with the Mahamyaing Wildlife Sanctuary. Specific on-site mitigation measures will address some impacts to this population; however it is recommended that additional offset measures be applied to achieve net-gain.		recommended in relation to Hoolock Gibbon contribution.	
6	*Dipterocarpus baudii*	-	CR	This species is found scattered in the greatly reduced lowland evergreen forests of South East Asia. Main threat is habitat destruction. It is rather rare and scattered in low-lying, well-drained or semi-swampy forests or on low hills. It can be found at elevations up to 800 m. The species is likely spread through similar forest types within the coal mine concession and adjacent forested areas. Impacts to the species will occur through clearing of forest for operations of the coal mine. It is recommended as a mitigation that the species be propagated and replanted during rehabilitation of the coal mining site. It is unknown if the species is recorded within the proposed offset site at the Mahamyaing Wildlife Sanctuary. Whilst propagation and replanting will	No specific conservation actions identified by IUCN.	It is recommended that a survey be conducted to identify the distribution of the species within the Project Area and the Mahamyaing Wildlife Sanctuary. If the species is identified within the Sanctuary, specific measures are to be undertaken to protect the species from illegal logging, including education and enforcement activities. The species should also be propagated on-site and used in the species mix for on-site rehabilitation. Actions are to be outlined in the BOP.	Further discussion and consultation required with appropriate NGO (To be updated).

SN	Species	Common Name	IUCN Listing/ Endemism	Assessment of Habitat Offset Suitability	IUCN Conservation Actions	Requirements to achieve net-gain	Proposed Delivery agent
				ensure that the species population is not reduced within the project area, it is recommended that additional programs be undertaken for the species.			

1.4.5 *Assessment of Offsets for Species in relation to No-Net-Loss*

The following species have been identified within the concessions and are subject to assessment of No-net-loss in Natural Habitats.

Limestone Concession:
- Eastern Hoolock Gibbon *Hoolock leuconedys* (VU);
- Bengal Slow Loris *Nycticebus bengalensis* (VU); and
- Hog Badger *Arctonyx collaris* (VU).

Coal Mine Concession:
- Phayre's Langur *Trachypithecus phayrei phayrei* (EN);
- Dhole *Cuon alpinus* IUCN (EN);
- Gaur *Bos gaurus* (VU)
- Bengal Slow Loris *Nycticebus bengalensis* (VU);
- Southern Serow *Capriconis sumatraensis* (VU);
- Red Goral *Naemorhedus baileyi* (VU); and
- Asiatic Black Bear *Ursus thibentanus* (VU);

Table 1.9 assesses whether these species would be sufficiently managed through conservation actions within the proposed habitat offset sites.

Further assessment and consultation is required to refine the management actions for these species.

Table 1.8 Species No-net-loss Assessment

SN	Species	Common Name	IUCN Listing/ Endemism	Assessment of Habitat Offset Suitability	IUCN Conservation Actions	Requirements to achieve no-net-loss	Proposed Delivery agent
Cement Plant Site							
1	*Hoolock leuconedys*	Eastern Hoolock Gibbon	VU	In Myanmar, shifting cultivation is a major threat to the species as well as hunting. Logging and habitat destruction is also considered a threat for this species. The population was detected in an area of forest that is joined with the Panlaung-Pyadalin Cave Wildlife Sanctuary. No population numbers exist for the species within the wildlife sanctuary. Specific conservation measures to manage illegal logging, habitat destruction and hunting poaching will be required. No-net-loss within the Offset site (being the Sanctuary).	No specific conservation actions have been identified by IUCN.	A census of the species should occur within the Panlaung-Pyadalin Cave Wildlife Sanctuary to determine current status of the population and required management actions. Actions to manage illegal logging, hunting and poaching will be required to be developed and outlined in the BOP.	Further discussion and consultation required with appropriate NGO (To be updated).
2	*Nycticebus bengalensis*	Bengal Slow Loris	VU	The major threats that this species' habitat faces include farming, timber removal, human settlement, road building, dams, power lines, fragmentations, soil loss and erosion, and deliberately set fires. They are hunted and traded for food, traditional "medicine", sport, and as pets. Road kills represent another threat to this species. No population numbers exist for the species within the wildlife	This species is found in a large number of protected areas throughout its range, but possibly at low numbers. Actual surveys rather than anecdotal reports are necessary to determine the true abundance of this species in the wild. The species has been recently transfer from Appendix II to Appendix I of CITES.	A census of the species should occur within the Panlaung-Pyadalin Cave Wildlife Sanctuary to determine current status of the population and required management actions. Actions to manage illegal logging, hunting and poaching will be required to be developed and outlined in the BOP.	Further discussion and consultation required with appropriate NGO (To be updated).

