FINAL REPORT

LUM MAWSHUN MINERALS PVT. LTD

Comprehensive Environmental Impact Assessment of Limestone Mine: *Village Nongtrai, Meghalaya, India*

February 2002

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August 2002

Reference I5286

For and on behalf of ERM	
Approved by:	***Subir Gupta***
Signed:	_____
Position:	***Managing Director***
Date:	***22 February 2002***

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1 INTRODUCTION

1.1 BACKGROUND

Lum Mawshun Minerals Private Limited (LMMPL) proposes to set up an open cast limestone mine at Phlangkaruh, Nongtrai, Shella Confederacy in the district of East Khasi Hills. The proposed mine will extract about 2 million tonnes per annum (MTPA) of limestone that will be transported to proposed cement plant at Chhatak in Bangladesh through a belt conveyor. Out of the 17.3 km (total length of the proposed belt conveyor corridor) 7.2 km will be within the Indian Territory and the rest will be in Bangladesh.

LMMPL is a private limited company incorporated in India. The company has a joint venture equity participation with a foreign partner Lafarge Surma Cement Limited (LSC), Bangladesh.

The project is a designated development under the Environmental Impact Assessment (EIA) Notification, 1994 and amendments promulgated under Environment (Protection) Act (EPA), 1986. As per the EIA notification, the project requires Environmental Clearance from State Pollution Control Board and Ministry of Environment and Forests (MoEF) based on EIA of the project in line with the guidelines of the MoEF.

Accordingly, the company has retained ERM India Pvt. Ltd, New Delhi to undertake Rapid & Comprehensive Environmental Impact Assessment (R-EIA & C-EIA) and preparation of Environmental Management Plan (EMP) study for various environmental components which may be affected due to the activities of the proposed mining project. This C-EIA report is based on four seasons baseline data generated for an area of 10 km radius around the proposed mine site.

MoEF has granted environment clearance to the project based on the R-EIA report through their letter no. J-11015/10/2000-IA-II-(M) dated 9 August 2001 (refer to *Annex C for the copy*).

1.2 SITE AND SURROUNDINGS

The mining lease area lies between the latitudes 25° 11' 25" N & 25° 12' 00" N and longitudes 91° 37' 28" E & 91° 38' 01" E. The lease area falls within hamlet Phlangkaruh of village Nongtrai and lies on the western side of the Umium River, about 2 km NW of village Shella Bazaar. The location map of Limestone mine area, and its key plan are shown in ***Figure 1.1 A*** and ***1.1 B*** respectively.

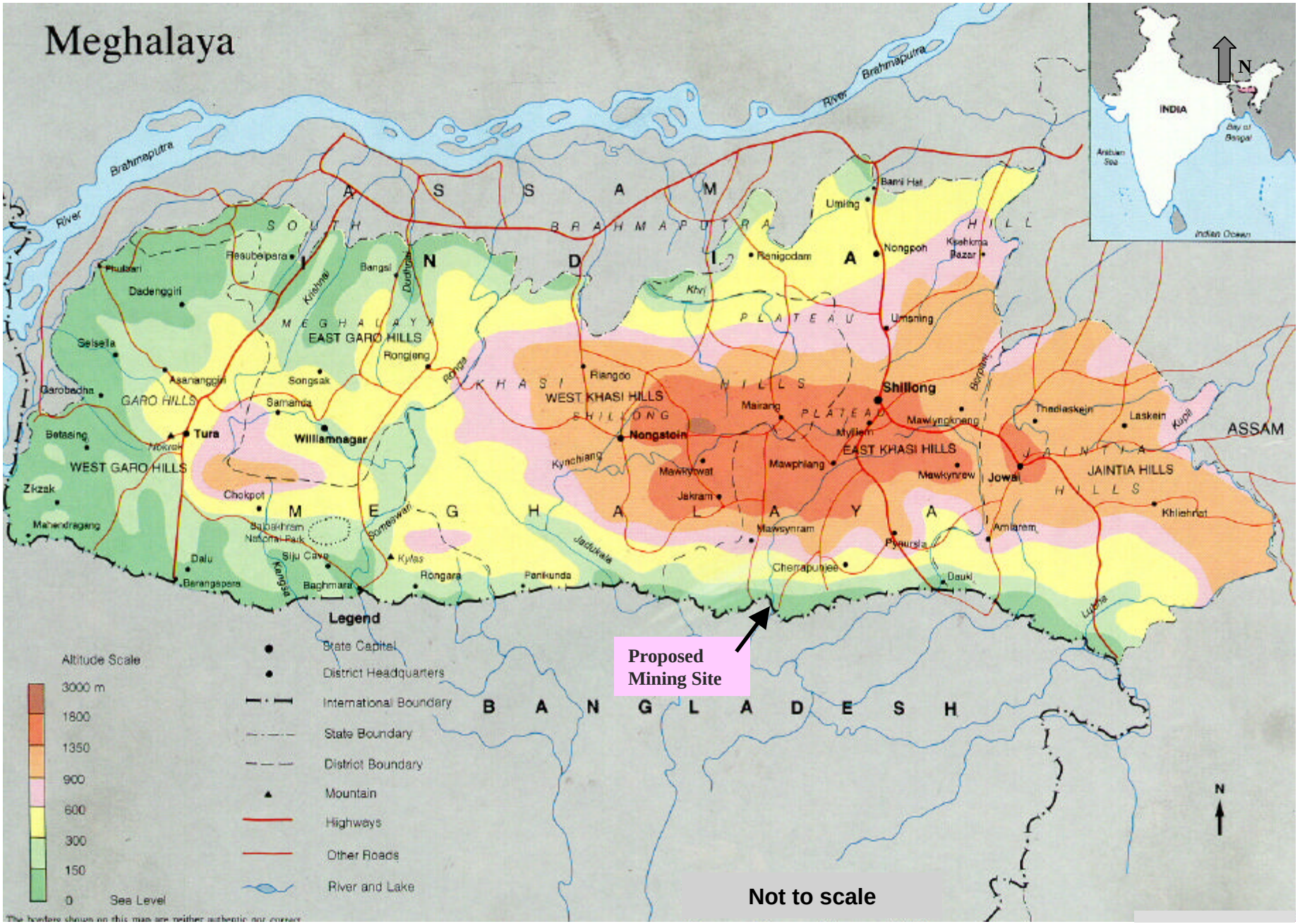
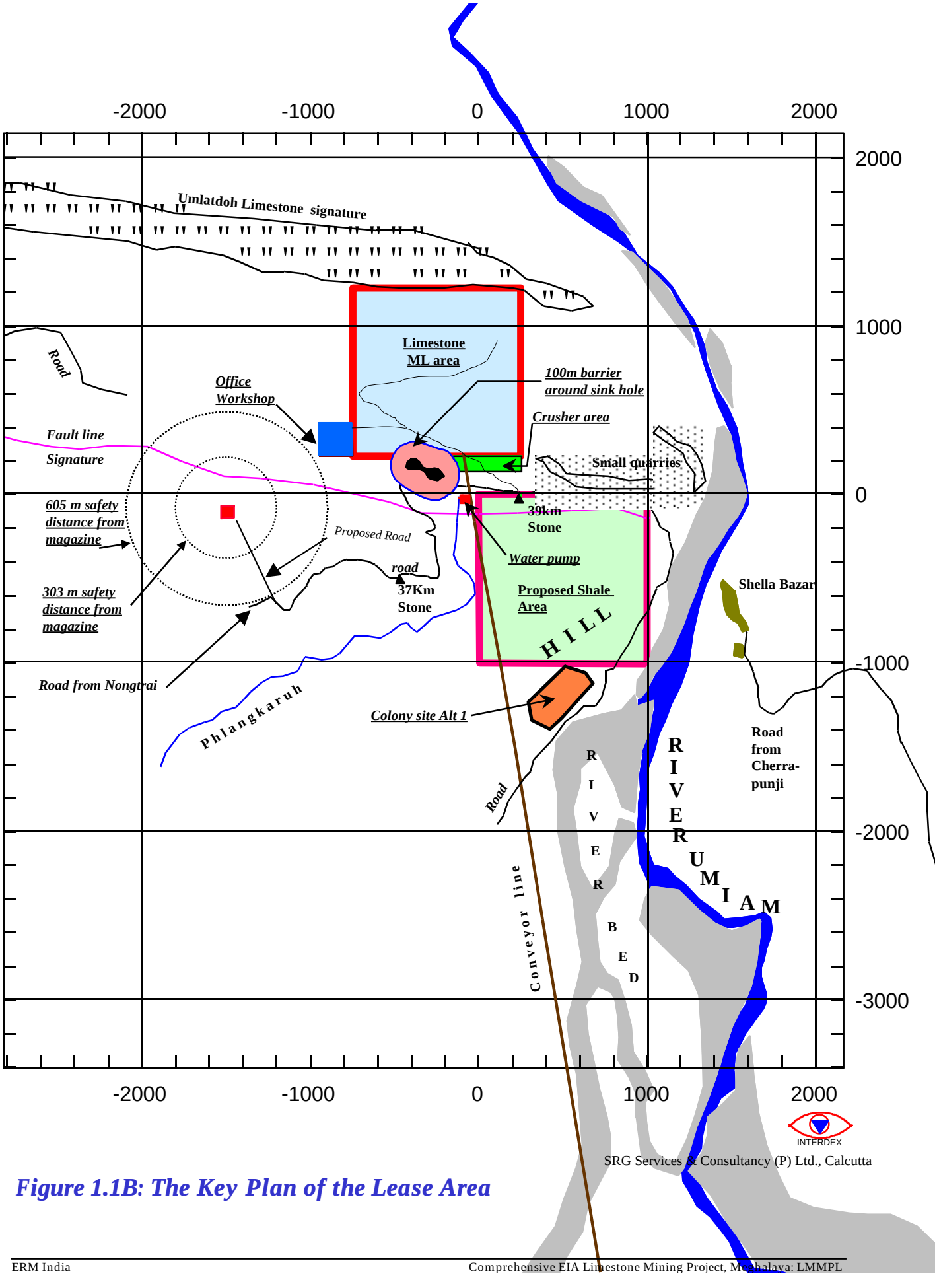


Figure 1.1A: Location Map showing Proposed Limestone Mining Site



SRG Services & Consultancy (P) Ltd., Calcutta

Figure 1.1B: The Key Plan of the Lease Area

The details of the land contained within the lease area are given in the following ***Table 1.1***:

Table 1.1: Details of the Lease Area

District & State	*P.S./ Taluka*	*Proposed Mine Area*	*Ownership of land within the lease area*	*Nearest Villages and crow fly distances*
East Khasi Hills, Meghalaya	Shella P.S.	100 hectares	Village Durbar of Nongtrai	• *Phalangkaruh (about 1 km to the South)* • *Shella Bazaar (about 2 km to the South-east)* • *Pyrkan Village (about 1.5 km to the South-southeast)*

The Nongtrai / Shella area is located in a remote part of Meghalaya State in India, away from urban and industrial centres, in the southern face of Khasi Hills. To the South of the lease area, there lies the international border between India and Bangladesh, which runs in an east-west direction in general.