SN	Species	Common Name	IUCN Listing/ Endemism	Assessment of Habitat Offset Suitability	IUCN Conservation Actions	Requirements to achieve no-net-loss	Proposed Delivery agent
				sanctuary. Specific conservation measures to manage illegal logging, habitat destruction and hunting poaching will be required within the Offset site.			
3	*Arctonyx collaris*	Hog Badger	VU	The main threat to this species is hunting and poaching through snaring and use of dogs (given that it is a ground dwelling mammal. No population numbers exist for the species within the wildlife sanctuary. Specific conservation measures to hunting and poaching will be required within the Offset site.	No current protected status in Myanmar. No specific conservation actions identified by IUCN.	A census of the species should occur within the Panlaung-Pyadalin Cave Wildlife Sanctuary to determine current status of the population and required management actions. Actions to manage hunting and poaching will be required to be developed and outlined in the BOP.	Further discussion and consultation required with appropriate NGO (To be updated).
Coal Mine Concession							
4	*Trachypithecus phayrei phayrei*	Phayre's Langur	EN	The threats faced by this species include pollution, inbreeding, and a local trade in the animals for zoos and as food. No population numbers exist for the species within the wildlife sanctuary. Specific conservation measures to hunting and poaching will be required within the Offset site.	The species is listed on CITES Appendix II. The species is a completely protected species in Myanmar since 1994.	A census of the species should occur within the Mahamyaing Wildlife Sanctuary to determine current status of the population and required management actions. Actions to manage hunting and poaching will be required to be developed and outlined in the BOP.	Further discussion and consultation required with appropriate NGO (To be updated).
5	*Cuon alpinus*	Dhole	*EN*	The threats facing this species include depletion of the prey base, habitat loss and fragmentation, persecution (retaliatory killings due to wildlife attacks); disease and pathogens and completion with other species.	Dholes are legally protected in the countries where they occur. However, enforcement of laws is insufficient to provide effective protection of Dholes in many of their range countries. Local governments sometimes may still offer bounties on Dholes to	A census of the species should occur within the Mahamyaing Wildlife Sanctuary to determine current status of the population and required management actions. Actions to manage hunting and poaching will be required to be developed and	Further discussion and consultation required with appropriate NGO (To be updated).

SN	Species	Common Name	IUCN Listing/ Endemism	Assessment of Habitat Offset Suitability	IUCN Conservation Actions	Requirements to achieve no-net-loss	Proposed Delivery agent
				No population numbers exist for the species within the wildlife sanctuary. Specific conservation measures to hunting and poaching will be required within the Offset site.	reduce livestock predation, as was recently the case in western Myanmar. Surveys and conservation within Protected Areas have been identified as a conservation action.	outlined in the BOP.	
6	*Bos gaurus*	Gaur	*VU*	The species suffers from hunting habitat loss and ongoing habitat degradation and conversion is continually reducing the potential population. Diseases, particularly rinderpest and foot-and-mouth disease, transmitted by domestic cattle are a potentially serious threat.	Gaur is listed in CITES Appendix I, and is legally protected in all range states. Gaur conservation is likely to come through identifying areas with positive underlying situations to achieve conservation. Protected area expansion and consolidation to slow further fragmentation of Gaur populations has been identified as an action.	A census of the species should occur within the Mahamyaing Wildlife Sanctuary to determine current status of the population and required management actions. Actions to manage hunting and poaching will be required to be developed and outlined in the BOP.	Further discussion and consultation required with appropriate NGO (To be updated).
7	*Nycticebus bengalensis*	*Bengal Slow Loris*	*VU*	The major threats that this species' habitat faces include farming, timber removal, human settlement, road building, dams, power lines, fragmentations, soil loss and erosion, and deliberately set fires. They are hunted and traded for food, traditional "medicine", sport, and as pets. Road kills represent another threat to this species. No population numbers exist for the species within the wildlife sanctuary. Specific conservation measures to manage illegal logging, habitat destruction and hunting poaching will be	This species is found in a large number of protected areas throughout its range, but possibly at low numbers. Actual surveys rather than anecdotal reports are necessary to determine the true abundance of this species in the wild. The species has been recently transfer from Appendix II to Appendix I of CITES.	A census of the species should occur within the Mahamyaing Wildlife Sanctuary to determine current status of the population and required management actions. Actions to manage hunting and poaching will be required to be developed and outlined in the BOP.	Further discussion and consultation required with appropriate NGO (To be updated).

SN	Species	Common Name	IUCN Listing/ Endemism	Assessment of Habitat Offset Suitability	IUCN Conservation Actions	Requirements to achieve no-net-loss	Proposed Delivery agent
				required within the Offset site.			
8	*Capriconis sumatraensis*	*Southern Serow*	*VU*	Poaching is not uncommon, and serows are caught in snares set for other game species, as well as shot, for local consumption of the meat, and for use of body parts in traditional medicines. Hunting occurs inside and outside of protected areas.	This species is listed on Appendix I of CITES. No specific management actions exist for the species in Myanmar.	A census of the species should occur within the Mahamyaing Wildlife Sanctuary to determine current status of the population and required management actions. Actions to manage hunting and poaching will be required to be developed and outlined in the BOP.	Further discussion and consultation required with appropriate NGO (To be updated).
9	*Naemorhedus baileyi*	*Red Goral*	*VU*	Hunting and habitat loss caused by rapid forestry expansion are the major threats. No population numbers exist for the species within the wildlife sanctuary. Specific conservation measures to manage illegal logging, habitat destruction and hunting poaching will be required within the Offset site.	The red goral is listed on Appendix I of CITES. No specific management actions exist for the species in Myanmar.	A census of the species should occur within the Mahamyaing Wildlife Sanctuary to determine current status of the population and required management actions. Actions to manage hunting and poaching will be required to be developed and outlined in the BOP.	Further discussion and consultation required with appropriate NGO (To be updated).
10	*Ursus thibentanus*	*Asiatic Black Bear*	*VU*	Habitat loss due to logging, expansion of agriculture and plantations, roadway networks and dams, combined with hunting for skins, paws and especially gall bladders are the main threats to this species. No population numbers exist for the species within the wildlife sanctuary. Specific conservation measures to manage illegal logging, habitat destruction and hunting poaching will be required within the Offset site.	The Asiatic Black Bear has been included on CITES Appendix I since 1979. A global Status Survey and Conservation Action Plan for this species, published by the IUCN in 1999.	A census of the species should occur within the Mahamyaing Wildlife Sanctuary to determine current status of the population and required management actions. Actions to manage hunting and poaching will be required to be developed and outlined in the BOP.	Further discussion and consultation required with appropriate NGO (To be updated).

1.5 *ESTIMATED OFFSET COSTS*

1.5.1 *Costs of Conservation in Myanmar*

Emerton *et al* (2015) has undertaken comprehensive research into protected area management costs in Myanmar.

Actual 2015 expenditure for the management of the Panlaung-Pyadalin Cave Wildlife Sanctuary was US $57/km^2/yr (US $0.57/ha/yr). No current figures are available for the Mahamyaing Wildlife Sanctuary. The average spending for the years 2010 to 2015 was US $25/km^2/yr (US $0.25/ha/yr) for all protected areas in Myanmar.

Emerton reports that this spending is significantly less than what is required for appropriate management. Based on research and benchmarking of Protected Area management across similar South East Asian countries, the actual funding required would be between US $185 to $644/km^2/yr (US$1.85 to $6.44/ha/yr). Larger protected areas generally require fewer funds owing to economies of scale.