The topography of the region is marked by rugged hilly terrain rising from the low altitudes of the plains on the south and up to 700 m above mean sea level northwards.

The general elevation of the lease area ranges between 90m Reduced Level (RL) and 190 m RL. To the north, the land rises abruptly to the higher altitudes of the plateau whilst to the south, the land slopes gently to the plains of Bangladesh. To the east, the land slopes gently forming a gorge through which the river Umium flows. To the west, the land rolls with hills of different elevations.

1.3 ACCESSIBILITY

The details of the accessibility of the area is as follows:

Road

The lease area lies on the western side of the Umium river valley, about 2 km NW of village Shella Bazaar and is approachable from Shillong (109 km), the capital of Meghalaya, via Mawsynram & Nongtrai villages by a tracked road. It is also accessible from Shillong (96 km) by a tracked road via Cherrapunji upto village Shella Bazar. However, there is no access road / bridge across the Umium River to connect the two villages Shella Bazar in the east and Pyrkan Shella in west of the river. During the dry season, the villagers for crossing the river by foot usually construct a temporary bamboo bridge. But in the rainy season, one has to cross the river by boat.

Rail

The nearest Railhead is at Guwahati, about 200 km away towards the North of the area.

Air

The nearest airports are in Upper Shillong (110 km away) and Guwahati (200 km away). However, no regular flights are scheduled to Shillong except helicopter service between Guwahati and Shillong.

1.4 NEED FOR THE PROJECT

Meghalaya is very rich in Mineral resources like limestone, shale, coal, sillimanite and uranium. Reportedly, the size of limestone deposits in Meghalaya has been estimated to be 2,166 million tonnes and another unconfirmed deposit of 180 million tonnes. Most of the deposits are currently lying unutilised and can be exploited commercially for the development of the state.

Bangladesh is almost wholly dependent on limestone imported from other countries, mostly from the state of Meghalaya in India. With the growing co-operation between India and Bangladesh, LSC is proposing to set up a cement plant in Bangladesh with limestone to be sourced from Meghalaya through LMMPL.

The objectives of the proposed mining project are to excavate limestone whilst achieving a balance between impacts on the local environment, community needs and economic viability. For the proposed mine, LMMPL aims at the following objectives:

1.4.1 Production and Operational

- establish open cast limestone mine producing export quality limestone;
- develop and manage the mine in an environmentally friendly manner;
- maximise operational flexibility;
- optimise resource use; and
- develop and operate a mine that meets or exceeds community expectations in terms of environmental outcomes and cost.

1.4.2 Environmental

- protect native flora and fauna;
- protect quality of local surface and groundwater;
- minimise public health risks from mine operations;
- ensure that ecological balance of the area should not be adversely affected by dust; and
- minimise noise and blasting impacts on surroundings.

1.4.3 Socio-economic

- maximise local employment and educational opportunities by direct and indirect means;
- maintain safety along the conveyor belt corridor while conveying limestone to Bangladesh;

- establish monitoring programme and provide procedures for the resolutions community concerns;
- ensure proper security arrangement around the mine and along conveyor belt corridor including point of its border crossing; and
- Improvement in the living standard of the local habitants.

1.5 SITE SELECTION

The proposed mining plant site has been selected based on following considerations:

- availability of rich belt of limestone in the state; and
- closeness of Indian territory to that of Bangladesh for supply of limestone for the proposed cement plant to be located in Bangladesh;

1.6 SCOPE OF THE STUDY

The C-EIA study covers an area of 10-km radius for all environmental attributes with the proposed mining project as per MoEF guidelines. The scope of the study broadly includes:

- literature review that includes identification of relevant data and articles from various publications, various government agencies and other sources;
- environmental monitoring so as to establish the baseline environmental status of the study area;
- identify various existing pollution loads due to industrial and domestic activities in the surrounding area;
- evaluate the predicted impacts on the various environmental attributes in the study area by using scientifically developed and widely accepted Environmental Impact Assessment Methodologies;
- prepare an Environmental Management Plan (EMP) outlining the measures for improving the environmental quality; and
- identify critical environmental attributes required to be monitored.

The environmental monitoring for ambient air quality, meteorology, dust fall, noise levels, soil quality and water quality, etc. was undertaken by ERM India through a recognized laboratory called Netel Chromatographs.The details of environmental monitoring are given in *Tables 1.2 & 1.3:*

Table 1.2 : Calendar of Environmental Monitoring of the Study Area

S.N	Monitoring Period	Seasons	Details of monitoring
1	End May to End June 1999	Pre-monsoon	Meteorology, Ambient Air Quality, Dust Fall, Noise Quality, Traffic Density, Water Quality and Soil Quality.
2	Mid August, 1999	Monsoon	Water Quality
3	Mid Nov to Mid Dec. 1999	Post-monsoon	Same as during Pre monsoon season
4	End Dec 1999 to End Feb 2000	Winter	Same as during Pre & Post monsoon Seasons

Table 1.3: Environmental Attributes & Frequency of Monitoring

Sr No	Attribute	Parameters	Frequency of Monitoring
1	Meteorology	Surface Wind speed and direction, temperature, relative humidity and rainfall.	Surface Continuous monitoring station for one month on hourly basis in a season and also data collection from secondary sources.
2	Ambient air quality	SPM, RSPM, SO_2, NO_x, CO & HC	24 hourly samples twice a week for four weeks at eight locations in a season.
3	Water quality	Physical, Chemical and Bacteriological parameters.	Once during the study period at fifteen locations in a season.
4	Noise levels	Noise levels in dB(A)	Hourly observation for 24 hours per location at fifteen locations in a season.
5	Soil characteristics	Parameters related to agricultural and afforestation potential.	Once during the study period at ten locations in a season.
6	Ecology	Existing flora and fauna.	Through field visit and substantiated through secondary sources.
7	Land use	Trend of land use change for different categories.	Based on data published in district census handbooks (1991) and Satellite imagery.
8	Socio-economic aspects	Socio-economic characteristics, labour force characteristics, population statistics and existing amenities in the study area.	Based on area surveys and data collected from secondary sources (census handbooks, 1991).
9	Geology & mining details	Geological history.	Based on Mining Plan of the project as approved by IBM
10	Hydrology & Siltation	Drainage area and pattern, nature of streams, aquifer characteristics of the area. Impact of siltation due to mining	Based on studies carried out at site and data collected from secondary sources

1.7 ORGANISATION OF THE STUDY

Reconnaissance survey was conducted and sampling locations were identified on the basis of the following:

- existing topography;
- proposed locations of water intake and treated effluent disposal points of mine / domestic / other sources;
- location of villages / towns / sensitive areas;
- accessibility, power availability and security of monitoring equipment;
- pockets of domestic pollution within the study area; and
- areas which represent baseline conditions.

1.8 REPORT FORMAT

This C-EIA Report is based on field data generated for four seasons at site and data collected from secondary sources. This EIA report is prepared in accordance with the MoEF guidelines and has been divided into eight *Sections* (in addition to Executive Summary) as briefed hereunder:

Section 1 - Introduction

The section provides description of project background, site and surroundings, objectives, scope and organisation of the study and format of this report.

Section 2 – Environmental Policy, Legal and Administrative Framework

This section provides information on Policy, Legal and Administrative framework applicable to mining projects. The Section defines major provisions required for mining projects, current status of the project and World Bank guidelines on EHS in Mines.

Section 3 - Project Description

This Section deals with the technology and specifications of the project. This also deals with the infrastructural development as a part of project and sources of pollution from the proposed mining project and proposed control measures.

Section 4 - Baseline Environmental Status

This Section presents the methodology and findings of field studies undertaken with respect to ambient air, meteorology, water, soils, noise levels, ecology to define the various existing environmental status in the area.

Section 5 – Socio-economic Profile of the Study Area

This Section presents socio-economic profile of the study area based on primary and secondary information on socio-economic aspects of the study area.

Section 6 – Prediction of Impacts

In this section, the potential impacts of the proposed mining and allied activities, which could cause significant environmental concerns, are identified and discussed. This discussion will form the basis for environmental management activities.

Section 7 – Evaluation of Impacts

In this section, environmental impacts due to the proposed Limestone mining activities have been quantified under two scenarios (1) without environmental management plan , and (2) with the environmental management plan using modified Leopold Impact Matrix to establish cause-effect relationship.

Section 8 - Environmental Management Plan (EMP)

This Section provides recommendation for environmental management plan aimed at minimising the negative environmental impacts of the project. Environmental monitoring requirements for effective implementation of mitigating measures during development as well as operation of the mine have also been delineated along with requisite institutional arrangements for their implementation.

2 ENVIRONMENTAL REGULATIONS & INSTITUTIONAL FRAMEWORK

2.1 OVERVIEW

India is endowed with a wide range of natural resources. Mining industry in India has been growing at an annual rate of 4 to 5% during last three decades. With the entry of Indian private sector and foreign equity participation in the mining sector, the growth is expected to increase further. Presently, both opencast and underground mining practices are prevalent in India. The extent of environmental damage caused by mining varies with the scale of operation, mining technology, nature of topography, etc. as discussed in the following sections:

2.1.1 Land Degradation

Land damage is a major impact of an opencast mining project. Land gets damaged either due to excavations made for extracting minerals or for locating waste disposal sites and other allied operations.

2.1.2 Socio Economic Impact

Both positive and negative Socio-economic implications are associated with mining projects. The positive impacts are in the form of new employment opportunities, educational facilities, improved communication and health care facilities, etc. The major negative impacts are the displacement of people from the neighbourhood and stress on local available resources.

2.1.3 Air Pollution

Air pollution during mining depends primarily on-site pollution and is also affected by ancillary operations *eg* transportation and processing of run-of-mine going away from the mining site. Other mining activities which may lead to problem of air pollution include drilling, blasting, loading and unloading of materials, mobile and fixed equipment (crushers, screens, conveyors etc). The general National Ambient Air Quality Standards (NAAQS) apply to mining projects.

2.1.4 Water Pollution

The Water pollution may be caused by discharge of untreated domestic and workshop wastewater. The General Standards for Discharge of Environmental Pollutants as applicable to mining operations can be referred through ***Annex A***.

2.1.5 Noise Pollution

Use of various equipment like rotary drills, electric shovels, graders, dozers, crusher, fixed / mobile plant installations etc cause noise pollution. Mechanised opencast mining operations also contribute to noise pollution. Due to blasting, pressure waves at wide range of frequencies are transmitted. Loss of hearing and damages to surface structures are the result of impulse noise or air

overpressure. The blasts also produce ground vibrations and there are different levels, *e.g.* 9.5-20.0 mm / sec as unpleasant; and 20.0-32.5 mm / sec as disturbing. These values at frequencies higher than natural frequency may not cause any damage to the surface structure but it may cause annoyance or disturbance to the inhabitants.

Ambient Noise Quality standards as laid down in Environmental Protection Act, 1986 (EPA, 1986) apply to all the mining activities.

2.1.6 Solid Waste Management

Solid wastes are generated consequent to mining operations and comprise of topsoil, overburden / waste rock, sub-grade ore etc. Proper disposal of solid waste is important as otherwise it may result in environmental pollution and cause land degradation.

The relevant provisions in the *Mineral Conservation and Development Rules, 1988* have been reproduced below:

Rule 33(4): Wherever possible, the waste rock, overburden etc. shall be back filled into the mine excavations with a view to restoring the land to its original use as far as possible.

Rule 33 (5) Wherever back filling of waste rock in the area excavated during mining operations is not feasible, the waste dumps shall be suitably terraced and stabilised through vegetation or otherwise.

2.2 ENVIRONMENTAL LEGISLATIVE FRAMEWORK

2.2.1 National Mineral Policy on Protection of Environment in Mines

The first significant step by GoI towards management of environmental concerns associated with the exploitation of mineral resources, was the constitution of a Working Group on "Mining and the Environment" by the Department of Science and Technology (DS&T). The group submitted the recommendations in 1981, which were included in legislation related to development of mines i.e. *Mineral Conservation and Development Rules (MCDR), 1988 and amendments.* Under these rules, chapter 5 is completely dedicated to environment protection.

The National Mineral Policy, 1993 for non fossil and non atomic minerals, prohibits mining operations in identified ecologically fragile and biologically rich areas and strip mining in forest areas. The latter could be permitted only when accompanied by a comprehensive time bound reclamation programme. It states further that:

- EMP should have adequate measures for minimising environmental damage by restoration of mined areas and by plantation in accordance with the prescribed norms;
- as far as possible, reclamation and afforestation should proceed concurrently with mineral extraction; and

- efforts should also be made to convert old disused mine sites into forests and other forms of land use.

2.2.2 Mineral Concession Rules (MCR), 1960

The MCR rules layout the provisions for assessment and payment of compensation which are as given below:

Payment of compensation to owner of surface right

The Rules provide for payment of annual compensation to land losers by the holder of a prospecting license or mining lease. The said compensation amount is to be decided by an officer appointed by the state government. The MCR Rules lay down the following principles:

- In case of agricultural land, the amount of annual compensation is to be worked out on the basis of average annual net income from the cultivation of similar land for the previous three years; and

- In case of non-agricultural land, the amount of annual compensation is to be worked out on the basis of average annual letting value of similar land for the pervious three years.

Assessment of compensation for damage to the land

There is a provision in the Act for payment of damages (to the mining block by the lessee) after the termination of the lease. After the termination of a mining lease, the State Government assesses the damage, if any, done to the land by mining operations and determines the amount of compensation payable by the lessee to the occupier of the surface land. Such an assessment is to be made within a period of one year from the date of termination of the mining lease. The assessment is to be carried out by an officer appointed by the State Government.

2.2.3 Mines & Minerals Legislation Pertaining To Environmental Protection

The environmental protection provisions covered under different legislation pertaining to mining are defined in the following subsections:

Mines & Minerals (Regulations & Development) Act, 1957

Mines and Minerals (Regulations & Development) Act (MMRD), 1957 as amended in 1986 and 1994 is the major act covering specific provisions relating to protection of environment in mines. Requirement of a "Mining Plan" for fresh grant or renewal of any mining lease was incorporated in the amended act. Salient features relating to mine environment are enumerated below:

Section 4A(1): Where the State Government, after consultation with the Central Government, is of the opinion that it is expedient in the interest of regulation for mines and mineral development, preservation of natural environment, control of floods, prevention of pollution or to avoid danger to public health and communications or to ensure safety of buildings, monuments or other

structures or such other purposes as the State Government may deem fit, it may, by an order, in respect of any minor mineral, make premature termination of prospecting licence or mining lease with respect to the area or any part thereof covered by such licence or lease.

Section 5(2): No mining lease shall be granted by the State Government unless it is satisfied that-there is a mining plan duly approved by the Central Government for the development of mineral deposits in the area concerned.

Section 18(1): It shall be the duty of the Central Government to take all such steps as may be necessary for the conservation and systematic development of minerals in India and for the protection of environment by preventing or controlling any pollution which may be caused by prospecting or mining operations and for such purposes the Central Government may, by notification in the Official Gazette, make such rules as it thinks fit.

Mine Act, 1952; Mine Rules, 1953

Occupational health and safety aspects of mine are regulated by Indian Mines Act, 1952, and the guidelines issued by Directorate General of Mines Safety, subsidiary of IBM. The above Act has stipulations with respect to working hours, occupational diseases, periodic medical check up, employment of female and children, employment of medical and welfare officers etc.

Mineral Concession Rules (MCR), 1960

These rules are framed under the *MMRD Act* and thereafter requires that "Mining Plan" shall incorporate amongst others, a plan of the area showing the water courses, limits of reserved and other forest areas, density of trees, assessment of impact of mining activity of forest, land surface and environment including air and water pollution; details of scheme of restoration of the area by afforestation, land reclamation, use of pollution control devices and such measures as may be directed by the Central or the State Government from time to time.

Mineral Conservation and Development Rules, 1988 as amended

These rules were also framed under the parent *MMRD Act*. Under these rules, chapter 5 is completely dedicated to environment protection. The rules at present provide for generation of environmental baseline data even before the commencement of prospecting operations and preparation of an EMP incorporating proposals for prevention and control of air and water pollution, progressive reclamation and rehabilitation of land disturbed by prospecting operations, a scheme of plantation trees and such other measures as may be directed by the Central or State Government from time to time for minimising the adverse effect of prospecting operations on the environment.

Prohibition of Mining Operation in Ecologically Fragile Areas

GoI has identified a number of areas / eco-systems as ecologically fragile areas where mining cannot be generally recommended. In case, any person / company is desirous of undertaking mining operations in the said areas, then, per the

notification, an application in the prescribed format has to be submitted to the Secretary, MoEF, New Delhi, specifying *interalia* the details of the area and the proposed process or operation duly supported by an EIA & EMP and such other information as may be required by the Central Government.

There are few ecologically sensitive areas where mining has been prohibited either by the court's order or by a MoEF notification. Limestone mining in the ecologically fragile Doon valley in the State of Uttar Pradesh has been prohibited under orders from the Hon'ble Supreme Court, the apex court of the country. The Aravali mountain range covering the northern States of Rajasthan and Haryana is another ecologically sensitive area where mining operations (including renewals of mining leases) have been prohibited under a notification No. S.O. 319(E) dated 7th May, 1992 issued by the MoEF. Mining operations in all areas of Sariska National Park and Sariska Sanctuary in the state of Rajasthan have been prohibited by the Central Government under the Wild Life (Protection) Act, 1972 as they pose a threat to the ecology of the area and to the wild life. No such prohibition is issued for Meghalaya State.

2.3 PRIMARY ENVIRONMENTAL LEGISLATION

The Constitution of India directs the State to endeavour to protect and improve the environment and to safeguard the forest and wildlife of the country. Article 51(g) of the constitution states that *it shall be the duty of every citizen of India to protect and improve the national environment including forests, lakes, rivers and wildlife and to have compassion for living creatures.* The language of the Directive principles of the state policy (Article 47) also contains a specific provision, which commits the state to protect the environment.

In addition to Constitutional provisions, India has established a comprehensive set of laws for the management and protection of the environment. The Acts, Notifications, Rules and Amendments applicable for setting up a new mining industry or its expansion of an existing mine and for operation of a mine include the following:

General

- The Environment (Protection) Act and Rules, 1986;
- The Environmental Impact Assessment (EIA) Notification, 1994 and amendments- for Environmental Clearance – including the Environmental Public Hearing a mandatory for the 30 categories of industries;
- Forest (Conservation) Act, 1980;
- The Air (Prevention and Control of Pollution) Act, Rules and Amendment, 1981, 1982, 1983, 1987;
- The Factories Act and Amendment, 1948, 1987;
- The Water (Prevention and Control of Pollution) Act and Rules, 1974, 1975;
- The Water (Prevention and Control of Pollution) Cess Act and Rules, 1977, 1978, 1991;
- The Public Liability Insurance Act, 1991;
- The Environmental Standards Notification, 1993, 1996;
- The Environmental Audit Notification, 1992;

- Hazardous Waste Management and Handling Rules, 1989 and amendment rules 2000;
- The Manufacture , Storage and Import of the Hazardous Chemical Rules , 1989 and amendment rules 2000; and
- The National Environment Tribunal Act, 1995.

Note:

1 Some environment, health and safety related aspects are also covered under the Indian Factories Act, 1948.
2 MoEF has stipulated general discharge standards for water effluents and general emission standards for air emissions. These standards limit the concentration and volumes of the effluents and emissions released to the atmosphere. These standards could be made more stringent by the SPCBs based on the environmental sensitivity of a specific location.
3 The project proponents are required to take Consents (for both air and water) and No Objection Certificates (NOCs) from the relevant SPCBs before initiating any activity.

In addition to the above, CPCB has also specified National Ambient Air Quality Standards (NAAQS) for residential, commercial, industrial and sensitive zones for the country as a whole. All the major rivers of the country have also been classified based on the designated best use criteria (Five Designated Best Use Classes from A to E). It is the responsibility of the respective State Governments to ensure that the water quality criteria are met per these specifications.

2.3.1 Major provisions in Primary Environmental Legislation

The Environment (Protection) Act; 1986 including Rules 1986

This Act is an umbrella legislation that provides a single focus for the protection of the environment and seeks to plug the loopholes of earlier legislation relating to the environment. Several sets of Rules relating to various aspects of the management of hazardous chemicals, wastes, microorganisms etc have been included in this Act. The salient provisions of the Act are as follows:

- Central Government's powers to take necessary measures for the purpose of protecting and improving the quality of the environment and prevention, control and abatement of environmental pollution;
- Central Government's powers include:
  - Lay down standards for the quality of the environment, emissions or discharges of environmental pollutants from various sources;
  - Restrict or prohibit industries, operations or processes in specified areas;
  - Restrict or prohibit handling of hazardous substances in specified areas;
  - Lay down procedures and safeguards for the prevention of accidents, which may cause environmental pollution; and
  - Enter and inspect any industrial establishments, records, registers and documents to ensure effective implementation of the provisions of the Act;
- Central Government has powers to issue directions for
  - The closure and prohibition or regulation of an industry, operations or processes or; and

- Stopping or regulating the supply of electricity, water or any other service in the prescribed manner.
- Industry to comply with such directions;
- Restriction on discharge or emission of pollutants in excess of the prescribed standards;
- Handling of hazardous substances in accordance with the prescribed procedures and safeguards;
- Industry to furnish information to specified agencies in case of discharges, emission of pollutants in excess of the prescribed standards, already occurred or likely to occur, resulting in environmental pollution, due to and unforeseen act or event;
- Central Government has the power to recover, expenses incurred by it on remedial measures to prevent or mitigate environmental pollution from the defaulting industry, as arrears of land revenue or of public demand;
- Central Government has the power to take samples of air, water, soil or other substances from any industrial plant of the purpose of analysis in the prescribed manner;
- Bar on filling of any suit or legal proceedings against the Government or officials empowered by it for action taken in good faith, in pursuance of the Act; and
- Bar of jurisdiction to Civil Court to entertain any suit or proceedings in respect of anything done, action taken or directions issued by the Central Government or any other authority empowered by it, in pursuance of the Act.