1.5.2 *Cost Assessment*

The costs of managing offsets for the STC project have been estimated based on the area of required offset multiplied by estimated conservation costs. These costs are a guide only and should be derived through an analysis of costs based on the management actions required for the final offset site(s).

ERM has used the upper range of estimated management costs from Emerton et al (2015) to calculate the management costs (US$6.44per ha/yr). Potential costs should be estimated using a precautionary approach to take into account the uncertainty of these cost estimates and the delivery of offsets to achieve the appropriate offset goal (no-net-loss or net-gain).

The cost estimations include an estimate of additional costs that may be required to achieve net-gain for Critical Habitat candidate species and no-net-loss for EN and VU listed species and their habitats. Further assessment is required to determine these actual costs in development of a BOP.

Development of a Biodiversity Offset Plan (BOP) for the site, capital equipment cost and monitoring and evaluation would be additional to the ongoing management costs outlined. An estimation of these costs has been included in the *Table 1.9* below. Further assessment is required to define these costs during the development of the BOP. The cost estimates should be used as a guide only.

It should be noted that these estimates are in 2017 US dollar values. Adjustments for inflation would need to occur in future years for annual expenditure.

Table 1.9 Estimated offset costs

Offset Description	Offset Size (Benchmark)	Estimated Annual Cost	One-off costs	Estimated 25 Year Cost
1. Biodiversity Offset Management Framework				
- Development of a Biodiversity Offset Plan for programs for offset sites		-	$15,000	$15,000
2. Offset Management Costs				
Limestone Concession				
- Limestone Habitat	1420	$9,145	-	$228,620
- Forested Habitat	127	$818	-	$20,447
Coal Mine Concession				
- Forested Habitat	5420	$34,905	-	$872,620
- Capital Equipment Cost		$7,500	-	$187,500
3. Critical Habitat species Offset Framework and Actions				
- Development of a Biodiversity Action Plan for Critical Habitat species		-	$15,000	$15,000
- Contribution for Pangolin conservation in Myanmar		-	$50,000	$50,000
- Shan State Langur census in Mahamyaing Wildlife Sanctuary and additional mitigation/ management		$ 1,000	$15,000	$40,000
- Hoolock Gibbon census west of the Chindwin River and additional mitigation/management		$1,000	$15,000	$40,000
- *Dipterocarpus baudii* census, propagation and additional mitigation/management		$1,000	$15,000	$40,000
4. Species assessed as requiring no-net-loss actions				
- Species censuses and management actions for EN and VU species requiring no-net-loss (further assessment required)		TBD	$30,000	$30,000
5. Monitoring and Evaluation				
- Monitoring and Evaluation costs (including for CH species)		$5,000	-	$125,000
Total		**$60,367**	**$125,000**	**$1,664,187**

Notes: All values are in 2017 US Dollar Values and are estimates only. Further assessment on actual costs within a Biodiversity Offset Plan would be required.

* Yearly expenditure would require annual adjustments for inflation.

+ Lump sum costs would require an appropriate investment vehicle to deliver annual payments.

1.5.3 *Management Actions*

A range of management actions will be required to be applied to the offset site to achieve measurable conservation gains. These standard management actions have been derived based on work undertaken by the Wildlife Conservation Society (WCS) (WCS, 2002; 2009) and SuFORD and FORCAP projects on sustainable forestry (Chanhsamone P et al, 2007).

The recommended management actions will consist of:

- Conservation Needs Assessment
- Management Plan
- Monitoring and evaluation
- Management of hunting
- Sustainable forestry management
- Wildlife Corridors
- Sustainable forest product use (NTFP)
- Management of weeds and pests
- Fire management
- Assisted natural regeneration
- Community engagement and development
- Education and awareness

A full description of the recommended management actions is contained at *Annex B*.