Industry, operations or process requiring consent under the Water Act or Air Act or Authorisation under the Hazardous Waste (Management and Handling) Rules, or both, to submit 'Environmental Statement' every year before September 30th for last financial year.

The Environmental Impact Assessment (EIA) Notification of 1994.

As per the EIA notification 1994 and amendments, new or expansion or modernisation of any activity falling in the 30 categories of Industries shall not be undertaken in any part of India unless it has been accorded environmental clearance by the Central Government in accordance with the procedures specified in the notification. As per the procedures, anybody who desires to undertake any project in any part of India or expansion or modernisation of any existing industry, a detailed project report which shall inter-alia include an Environmental Impact Assessment (EIA) report needs to be submitted.

Until January 1994, obtaining environmental clearance from the MoEF was only an administrative requirement intended for mega projects undertaken by the government or public sector undertakings. 1'he EIA Notification issued in 1994 with amendments makes carrying out EIA, a statutory requirement for 30 categories of activities (*Schedule I*), which can be broadly categorized into the following sectors:

- industries;
- mining;

- thermal power plants;
- river valley development;
- ports; harbors and airports;
- communication;
- atomic energy; and
- transport (rail, road, highway); and tourism (including hotels and beach resorts in the Coastal Regulation Zone).

As per the notification all projects listed under *Schedule -1* are required to:

- Obtain prior environmental clearance from the MoEF;
- Projects, which although fall under the de-licensed category of the New Industrial Policy but included in the 30 categories are also, required to obtain environmental clearance from the MoEF;
- Industrial projects where the investment is Rupees 500 million or above must receive MoEF clearance. The provisions of the notification do not apply to 17 of the 30 categories;
- Industrial activities including ***mining*** will be subjected to prior environmental clearance from MoEF unless they are reserved under Small Scale Industrial sector with investments less than Rupees 10 million; and
- Industrial projects are further required to obtain a Letter of Intent (LoI) from the Ministry of Industry, and a No Objection Certificate (NOC) from the SPCB and state Forest Department if the location involves forest land. Once the NOC is obtained, the LoI is converted to an Industrial License by the state authorities. However, if the project falls under Schedule - 1 of the EIA Notification, it must obtain an environmental clearance from the MoEF. Obtaining the necessary approvals from the MoEF is facilitated by set of "Siting Guidelines" which are issued by the MoEF.

The EIA Notification requires each project to submit following documents to the MoEF in order to obtain environmental clearance:

(a) Feasibility / Project Report;
(b) Site clearance (only for site-specific projects mentioned in the Notification);
(c) No Objection Certificate from the SPCB and other state authorities;
(d) Completed Environment Appraisal questionnaire;
(e) EIA Report and Environment Management Plan;
(f) Risk Analysis, Emergency Preparedness Plan (only in case of projects involving hazardous substances); and
(g) Rehabilitation plans where large scale displacement of people is anticipated.

The EIA notification also outlines following environmental appraisal procedure:

(a) the documents listed above are reviewed first by the multi-disciplinary staff in the MoEF. They may also visit the project site, and consult with experts as necessary;
(b) after the initial review, the proposals are placed before specially constituted committees of experts known as Environmental Appraisal Committee (EAC) for each sector. Besides the review of documents, the

Committees may also undertake site visits, and directly interact with affected people and environment groups;

(c) the Committee also arrange public hearings to ensure public participation. Announcements for public hearings are made at least 30 days before through newspapers.

(d) after the above steps are completed, the Appraisal Committee makes a recommendation for approval or rejection of the project. The MoEF makes the final decision.

Whenever a project is given environmental clearance, a set of recommendations and conditions are stipulated by the Appraisal Committee which have to be complied with by the proponent once the project is commissioned. Project authorities are required to submit semi-annual compliance reports to the MoEF to enable the Ministry to monitor the implementation of the recommendations and conditions of environmental clearance. The six Regional Offices of the MoEF (*Bangalore, Bhubaneswar, Bhopal, Chandigarh, Lucknow, and* ***Shillong***) assist the MoEF in monitoring of environmentally cleared projects. Cases of non-compliance of recommendations and conditions of environmental clearance are brought to the notice of the concerned SPCB for action.

Forest (Conservation) Act, 1980

The Forest (Conservation) Act (FCA), 1980 (No 69 of 1980) came into force on 25 October 1980 and was subsequently amended in 1988. Relevant provisions of FCA 1980, and the Rules made thereunder in 1981 provide for prevention of diversion of any forest land for non-forest uses including mining even though, of late, considerable relaxation has been granted by the Central Government. In all such cases, prior approval is required from Central and State Government. Under the Act, an Advisory Committee advises GoI for grant of approval and other matters connected with the conservation of forests.

Details pertaining to status and type of flora & fauna, map of the area, importance of the said area in the hydrology of the region, details of the proposed compensatory afforestation plan is to be filled in the prescribed proforma for diversion of forest land for non-forest usage. Per the amended Rules, Regional Chief Conservator of Forests can decide on the proposals involving forest land upto 5 hectares and in consultation with the State Advisory Group for forest land upto 5-20 hectares. For diversion of more than 20 hectares of forest land for non-forest use, Advisory Committee of MoEF examines the proposals. Compensatory afforestation is one of the most important conditions stipulated by the Central Government while approving proposals for diversion / dereservation of forest land for non-forest uses. Compensatory afforestation may be raised over degraded forest land having an area equal to the forest area diverted / dereserved.

The Air (Prevention and Control of Pollution) Act, 1981 Including Rules 1982 and 1983

The Act was enacted to prevent, control and reduce air pollution including noise pollution and to establish Boards at the States as well as Union Territories levels to achieve this. This Act prohibits the construction and operation of any industrial plant without the consent of SPCBs. The Act assigns powers and

functions to the CPCB and the SPCBs for prevention and control of air pollution and all other related matters. In addition, the CPCB can exercise the powers and perform the functions of a State Board in the Union Territories. For the prevention and control of air pollution, the State Government, in consultation with the SPCB has the powers to set standards for emissions from automobiles, impose restrictions on use of certain industrial plants and prohibit emissions of air pollutants in excess of the standards laid down by the SPCB. It can also make an application to the court for restraining persons from causing air pollution. In addition, it also has the power of entry and inspection, power to obtain information and power to take samples of air emissions and conduct the appropriate follow up. The CPCB, as well as the SPCBs are eligible for contributions from the Central as well as the State Government, respectively, to perform their functions appropriately. The Act also allows for appropriate penalties and procedures for non-compliance. The salient provisions of the Act are as follows:

- State Government's powers include:
    - To declare any area within the state as an *Air Pollution Control Area;*and
    - To prohibit use of any fuel or burning of any material which may cause air pollution in the Air Pollution Control Area.
- Restriction on establishment and operation of any industrial plant in an air pollution control area likely to emit air pollutant(s) into the atmosphere, without the prior consent of the SPCB;
- SPCBs to make inquiries in respect of grant of consent in prescribed manner;
- SPCBs to grant consent within four months after the date of the receipt of an application complete in all respects;
- Industry to comply with the conditions stipulated in the consent;
- Restriction on emission of air pollutants in excess of the standards prescribed by SPCBs;
- SPCBs right to make an application to the court for restraining an industrial plant, located in an air pollution control area, likely to emit air pollutants in excess of the prescribed standards;
- Industry to furnish information to the SPCBs and other agency(ies) in case of emission of air pollutant(s) in excess of prescribed standards, having occurred or likely to occur, resulting in air pollution, due to an accident or an unforeseen act or event;
- PCBs rights include:
    - To enter and inspect any industrial plant, records, registers, or documents at all reasonable times;
    - To obtain any information related with the implementation of the provisions of the Act ;and
    - To take samples of air and emissions for analysis in the prescribed manner.
- Industry to appeal to the Appellate Authority in case of grievances against the order made by SPCBs under the Act, within a specified time and in the prescribed manner;
- SPCBs power to issue directions for:
    - The closure, prohibition or regulation of any industry, operation or process or;

- The stoppage or regulation of supply of electricity ,water or any other service to an industry in a prescribed manner;

- Industry to comply with the directions of the SPCB
  - Bar of jurisdiction to Civil Court in respect of any matter within the purview of the Appellate Authority constituted under the Act and no grant of injunction in respect of any action taken or proposed in pursuance of the Act;
  - Bar on filling of any suit or legal proceedings against the Government or Board officials for action taken in good faith in pursuance of the Act; and
  - SPCBs to maintain consent-register-containing particulars of consent issued and to provide access to industry at all reasonable hours.

The Water (Prevention and Control of Pollution), Act, 1974 including Rules, 1975 (as amended up to 1988)

This Act provides for the prevention and control of water pollution and maintaining or restoring good water quality for any establishment. The Act assigns functions and powers to the CPCB and SPCBs for prevention and control of water pollution and all related matters. Subject to the provisions of the Act, the functions and powers of CPCB as well as the SPCBs have been delineated individually and with respect to each other. The salient provisions applicable to industrial establishments are as follows:

- SPCB has the right
  - To obtain any information regarding the construction, installation or operation of an establishment or treatment and disposal system;
  - To make samples of trade effluent for the purpose of analysis in the prescribed manner;
  - To enter and inspect any establishment, record, register, document or any other material object and
- To prohibit use of stream or sewer or land for disposal of polluting matter, not in accordance with the standards laid down by the SPCB
- Restriction on establishment and the operation of an industry, process or any treatment and disposal system without prior consent of the SPCB
- SPCBs right to refuse or withdraw consent, for discharge of effluents
- Industry to comply with the conditions stipulated in the consents
- SPCBs grant consent within four months after the date of receipt of the application complete in all respects
- Establishments to appeal to the Appellate Authority, in case of grievances against the order passed by the SPCB regarding grant, refusal or withdrawal of the consent within the specified time in the prescribed manner.
- Establishments to furnish information to the SPCB and other specified agency (ies) in case of discharge of poisonous, noxious or polluting matter into a stream, sewer or land, occurred or likely to occur resulting in pollution due to an accident of any other unforeseen event.
- SPCBs right to issue orders restraining or prohibiting an establishment from discharging any poisonous, noxious or polluting matter; in case of emergencies, warranting immediate action.
- SPCBs power to make an application to the Court for restraining apprehended pollution of water due to likely disposal of polluting matter in a stream or on land.

- Bar of jurisdiction to Civil Court in respect of any matter under purview of the Appellate Authority constituted under the Act and no grant of injunction in respect of any action taken or proposed in pursuance of the Act.
- Bar on filing of any suit or legal proceedings against the Government or Board officials, for action taken in good faith in pursuance of the Act.
- SPCBs to make inquiries, in the prescribed manner, for grant of consent for discharge of effluents
- SPCBs have power to issue directions for
  - the closure prohibition or regulation of any establishment, operation or process or;
  - the stoppage or regulation of supply of electricity, water or any other service to an establishment in the prescribed manner.
- Industry to comply with the directions of the SPCB within the specified time
- SPCBs to maintain a consent register containing particulars of the consent issued and to provide access to industry at all reasonable hours.

The Water (Prevention and Control of Pollution), Cess Act, 1977 including Rules 1978 and 1991

This Act provides for levy and collection of Cess on water consumed by persons carrying on certain industries and by the local authorities with a view to augment the resources of CPCB and SPCBs for the prevention and control of water pollution, constituted under the Water Act, 1974. It also covers specifications on affixing of meters, furnishing of returns, assessment of Cess, interest payable for delay in payment of Cess and penalties for non-payment of Cess within the specified time. The salient provisions of the Act are as follows:

- Only specified industry sectors to pay Cess on the quantity of water consumed for specific purposes at prescribed rates
- Any specified industry liable to pay water cess;
  - To affix meters of prescribed standards and at prescribed places by SPCBs for measurement of quantity of water consumed;
  - To furnish water Cess returns in the prescribed from at prescribed intervals;
  - To pay interest for delay in payments of Cess, not made within the specified time, as mentioned in the assessment order of the SPCB;and
  - To pay penalty not exceeding the amount of Cess in arrears, for non-payment of cess within the specified time as mentioned in the Assessment Order of the SPCB
- Specified industries entitled to 25% rebate in water cess, if they comply with the prescribed consent provisions and consume a quantity of water, which is not in excess of the prescribed quantity;
- SPCBs right to make inquires for assessing water cess payable by any specified industry;
- SPCBs right to recover any amount due under the Act as arrears of land revenue from industry;
- SPCBs right of entry and inspection in pursuance of the provisions of the Act including testing of the correctness of the meters affixed;

- Industry to appeal to Appellate authority in case of any grievance against the Water Cess Assessment, within the specified time, in the prescribed manner.

The Hazardous Wastes (Management and Handling) Rules, 1989 and amendment Rules, 2000

The Act requires industries to identify their wastes for applicability under the hazardous wastes amendment rules 2000 and manage them as per the prescribed guidelines. The assessment criteria under the amended rules are based on process and concentration. The specific provisions of the Rules are as follows:

- Occupier's responsibility to ensure proper handling and disposal of hazardous wastes either by themselves, or through the operator of hazardous waste management facility;
- Restriction on handling or hazardous wastes without prior authorisation from the SPCB;
- SPCB has the power to suspend or cancel an authorisation for handling hazardous wastes, after providing an opportunity to show cause and recording the reasons thereof;
- SPCB has the powers to refuse grant of authorisation after providing reasonable opportunity of hearing to the occupier;
- Packaging, labelling and transportation of hazardous wastes to be done in the specified manner;
- State Government to identify sites for disposal of hazardous wastes within the states, and publish inventory containing relevant information;
- Occupier generating hazardous wastes, or the operator handling the facility, to maintain records of such operations in the prescribed manner;
- Occupier generating hazardous wastes, or the operator handling the facility, to submit annual returns in the prescribed forms;
- Occupier or the operator handling facilities to report to the SPCB in the prescribed forms, in case of accident occurred at the hazardous waste handling site or during transportation;
- Specified procedures to be followed for import of hazardous wastes to be used for processing or reuse as raw materials;
- Any person importing hazardous waste to maintain records of the imports in the prescribed form for inspection purposes by regulatory agencies; and
- An occupier's right to appeal to the Appellate Authority in the prescribed manner in case of grievance(s) against any order of suspension, cancellation or refusal of authorisation by SPCB.

The Environmental Audit Notification of 1992

The MoEF through its notification No G.S.R. 329(E) dated March 13, 1992, incorporated Rule 11 on submission of Environmental Audit report by every industry as an amendment to the Environmental (Protection) Rules, 1986. This notification applies to every person carrying on an industry, operation or process requiring consent to operate under the Water Act, Air Act, or both or authorization under the Hazardous Wastes (Management and Handling Rules), 1989, issued under the Environment (Protection) Act, 1986. The word *audit*

report was later substituted by the word *Statement*. The Environment Statement is required to be submitted in a prescribed format (FORM V) by 30th September every year for the relevant financial year ending 31st March. The industries are required to furnish information about their activities, raw materials consumption, products, air and wastewater management, water consumption, solid and hazardous waste management, etc in the Environmental Statement.

The Public Liability Insurance Act, 1991

The Public Liability Insurance Act, (PLI), 1991, imposes on the industry owner the liability to provide immediate relief in respect of death or injury to any person or damage to any property resulting from an accident while handling any of the notified hazardous chemicals. This relief has to be provided on "no fault" basis. Owner handling hazardous chemicals has to take an insurance policy of an amount equal to its "paid up capital" or upto Rs 500 millions, which ever is less. The policy has to be renewed every year. New undertakings have to take this policy before the commencement of the activity. The owner also has to pay an amount equal to its annual premium to the Central Government's Environment Relief Fund (ERF). The payment under the Act is only for the immediate relief; owners shall have to provide the final compensation, if any, arising out of the legal proceedings.

2.4 APPLICABLE ENVIRONMENTAL STANDARDS

The MoEF has the overall responsibility to set policy and standards for the protection of environment along with Central Pollution Control Board (CPCB). This includes air, noise, water, and hazardous waste standards. The relevant standards, which are of significance to the mining industry, are as follows:

2.4.1 Emissions Standards

The emissions standards for pollutants like Particulate matter, sulphur dioxide, carbon monoxide and oxides of nitrogen are given by CPCB in its document *Standards For Liquid Effluents, Gaseous Emissions, Automobile Exhaust, Noise And Ambient Air Quality – Pollution Control Law Series: PCL/4/1995-96, June 1997.*

Particulate Matter

There are no specific standards for particulate matter emission from mining industry, therefore, the emission of pollutants will be governed by General Standards for Discharge of Environmental Pollutants promulgated under the Environment Protection Rules (1993), which are enclosed in ***Annex A.*** As per the General Emission Standards, the standard for particulate matter emission concentration should not exceed 150 mg / Nm^3.

Sulphur Dioxide (SO_2)

There is no specific standard for sulphur dioxide emission from mining industry, however, its emissions are governed by stack height criteria for SO_2 emission *i.e.* H $= 14\ Q^{0.3}$ where H is stack height in meters and Q is SO_2 emissions in kg per hour.

Carbon Monoxide (CO)

No specific standard for CO emission from foundries is available. However, in such case General Emission Standards are applicable. As per the General Emission Standards, the CO emission should be limited to 1% (v / v basis).

Oxides of Nitrogen (NO_x)

No specific standard for NO_x emission is available. The NO_x emission standards also do not figure in the General Standards for Discharge of Industrial Emissions, except for in case of Power Plants.

2.4.2 Ambient Air Quality Standards

The standards for National Ambient Air Quality (NAAQ) has been prescribed by CPCB vide Gazette Notification dated 11th April 1994. The prescribed Indian standards are given below in ***Table 2.2***.

Table 2.2: National Ambient Air Quality Standards

Pollutant	***Time Weighted Average***	***Concentration in Ambient Air (mg/m³)***		
		Industrial Area	***Residential, Rural & Other Areas***	***Sensitive Areas***
Sulphur Dioxide (SO_2) (µg / m³)	Annual Average*	80	60	15
	24 Hours**	120	80	30
Oxides of Nitrogen (NOx) (µg / m³)	Annual Average*	80	60	15
	24 Hours**	120	80	30
Suspended Particulate (SPM) (µg / m³)	Annual Average*	360	140	70
	24 Hours**	500	200	100
Respirable Particulate Matter (Size less than 10 microns)	Annual Average*	120	60	50
	24 Hours**	150	100	75
Lead (Pb) (µg / m³)	Annual Average*	1.0	0.75	0.50
	24 Hours**	1.5	1.0	0.75
Carbon monoxide (CO) (µg / m³)	8 Hours	5000	2000	1000
	1 Hour**	10000	4000	2000

NOTE

* Annual arithmetic mean of minimum 104 measurements in a year taken twice a week 24 hourly at uniform interval.

* 24 hourly / 8 hourly values should be met 98% of the time in a year. However 2% of the time, it may exceed but not on two consecutive days.

2.4.3 Ambient Noise Standards

Ambient standards with respect to noise have been notified by the MoEF vide gazette notification dated 26th December 1989. It is based on the A weighted equivalent noise level (L_{eq}). The standards are presented in ***Table 2.3***.

Table 2.3: Ambient Noise Standards

Area Code	Category of Area	Limits in dB(A) Leq	
		Day time*	Night Time
A	Industrial Area	75	70
B	Commercial Area	65	55
C	Residential Area	55	45
D	Silence Zone**	50	40

* Day time is from 6.00 am to 10.00 pm, Night time is 10.00 pm to 6.00 am

** Silence zone is defined as area up to 100 meters around premises of hospitals, educational institutions and courts. Use of vehicle horns, loud speakers and bursting of crackers are banned in these zones.

2.4.4 Noise Standards For Occupational Exposure

Noise standards in the work environment are specified by Occupational Safety and Health Administration (OSHA-USA) which in turn are being enforced by Government of India through model rules framed under the Factories Act. These are given in ***Table 2.4*** as follows.

Table 2.4: Standards for Occupational Noise Exposure

Total Time of Exposure per Day in Hours (Continuous or Short term Exposure)	*Sound Pressure Level in dB(A)*
8	90
6	92
4	95
3	97
2	100
3/2	102
1	105
¾	107
½	110
¼	115
Never	>115

Note:

1. *No exposure in excess of 115 dB(A) is to be permitted.*
2. *For any period of exposure falling in between any figure and the next higher or lower figure as indicated in column (1), the permissible level is to be determined by extrapolation on a proportionate scale.*

2.4.5 Wastewater Discharge Standards

The wastewater discharge from Limestone mining units is negligible. However, the discharge of wastewater from mining units will be based on General Standards for Discharge of Environmental Pollutants promulgated under the Environment Protection Rules (1993), which are enclosed in ***Annex A***.

2.5 ENVIRONMENTAL PERMITS REQUIRED FOR MINING PROJECTS

The principal Environmental Regulatory agency in India is the Ministry of Environment and Forests (MoEF), New Delhi, which accords environmental clearance.

As per the policies and legal framework, for a mining industry following set of environmental approvals are necessary:

- *Consent to Establish* by the State Pollution Control Board (SPCB);
- *Environmental Public Hearing proceedings* by the SPCB;
- *Approval of Mining Plan by the Bureau of Indian Mines;*
- *Site Clearance by the MoEF;*
- *Environmental Clearance* by the MoEF;
- *Forest Clearance by the MoEF, if project falls within forest land; and*
- *Consent to Operate* by the SPCB.

Procedure for Environmental Clearance

Per the notification dated 27 January 1994 as amended on 4th May, 1994 issued under EPA, 1986, an environmental clearance is required for setting up projects listed in the notification provided the investment cost is more than Rs 500 million (***Annex B***). However, mining is one of the highly polluting industries listed in the Schedule and requires clearance irrespective of the investment cost. The application for clearance has to be made in a prescribed proforma (specified in Schedule II of the amendment) and is submitted to MoEF alongwith the project report which includes an EIA & EMP. MoEF examines the environmental implications of these operating / new projects. The categories of mines which are referred to MoEF include:

- Mining projects of more than 5 hectare in area, of both public sector and private sector, financed partly or wholly by international funding agencies like World Bank, etc;and

- Mining projects of more than 5 hectare in area, of both public sector and private sector, needing forest clearance (In this case, the main objective is to assess the realistic minimum need of forest land).