1.6 *NEXT STEPS*

The following steps are required to occur to define the offset strategy:

1) Consultation is required with the Myanmar Department of Forestry to discuss offset options, including capacity, management actions, suitability of the recommended offset sites and costs;

2) Further consultation with NGOs in Myanmar is required to determine the capacity of NGOs to administer conservation programs and chosen offset sites. Consultation is also a requirement of IFC PS6;

3) Further assessment of the legal options to secure the offset site, including assessing the requirements to make additions of land to the Panlaung-Pyadalin Cave Wildlife Sanctuary for a portion of the limestone range, including any existing mining leases and associated costs;

4) Analysis of the requirements to achieve Net-Gain for Critical Habitat Species and Habitats and associated costs;

5) Analysis of the requirements to achieve no-net-loss for EN and VU listed species;

6) Development of a Biodiversity Offset Plan to outline the required management framework, financial support, roles and responsibilities and monitoring/evaluation requirements.

Annex A Current Biodiversity Conservation Programs in Myanmar

Program Name	Location	Organisation	General Description	Year	Sponsors	Government Bodies Involved	Funds (USD)
Red Panda Conservation Programme	Imawbum National Park	Fauna & Flora International (FFI)	The program aims to increase awareness amongst local indigenous people for the protection of the Red Panda (VU) and support the Myanmar Forest Department in its designation of a new protected area - Imawbum National Park.A community-managed no-hunting-zone was also established amongst indigenous Law Waw and Lisu communities. Community rangers were employed for the protection of the species.	2012	Not specified	Myanmar Forest Department	Not specified
Western Hoolock Gibbon Project (Rhakine Yoma Range)	Pauk Sa Mountain, Rhakine Yoma Range	(1) Fauna & Flora International (FFI) (2) People Resources and Conservation Foundation (PRCF) (3) Biodiversity and Nature Conservation Association (BANCA)	Program involves managers and local communities in conservation activities in 2 protected areas - Natmataung National Park and Kyauk Pan Taung protected forests. Targets were to set up a site-based community conservation group and an action plan for gibbon conservation by 2011.	2013	Arcus Foundation Great Apes Fund US Fish and Wildlife Service Great Ape Conservation Program	Myanmar Ministry of Environmental Conservation and Forestry	Not specified
Eastern Hoolock Gibbon Project (Indawgyi Wildlife Sanctuary)	Indawgyi Wildlife Sanctuary	(1) Fauna & Flora International (FFI) (2) People Resources and Conservation Foundation (PRCF) (3) Biodiversity and Nature Conservation Association (BANCA)	Program aims to manage unsustainable logging through the establishment of community woodlots, forest use zonation, wood substitution and reduction programs in local communities. Long term research and monitoring will also be carried out to further knowledge of the species and inform management measures.	2013	Arcus Foundation Great Apes Fund US Fish and Wildlife Service Great Ape Conservation Program	Myanmar Ministry of Environmental Conservation and Forestry	Not specified

Program Name	Location	Organisation	General Description	Year	Sponsors	Government Bodies Involved	Funds (USD)
Community Based Conservation of Asian Elephants	Rakhine Yoma	Indo-Myanmar Conservation	The conservation program occurs within the 175,000 ha Rakhine Yoma Elephant Sanctuary, at the heart of one of Myanmar's two largest elephant ranges. The Sanctuary also supports important populations of Hoolock gibbon, gaur and the endemic Arakan forest turtle (CR).The goal of the project is to negotiate agreements with Chin minorities for a commitment to stop hunting in exchange for livelihood support. The Chin people will also monitor the region's wildlife with a particular focus on elephants and the Arakan forest turtle. Two agreements have been signed in 2007 and 2008, paving the way for the provision of rice supplements, salary supplements for two teachers and support for a community plantation forest.	2007	Not specified	Not specified	Not specified
Eld's Deer Conservation	Chatthin Wildlife Sanctuary, Sagaing State	Indo-Myanmar Conservation	Chatthin Wildlife Sanctuary, in Myanmar's Sagaing Region, is home to more than 1,800 Eld's deer (EN), by far the world's largest wild population. The Sanctuary also contains the largest remnant of Myanmar's highly threatened deciduous dipterocarp forests. The Sanctuary faces major threats in the form of conversion to agriculture, fuelwood extraction, and hunting, particularly of Eld's deer. The goal of the Eld's Deer conservation program is to reduce the impact of local people on the sanctuary's resources through a program of environmental education and establishment of a community forest.	Not specified	Not specified	Not specified	Not specified