For grant of Environmental Clearance from the State or Central Government, an application is to be submitted to MoEF (at the Centre) or Department of Environment (DoE, at the State level), with the following particulars:

- Filled in Application Form;
- NOC from the SPCB;

- Summary Project Report (one copy);
- EIA / EMP;
- Risk Analysis Report;
- Comprehensive Rehabilitation Plan - if more than 1,000 people are likely to be displaced, other wise only the summary plan; and
- Commitment regarding availability of water and electricity from competent State authorities.

The EIA & EMP reports should be prepared in accordance with the guidelines issued by MoEF.

MoEF has constituted EAC for mining projects which gives recommendations for the projects under its purview based on technical assessment of documents and data furnished by the project authorities, supplemented by data collected during visits to sites, if undertaken, and interaction with the affected population and environmental groups, if necessary. EAC is not a statutory body, but only a recommending authority, generally with the following terms and conditions:

- to examine the environmental aspects of Mining Projects alongwith their EMP referred to MoEF and make recommendation for their approval or rejection;
- to suggest preventive and mitigative measures and pollution control devices including choice of appropriate technology for projects recommended for approval;
- to review and analyse EMP submitted in respect of the new Mining Projects; and
- to ensure, through appropriate monitoring mechanisms, that environmental safeguards proposed / recommended are effectively implemented.

The committee is constituted of members drawn from MoEF, Indian Bureau of Mines, Institutes / organisations dealing with mines and mining environment, mines safety and mining research, as well as eminent people connected with pubic life. It is headed by a very senior and eminent mining engineer. A Senior Officer of MoEF acts as the Member Secretary. The Committee may co-opt other experts to facilitate evaluation of the proposals, if there is any specific evaluation of the proposals and also if there is any specific requirement of expertise regarding technology / methodology, etc.

The assessment is completed within a period of ninety days from the receipt of the requisite documents and data from the project authorities. Based on the recommendations of the EAC (M), environmental clearance is granted by MoEF, with or without any additional safeguards, which are spelt out in the formal letters issued to the project proponent. MoEF, upon evaluation of the data would specify an insufficiency or inadequacy to the project proponent within 30 days from the date of submission of the proposal. The project would be reviewed as and when submitted along with the requisite data. It should be noted that submission of inadequate data for the second time would mean rejection of the project summarily. MoEF may also recommend the need for a public hearing within 30 days, from the date of receipt of the proposal. However, at least one month's notice, in at least two newspapers, would be required for such a public hearing. If no comments are received from MoEF

within the specified time limit, the proposal would be deemed to have been granted an `Environmental Clearance' unconditionally. The clearance granted is valid for a period of five years for commencement of construction or operation. No construction work, preliminary or otherwise, relating to the setting up of the project is allowed to be undertaken till the environmental clearance is obtained.

Procedure for Forest Clearance

Prior approval of the Central Government is essential before a mining lease is granted in respect of any forest area. Under *the FCA, 1980*. Central Government is empowered to constitute Advisory Committee, headed by the Inspector General of Forests, MoEF, to advice government on the Forest Clearance issue. The existing provisions under FCA affecting mining operations are:

- Prior approval of the Central Government, before the grant of any mining lease;
- All proposals involving diversion / dereservation of forest land up to 20 hectares; or proposals for clearing naturally grown trees in the forest area or portion thereof; are referred by the State Government to the relevant regional office of MoEF for clearance from the environmental angle;
- All proposals involving forest land of more than 20 hectares are referred to the Advisory Committee headed by the Inspector General of Forests, MoEF;
- The Chief Conservator of Forests (CCF) of the concerned regional office can dispose of all proposals involving diversion / dereservation of forest land only up to 5 hectares, except proposals for regularisation of encroachments and mining (including renewal of mining leases);
- Forest area required for safety zone for mining operations should not be part of the forest area proposed for diversion. Such area will have to be fenced at the cost of the project authority. Further, project authority have to deposit funds with the Forest Department for the protection and regeneration of such Safety Zone Area (SZA) and also bear the cost of afforestation in the degraded forest elsewhere;
- Compensatory afforestation is one of the most important conditions stipulated by the Central Government while approving proposals for diversion / dereservation of forest land for non-forest uses. Compensatory afforestation shall be raised over degraded forest land on area equal to the forest area diverted de-reserved;
- The cost of compensatory afforestation has to be built into the project cost. The non-forest land identified for afforestation should be:
  - in compact patches and not too much scattered, preferably be
  - adjacent to a forest area and be near as possible to the locality were diversion is allowed;
  - it has to be physically seen by the Divisional Forest Officer (DFO); and
  - certified to be suitable for afforestation.

There are specific guidelines for project proponents where diversion of forest land for mining activities is proposed. These include the following:

- Utmost care should be taken to avoid forest land or keep the forest land requirement to the minimum. The mine plan / project layout should make

maximum utilisation of the non-forest area, for locating different project units.

- Diversion of forest land for purposes of ancillary mining works like office building, workshop, magazines, residential colonies etc are not considered.

- Justification for location of project in the forest land and justification for the same being the minimal area required for purpose including the alternatives examined and rejected, should be furnished to the Divisional Forest Officer for approval.

- The proposed forest area should not be a habitat of any endangered species of flora or fauna; or a corridor to the migratory routes of wild animals; and its loss should not impair important hydrological system / catchment area.

- The distance of mining area from the perennial water courses, National and State Highways, National Parks and Sanctuaries should be away as far as possible. Major mining operations are not permitted within one km of National and State Highways.

The Central Government after considering the advice of the committee may grant approval to the proposals with or without conditions or reject the same.

Consents to Establish

The provision of *`Consent to Establish'* under the Water and Air Acts have been made obligatory after amendments to the Acts made in 1988 and 1987 respectively. Earlier, SPCBs were issuing separate NOCs for siting an industry and for adequacy and appropriateness of pollution control equipment and related measures. This requirement has now been replaced by the *`Consent to Establish'*. However, some SPCBs have not yet notified the amended rules. In such cases, the proponent is still required to obtain a NOC from the SPCB and not the *`Consent to Establish'*. For obtaining a NOC, an application is to be submitted to the SPCB with the following details:

- Application mentioning the purpose of NOC;
- EIA proforma specified by the SPCB, in quadruplicate; and
- Feasibility report.

Consent to establish for discharge of effluents under the Water Act, 1974

All industrial units (operation, process or any treatment and disposal system) which are likely to discharge sewage or trade effluents into a stream, sewer or on land, are required to obtain `Consent to Establish for Discharge of Effluents' under the Water Act, 1974 (amended in 1988). For obtaining this consent, an application is to be submitted to the concerned SPCB in the prescribed form alongwith the prescribed application fee.

Consent to establish for emission under the Air Act, 1981

All industrial units (operation or process) located in an Air Pollution Control Area (APCA) declared so by the concerned SPCB, and likely to emit air

pollutants in the atmosphere, are required to obtain `Consent to Establish for Emissions' under the Air Act, 1981 (amended in 1987). For obtaining this consent, an application is to be submitted to the concerned SPCB, in the prescribed form and along with the prescribed application fee.

After obtaining the `Consent to Establish' and `Environmental Clearance', the project proponents can begin work related to the setting up of the project. After this, a half yearly compliance report is to be submitted indicating effective implementation of the recommendations and connotations, subject to which the `Environmental Clearance' has been granted by MoEF.

Environmental Public Hearing (Public Consultation)

The public participation in the EIA process has become mandatory as per latest notification SO 318 (E) dated 10 April, 1997. As per the notification, the environmental public hearing process shall precede the grant of Consent to Establish. On receipt of application of Environmental Public Hearing and Consent to Establish, the SPCB constitutes Public Hearing Panel comprising of members representing:

- State Pollution Control Board
- State government department dealing with the subject
- District Collector or his nominee
- State government department dealing with the Environmental matters
- members (maximum) of Municipality / Panchayat
- Senior Citizens from local area.

Following panel constitution, SPCB releases Notice for the EPH in two local newspapers inviting objections from the bonafide people likely to be affected by a project covered under EIA notification.

World Bank Guidelines on Environment, Health and Safety (EHS) in Mines

The World Bank has prepared two sets of guidelines on EHS viz. General guidelines and Specific guidelines applicable to mining projects. The General guidelines are used for those new projects for which no specific guidelines are available. The details of these General and Specific guidelines on EHS for new projects along with the stipulated standards are given in *Annex A*.

The general guidelines relate to workplace air quality, workplace noise level, work in confined space, health of workers including the sanitary facilities, safety of workers, drinking water quality, training needs of the workers, monitoring of occupational health and safety standards, emission standards with respect to liquid effluent and air quality, hazardous materials and wastes including solid wastes.

The World Bank's specific guidelines for environmental management in mines requires the following:

(1) [1] World Bank Policies and Guidelines, supplemented with information from OECD sources and the proposed revisions to the World Bank Guidelines.

- *Tailings disposal*: Tailings must be disposed of in a manner that optimises protection of human safety and the environment. Riverine discharges are, however, not acceptable unless no other alternative is available.

- *Liquid effluents*: Discharge standards (for Residual Heavy Metals, Cyanide, etc.) have been prescribed for effluents from tailings impoundment, mine drainage, sedimentation basins, sewage systems, and storm water drainage.

- *Ambient air quality*: Concentration of air contaminants, in the area outside the project boundary, has been prescribed for Particulate matter, Nitrogen Oxides and Sulphur oxides.

- *Other general environmental requirements* include guidelines for erosion and sediment control plan, and mines reclamation plan. Per these guidelines, the project proponents are required to integrate appropriate soil stabilisation measures in the erosion control plan. Also, the mine plan should include reclamation of tailings deposits, any open pit areas, sedimentation basins, and abandoned mine, camp sites, etc.

- *Hazardous materials handling and storage* guidelines require all hazardous materials to be used, stored, labelled, handled and managed per the local regulations and appropriate to their hazard characteristics.

Health and Safety in Mines

These guidelines relate to sanitary facilities, ventilation systems, personal safety of workers, medical examinations, safety in machineries and equipment, employee's training on hazards, precautions and procedures for safe storage, handling and use of all potentially harmful materials.

2.6 INSTITUTIONAL FRAMEWORK

MoEF and Ministry of Mines (MM) are the nodal ministries of Government of India (GoI) responsible for bringing out the legislation to mitigate and control environmental pollution during mining operations. Central Pollution Control Board (CPCB) and State Pollution Control Boards (SPCBs) have been created for control of water and air pollution; Chief Conservator of Forest (Zonal Office of the Forest Department of Central Government) and District Forest Officer (DFO) of State Government are for forest conservation; Indian Bureau of Mines (IBM) for Mineral conservation and environment protection and approval of mining plan and State directorates of Geology and Mining for granting lease. A brief on major institutions responsible for planning, instituting, formulating, implementing, monitoring and enforcement of environmental laws and regulations is as follows:

- The **MoEF**, constituted in 1985, is the nodal agency at Central level for planning, promoting and co-ordinating environmental programmes, apart from policy formulation. A number of enforcement agencies assist MoEF in executing the assigned responsibilities. The specific functions of MoEF are as follows:

- environmental policy planning;
- ensure effective implementation of legislation;
- monitoring and control of pollution;
- environmental clearance for industrial and development projects;
- promotion of environmental education, training and awareness; and
- Forest conservation and development, and wildlife protection.

- MoEF, through its six regional offices located in the country, monitors the conditions stipulated in the letters issued by MoEF, while granting approval to various projects including mining projects.

- The **CPCB**, was established in September 1974, for the purpose of implementing provisions of the Water (Prevention and Control of Pollution) Act, 1974. The executive responsibilities for the industrial pollution prevention and control are primarily executed by the CPCB at the Central level, which is a statutory body, attached to the MoEF. The specific functions of CPCB are as follows:

  - prevent pollution of streams and wells;
  - advise the Central Government on matters concerning prevention, control and abatement of water and air pollution;
  - co-ordinate the activities of State Pollution Control Boards (SPCBs) and provide them with technical and research assistance;
  - establish and keep under review quality standards for surface and ground water and for air quality;
  - planning and execution of national programme for the prevention, control and abatement of Water and Air Acts; and
  - ensure compliance with the provision of Environmental (Protection) Act (EPA), 1986.

- The **SPCBs** (for this project, it will be the Meghalaya Pollution Control Board, MPCB, with head office in Shillong) were constituted, to implement the Water Act in respective States of the Indian Union. SPCBs were also made responsible for implementation of Air Act and to a large extent the EPA. The specific functions of MPCB are as follows:

  - plan and execute state wide programmes for prevention, control and abatement of water and air pollution;
  - advise the State Government on prevention , control and abatement of water and air pollution and siting of industries;
  - ensure compliance with the provisions of relevant environmental legislation;
  - establish and review local effluent and emission standards;
  - ensure legal action against defaulters;
  - develop cost effective methods for treatment, disposal and utilisation of effluent.

- **National Environment Appellate Authority (NEAA)** was formed in March 1997, to act as a vigilant body for dealing with the representations, complaints, and appeals made by any person / body / NGO against the

decisions of competent authorities (under the EPA), granting environmental clearance covered under the EIA notification. NEAA is also expected to avoid the delays arising out of protracted litigation involving development projects and affected people.

- MoEF has also made environmental public hearing mandatory for industrial developmental projects, (especially the new developmental projects), under the EIA notification of January 1994 (as amended); thereby making the process more transparent to the public.

2.7 C*URRENT STATUS OF THE PROJECT*

ERM understands that the LMMPL's limestone Mining Project does not fall in designated forestland therefore, forest clearance is not a part of the approval. The other approvals accorded to LMMPL include the following:

- Grant of **Mining Lease** vide letter no. MG.41/94/222 dated 29 August 2001.

- **Environment Clearance** as per MoEF's letter no. J-11015/10/2000-IA.II(M) dated 9 August 2001, subject to certain specific and general conditions.

- **Site Clearance** vide MoEF's letter no J-11016/13/98 - IA.II (M) dated 18 June 1999, subject to certain conditions.

- **No Objection Certificate** issued by Office of the Executive Committee, Khasi Hills Autonomous District Council, Shillong, Meghalaya describing the project area at Phlangkaruh, Nongtrai village, Shell confederacy stating the area does not fall within a forest land vide their letter no. DC/XIV (A) PF/301/97/6 dated 27 August 1997;

- **Consent to Establish** (for 2.0 mtpa of limestone mining capacity) issued by MPCB for vide amendment letter no. MPCB/TB-227/98-99/25 dated 14 December 1999 and earlier letter no. MPCB/TB-227/98-99/25 dated 24 July 1998.

- **Proceedings of Environmental Public Hearing** conducted on 3 June 1998 issued by Meghalaya Pollution Control Board (MPCB) on 28 July 1998;

The copies of the above are enclosed in ***Annex C***

The proposed mining lease area (hereafter referred to as site) lies between

- Latitudes : 25° 11' 25" N & 25° 12' 00"N; and
- Longitudes : 91° 37' 28" E & 91° 38' 01"E.

The details of the land contained within the lease area are given in following ***Table 3.1***and ***Figure 3.1*** shows the project site and its surroundings**.**

Table 3.1: Details of the Lease Area

District & State	*P.S./ Taluka*	*Nearest Villages and crow fly distances*	*Proposed Mine Area*	*Ownership of land within the lease area*
East Khasi Hills, Meghalaya	Shella P.S.	• *Phalangkaruh (about 1 km to the south)* • *Shella Bazaar (about 2 km to the south-east)* • *Pyrkan Village (about 1.5 km to the South-south-east)*	100 hectares	Village Durbar of Nongtrai

3.1 GEOLOGY AND LIMESTONE RESERVES

3.1.1 Regional Geology

The sedimentary rocks of the area form a part of the Cretaceous-Tertiary Sequence, which occupies the southern fringe of the Meghalaya plateau. The Limestone deposit of Nongtrai-Shella West belongs to the Shella Formation of Jaintia Group of Eocene AGE, which are considered equivalents of Sylhet Limestone Formation of the Bengal-basin. The Jaintia Group is prominent with its three calcareous members – Lakadong limestone, Umlatdoh limestone and Prang limestone. The Nongtrai-Shella (west) limestone is essentially a part of Prang limestone. The Prang limestone belt occupies a large tract mainly at the southern foothill of Meghalaya over a distance of several kilometres. The width of the belt averages about 1 km. The Jaintia Group has been divided into three formations, *viz.*:

- the Langper formation;
- the Shella formation; and
- the Kopili formation.

The Langper formation is a basal formation consisting of impure limestone, calcareous sandstones and calcareous shale. The total thickness is about 120 m. The Langper Formation lies above a thick Khasi Group of conglomerate beds, which overlie non-conformably on the Sylhet traps at the edge of the plateau.

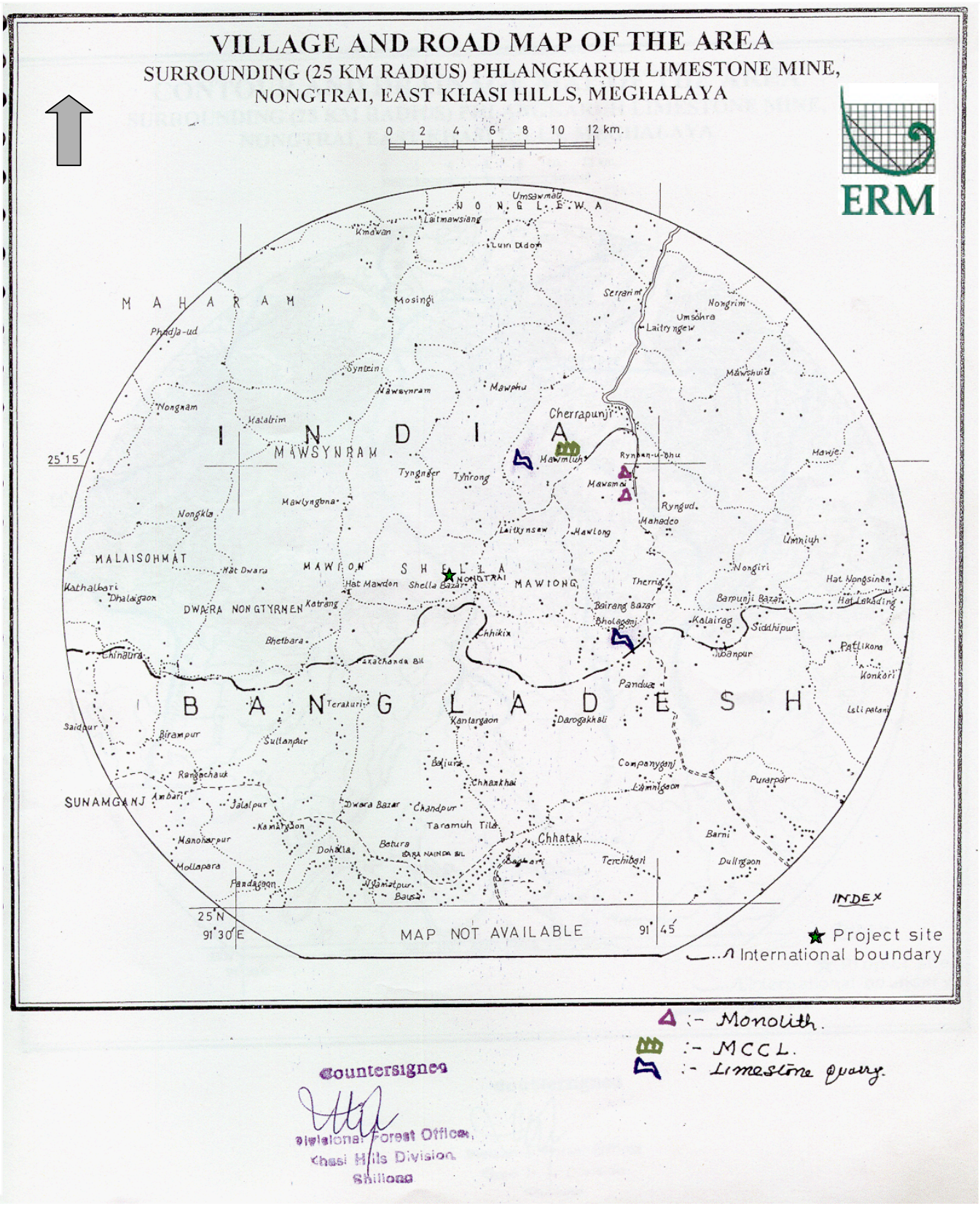


Figure 3.1: Map showing Project Site and surroundings

The Shella Formation, with a total thickness of about 540-m, consists of six lithological units designated as -

- Therria Sandstone;
- Lakadong Limestone;
- Lakadong Sandstone;
- Umlatdoh Limestone;
- Narpuh Sandstone; and
- Prang Limestone.