Program Name	Location	Organisation	General Description	Year	Sponsors	Government Bodies Involved	Funds (USD)
Conservation of Two Ficus Species with Local Community Participation	Pindaya Region, Southern Shan State	The Rufford Foundation	This project was targeted at raising awareness amongst the local communities of the importance of 2 Fig species (Local names: Nyaung Painn Nell & Nyaung Chyin).Collection of tree population data, young plants and seedlings were also carried out.	2008	The Rufford Foundation	Not specified	Not specified
Ecology and Conservation of Green Peafowl	Pwe Hla Region and its Vicinity	The Rufford Foundation	This project was targeted at improving the understanding of the ecology of the species through the identification of roosting sites, mating ground and establishment of ranging behaviour. Awareness was also raised amongst local communities and farmers on the threats facing the species (pesticide use, hunting by domestic dogs).The information collected was fed into Myanmar's National Biodiversity Strategy and Action Plan (NBSAP).	2016	The Rufford Foundation	Not specified	Not specified
Pangolin Conservation on Shan State Plateau	Shan State Plateau	The Rufford Foundation	This project was targeted at improving the understanding of the ecology of pangolins and raising public awareness in schools. A pangolin conservation team was also established.	2008	The Rufford Foundation	Not specified	Not specified
Conservation of Endangered Endemic Black Orchid (*Paphiopedilum wardii*) Population and Native Orchid Species	Naing Ngun Area, Putao District, Kachin State	The Rufford Foundation	This project was targeted at the conservation of *P. wardii*, an endemic and CR orchid species in Myanmar. Field studies were carried out to understand the distribution of the orchid, orchid rehabilitation centres were set up and conservation talks were conducted to improve awareness on sustainable utilisation of native flora and its importance to the conservation.	2010	The Rufford Foundation	Not specified	Not specified

Program Name	Location	Organisation	General Description	Year	Sponsors	Government Bodies Involved	Funds (USD)
Installation the Sal Tree (*Shorea robusta*) Conservation Awareness Programs to Local Communities	Phet Nam Village	The Rufford Foundation	In the first 4 months of the programme, field investigations were conducted and local communities were engaged to establish nurseries for the propagation of the Sal Tree. Planting of the sapling were carried out subsequently. Meetings and talks were also conducted in local communities to raise public awareness of the importance of and threats facing the Sal Tree.	2008	The Rufford Foundation	Not specified	Not specified
Initiation of Community Conservation Efforts in Myanmar with Focus on Endemic Queen of Flowering Tree (*Amherstia nobilis*)	Hlawga National Park	The Rufford Foundation	This project was targeted at understanding the distribution of the species, the establishment of a nursery for propagation, awareness raising and training on propagation techniques. Saplings from the nursery were planted around villages near Hlawga National Park and monitoring efforts were undertaken for further management and protection.	2008	The Rufford Foundation	Not specified	Not specified
Conservation of Sun Bears and its habitat in Myanmar	Not specified	(1) Oikos Institute (2) Wildlife Conservation Singapore	Program activities focus on (i) gaining a better understanding of the status and distribution of the Sun Bear, (ii) securing the long term protection of at least 15,000 acres of forest habitats, and (iii) the improvement of the local capacity on monitoring, patrolling and forest management. The project will train Forest Department staff and support them in the implementation of monitoring and patrolling activities, in conjunction with community members. Finally, the project will involve local communities through the establishment of community forests and community managed buffer zones.	2016 - 2020	Foundation Segre	Not specified	Not specified

Program Name	Location	Organisation	General Description	Year	Sponsors	Government Bodies Involved	Funds (USD)
Mahamyaing Wildlife Sanctuary (MWS) Management Plan	Mahamyaing Wildlife Sanctuary	(1) Rainforest Trust (2) Friends of Wildlife (FOW)	A collaboration between the Rainforest Trust and Friends of Wildlife to protect the Mahamyaing Wildlife Sanctuary in North-central Myanmar. The project builds upon existing Eastern Hoolock Gibbon conservation efforts by FOW since 2014, and will implement supervisory teams to bolster wildlife protection, community outreach and wildlife monitoring in the sanctuary. These activities will feed into the development of a management plan for the sanctuary and operationalized by FOW. Work is also underway to empower villagers with alternatives to extractive industries through promotion of customary land rights and conservation education. Gibbon census surveys have been undertaken together with local villagers and park rangers.	Not specified	Not specified	Nature-Wildlife Conservation Division, Forestry Ministry	200000 (0.68 usd / acre)
Conservation of Karst Biodiversity	Not specified	Fauna & Flora International (FFI)	The program conducted comprehensive bat and invertebrate surveys at karst areas in 2014 and based on these results, selected 8 priority caves for pilot conservation action. In May 2016, the first national workshop on the conservation of karst ecosystems was organised in collaboration with the Forestry, Environmental Conservation, Mining and Industry departments and cement companies. A tourism cave management workshop was held in July 2016.FFI has plans to organise training on sustainable guano harvesting in the next step of karst conservation.	2014	Not specified	Ministry of Forestry and Environment Ministry of Mines	Not specified

Program Name	Location	Organisation	General Description	Year	Sponsors	Government Bodies Involved	Funds (USD)
Meinmahal Kyun Wildlife Sanctuary Conservation Project	Meinmahal Kyun Wildlife Sanctuary	Fauna & Flora International (FFI)	Meinmahla Kyun Wildlife Sanctuary is one of the oldest protected areas in Myanmar. Despite suffering habitat degradation from years of fuelwood and timber demand, the site continues to support diverse fauna (marine and freshwater fauna, waterbirds etc).The program worked with local partners to develop a protected area management plan for the site, including nominating it as a RAMSAR site. Other activities include community-managed fish conservation zones, agroforestry, efficient cookstove introduction, community-based mangrove rehabilitation and restoration and community-based ecotourism.	Not specified	Not specified	Not specified	Not specified
Mounta Imawbum Conservation Project	Mounta Imawbum	Fauna & Flora International (FFI)	The mountain range supports one of the highest levels of biodiversity in the eastern Himalayas. The program had recorded a new species of snub-nosed monkey, *Rhinopithecus strykeri* (CR), and other globally threatened species such as the Red Panda, Asiatic Black Bear, Blyth's Tragopan from the range. This prompted conservation efforts including the establishment of a community-based conservation area with support from indigenous communities and local township authorities; securement of approval of the establishment of Imawbum National Park; and initiation of a buffer-zone development program.	2012	Not specified	Not specified	Not specified
Tanintharyi Elephant Project	Tanintharyi	Fauna & Flora International (FFI)	The project was set up to undertake a more detailed assessment of elephant status and threats, assess and manage human-elephant conflict, raise awareness of elephant conservation issues and identify long term	2014	Initial funding provided by the US State Department	Not specified	Not specified

Program Name	Location	Organisation	General Description	Year	Sponsors	Government Bodies Involved	Funds (USD)
			management priorities. In the first year of the program, a field team was trained, a monitoring mechanism established and records of human-wildlife conflict mapped across the landscape.				
Tanintharyi Tiger Project	Tanintharyi	Fauna & Flora International (FFI)	A three-year initiative to establish and support tiger and prey monitoring, community patrolling, improved law enforcement, village forest management, ecotourism development and cooperation with Thai authorities. The project focuses on the southern landscape of Tanintharyi, spanning 400,000 ha and including two reserve forests identified for long term protection under Myanmar's commitments for the CBD.	Not specified	Not specified	Not specified	Not specified

Annex B Recommended offset management actions

Management Action	Purpose	Description
1. Conservation Needs Assessment	Determine the priority biodiversity values and management requirements for biodiversity values	This would be informed by the baseline biodiversity data and local stakeholder participation; and would inform the design of the management plan. A baseline for management should be established and enable future tracking for effectiveness by using a tracking tool (such as the GEF tool), which could be updated periodically to guide future adaptive management actions.
2. Management Plan	Defines governance framework for management of offset projects.	The management plan is to provide the roles, responsibilities, accountabilities, actions, resources and budgets available to actively manage biodiversity offset sites. Clear goals and objectives linked to the monitoring and evaluation framework should be set. Development of the management plan would normally be prepared through consultation with key stakeholders and participation of affected local communities.
3. Monitoring and evaluation	Defines approach to monitor the implementation of management actions	The monitoring and evaluation framework is to define an approach to determine the effectiveness of the management actions in achieving biodiversity conservation goals. The approach should look at the institutional, financial and governance frameworks applied as well as relevant biodiversity indicators (species richness, basal area).The monitoring and evaluation should directly relate to goals and objectives set for offset management. The outcomes of the monitoring and evaluation should be used as a basis for (i) reporting to relevant stakeholders; and (ii) informing adaptive management actions, including the periodic update of management plans.
4. Management of hunting	Manages threats to animals from illegal hunting and poaching.	The management of hunting should aim to monitor and enforce in conjunction with the Myanmar Government and the community, activities that illegally hunt and poach wildlife within the offset site. The approach should include: patrols and surveillance for illegal hunting activities; education and awareness; and incentives.
5. Sustainable forestry management	Manages unsustainable and illegal use of timber.	Sustainable forestry management should focus on the ecologically sustainable harvesting of timber from the offset site for the use within the local community. The approach should restrict impacts on known habitats to threatened species; sustainable yield assessment and harvesting approaches; patrols and surveillance for illegal forestry activities; education and awareness and incentives.
6. Wildlife Corridors	Links habitats within the landscape	Development of appropriate wildlife corridors enables the movement of wildlife between discrete areas of habitat within the landscape. This can be achieved through landuse planning or supplementary establishment of habitat.
7. Sustainable forest product use (NTFP)	Manages unsustainable NTFP use.	The sustainable use of NTFP should focus on documenting cultural and heritage usage of NTFP; analysis of sustainable yield for NTFP; identifying alternatives where sustainable collection is identified; and education and awareness on sustainable collection practices.
8. Management of weeds and pests	Manages threats to biodiversity from introduced weeds and pests.	Managing weeds and pets should: identify and monitor the distribution and abundance of weeds and pests in the area; identify appropriate controls at a spatial and temporal scale; define control techniques and actions. Actions may include active control of weeds or specific hunting programs for pest animals.
9. Fire management	Manages impacts on biodiversity from inappropriate use of fire.	Managing fire should: identify historical fire regimes within the offset site at a spatial and temporal scale; determine ecological fire regimes based on intensity and frequency of fire; defining and map exclusion zones; consider threatened species responses to fire; and design ecological fire control methods.

Management Action	Purpose	Description
10. Assisted natural regeneration	Promotes biodiversity where natural regeneration is constrained due to past land use or ecological factors.	Assisted natural regeneration should focus on the establishment of relevant plant stock to assist natural regeneration of disturbed areas. Assessment and mapping of areas identified as being suppressed or degraded; determination of suitable plant stock and planting regime; collection and propagation of plant stock; preparation and management of regeneration areas. Local community engagement in horticultural activities is recommended.
11. Community engagement and development	Provides consultative mechanisms and engages the community in active participation in biodiversity conservation.	Community engagement and development is designed to involve the local community in the management actions developed for each the offset sites. Consultation during the preparation of the management plans is required to ensure that the management actions and approaches are acceptable to the community. This can include direct engagement in undertaking actions (hunting patrols, employment at the nursery; manufacture of nest boxes).Community engagement is an essential component in determining the appropriateness and ensuring success of the sustainable forest practices and NTFP development.
12. Education and awareness	Provides education and awareness for local communities to promote biodiversity conservation.	Education and awareness approaches are integral to the success of offset management. This should include community engagement surveys; education seminars; posters and flyers; identification of community champions and incentives. Each management action should include an education and awareness component.

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