The stratigraphic and lithological succession of the formations and belts in the region is shown in ***Table 3.2*** below:

Table 3.2 Statigraphic Sequence at Shella Block

Age	Group	Formation	Rock Types	Thickness
Pleistocene to Recent	Older and Newer Alluvium	Unclassified	Sand, Gravel, Silt and Clays	Not known
---------- Non -conformity ----------				
Oligocene to Upper Eocene	Garo Group	Kopili formation	Shale, Sandstone, Marl	450 m
Upper Eocene to Middle Palaeocene	Jainita Group	Shella For-Mation -Prang Limestone	Nummulitic Limestone,	± 200 m
		-Narpuh Sandstone	Calcareous Sandstone,	20 – 25 m
		-Umlatdoh Limestone	Foraminiferal Limestone,	122 m
		-Lakadong Sandstone	Sandstone with lenses and Seams of coal	
		-Lakadong Limestone	Fossiliferous Limestone Greyish-white And brown Sand stones	192 m
		-Therria Sandstone		
Lower Palaeocene	Jaintia Group	Langper Formation	Calcareous shale, Sandstone and Limestone	120 m
Upper Cretaceous	Khasi Group	Mahadeo or Sohbar Formation	Glauconitic Sandstone and Conglomerates	350 m
---------- Non-conformity ----------				
Flood Basalt and Metamorphic				

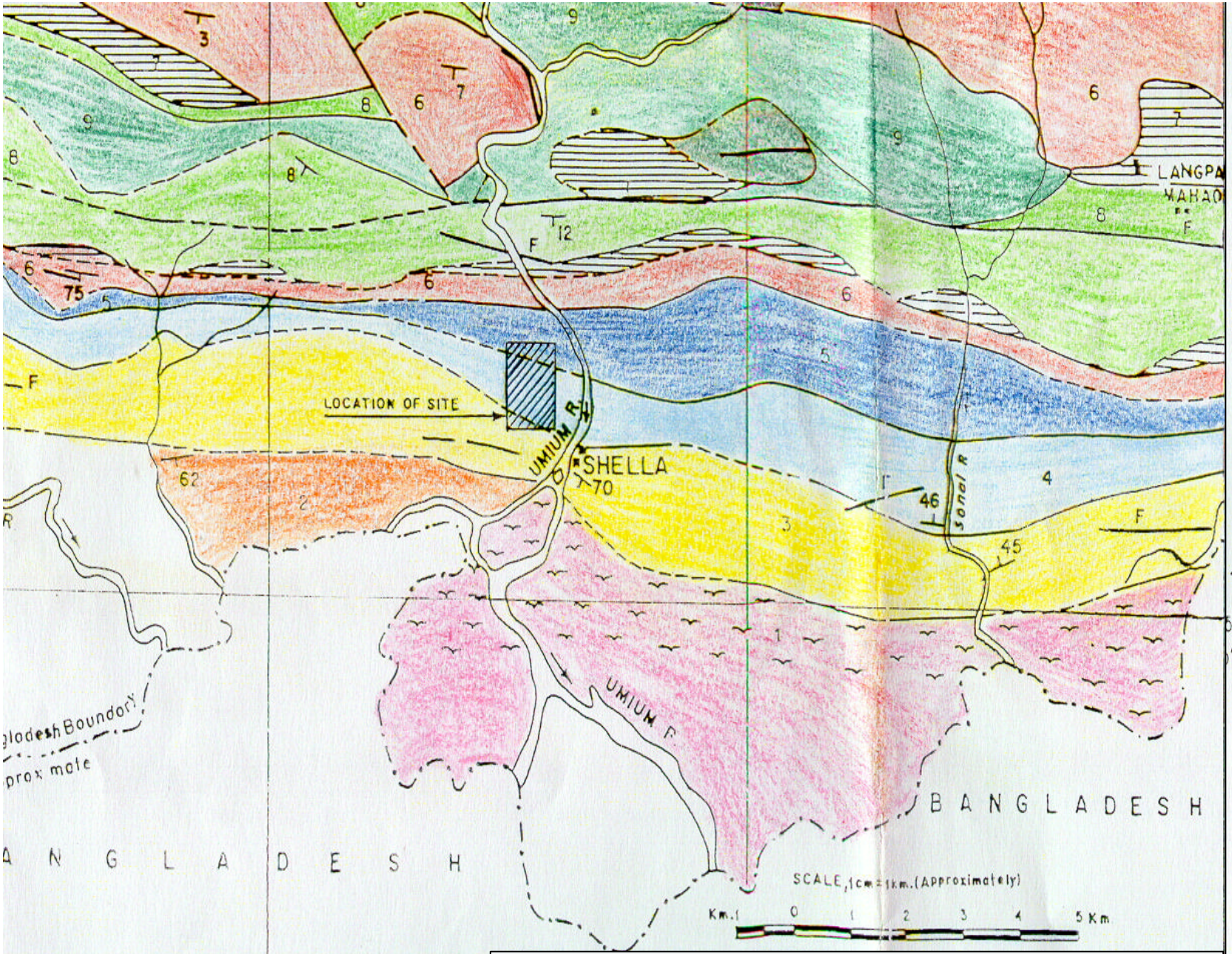
The southern fringe of the Meghalaya plateau experienced eruption of basalt plateau along E-W fissures. The southern block subsided whilst the northern block underwent an up-throw. Subsequently, marine invasion from the south caused deposition of cretaceous sediments. Subsidence of the southern block gradually reduced and the block became stable towards Palaeocene-Eocene times. The region which became like a continental shelf on a smaller scale, turned into a region on which calcareous matter is deposited which latter became calcareous formations of the Jaintia Group. The calcareous members of the group are characterised by high grade limestone with fossils like foraminifer and algae. The sedimentary beds of the group shaped into a monocline generally dipping into the plains of Bangladesh. In the extreme south of Khasi Hills the monocline of tertiary formation splits along E-W fault system. The southern side being the downthrown side dips steeply into the plains of Bangladesh.

Regional geology is shown in the ***Figure 3.2***

3.1.2 Local Geology

The Nongtrai-Shella west i.e. proposed lease area, contains the Prang limestone, the topmost layer of the Shella Formation. The Prang limestone is exposed over a wide area and at certain points the exposed thickness is 100-175 m depending on the slope of the ground. At the northern end of the proposed lease area, the base of the limestone appears to rest on the narrow calcareous sandstone layer of about 20-25 m thick which is known as Narpuh sandstone. The Narpuh sandstone rests conformably on the lower limestone layer known as Umlatdoh limestone which is exposed over the southern slopes of Nongtrai hill which is located to the north of the proposed lease area. At the southern end of the area, the Prang limestone bed is overlaid by shale bed of the Kopili Formation. The boundary between Prang limestone and Kopili shale here is marked by an E-W trending fault.

Taking into account the outcrops of different beds and the data from the boreholes, the litho-stratigraphic sequence of the area is shown in ***Table 3.3*** in the order of their super-imposition:



1 Alluvium

2 Post - Kopili Sediments

3 Kopili Formotion (Shales, Sandstone with oligocene Limestone)

4 Prang Limestone Formation

5 Umium Formation (Narpuh Sandstone and Umlatodoh Limestone)

6 Lama Formation (Lakadong Sandstone, Lakandong Limestone, Therria Sandstone and Therria Limestone)

7 Langpar Formation (Calcareous---------- Shales, Sandstone and Limestone)

8 Sohbar Formation (Glauconitic ---------- Sandstones and Conglomerates)

9 Sylhet trap Formation ----------

10 Crystalline Gneissic Complex ---

Dip and Strike

F ----------Fault Zone (Observed / Postulated

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A.K. Roy Chowdhuri, 1983)

Table 3.3 Local Stratigraphy of Rocks

Age	Formation	Rock Types	Thickness
Oligocene to Upper Eocene	Kopili Formation	Light grey to yellowish brown calcareous shale and silt-stone	-
Upper to Middle Eocene	Prang Limestone	Hard, massive, fossiliferous grey limestone	100 – 175 m
Lowe Eocene	Narpuh Sandstone	Pinkish and brownish white, friable, medium to coarse sandstone	20 – 22 m
Lower Eocene	Umlatdoh Limestone	Pinkish-white to grey, hard forminiferal limestone associated with subordinate calcareous sandstone	-

Lithological units

Umlatdoh Limestone

It is a limestone unit, which occurs at the bottom of the sequence and is exposed on the north alongwith steep hill slopes forming cliffs. Umlatdoh limestone is light pink to pinkish grey in colour; hard, densely consolidated and fossiliferous with larger foraminifer. The limestone is interbedded with thin bands of soft, fine grained calcareous sandstone and is light grey to greyish white in colour. Ferruginous and calcareous siltstones and mudstones occur as thin intercalation.

Narpuh sandstone

It lies above Umlatdoh limestone and has a thickness of 18-22 m . It is found to be exposed over a depression along a nalaha about 150-200 m from the northern boundary of the area. The bed dips gently towards south at 10° - 15° and serves as a distinct marker for the important Prang limestone overlying it.

Prang limestone

The Prang limestone occupies practically the entire area of the proposed lease area and is exposed everywhere. The area is practically devoid of any overburden. However interstitial clay and soil occur in cavities, sinkholes and fissures. The area presents a typical Karst topography and is marked by the presence of caverns in pockets over a thickness of 10-45 m from the surface. The ground feature presents sharp edged limestone outcrops intersected by fissures, solution cavities and a large sink hole near the south-western corner of the proposed lease area with a dimension of about 200 m X 50 m X 30 m. Wide channels are also found along fractures, vertical joints and bedding joints. The surface is also strewn with boulder like large blocks of limestone formed by partial collapse and fall of limestone blocks over the cavernous part of the site. The whole deposit is essentially limestone with thin bands of argillaceous limestone towards the upper stratigraphic contact. The rock is medium to coarse-grained, light grey to dark grey. It is well bedded, hard and consolidated

with specific gravity of 2.5 to 2.8. The limestone is highly fossiliferous of foraminifer as seen in coarse-grained calcitic rock mass. The limestone is generally uniform in character except at the upper layers close to the Kopili shale contact where the rock tends to change to darker colour and earthy appearance with argillaceous interlayer.

Kopili shale

At the southern end of the area and to the south of the border road running East-West, weathered outcrops of dark grey and brown shale and calcareous siltstone are found exposed. They represent the Kopili Formation. However, the junction between the Prang limestone and the Kopili Formation outcrops is not concordant because of the major fault in the vicinity. Here the shale beds show a dip of 50° to 55° due south.

3.1.3 Structure

The limestone beds are exposed along an E-W monocline, plunging south and terminate against a fault running E-W along the southern margin of the proposed mining lease area. The limestone bed is characterised by bedding planes. Within the area the limestone bed shows a general dip towards Southwest, the strike being regularly NW-SE. The dip of the bed in the northern part of the area is about 8° - 15°. The Shale beds in the south, on the down-thrown side of the fault show an E-W strike with dips ranging 50° - 55° towards south. Three sets of joints are present - one set is parallel to the bedding and the other two are sleepy inclined or sub-vertical along NW-SE and E-W directions. The joints serve as channels for flow of rainwater and resulting solution weathering with formation of caverns in the area.

3.1.4 Limestone Occurrence & Reserves

The surface outcrops of Prang limestone in the proposed mining block and the core logs from the borehole show that liemstone bed is uniformly persistent both in quantity and quality. Considering the monoclinic nature of the deposit, the borehole pattern and the lithological sequence, the cross – sectional method has been adopted for estimation of reserves.A total of five geological cross – sections along N-S and E-W have been prepared at 100 m intervals on the basis of surface geological map and borehole logs to calculate the total reserves**.** The reserves estimated for the lease area are given in ***Table 3.4.***

Table 3.4: Geological Reserves & Anticipated Life

Particulars /Reserve Type	***Proved* (P1)**	***Probable* (P2)**	***Possible* (P3)**	***Total* (P1+P2+P3)**
Level (meters (RL)	>90	>90	>90	>90
Command area (hectare)	26.0	19.00	45.40	90.40
Geological reserves (million tonne)	35.70	35.84	136.12	207.66
Mineable Reserves (million tonnes)	32.01	23.68	49.83	105.52
Approximate life of the mine (years)	16.0	12.0	25.0	53.0

As per the mining plan the anticipated mine life based on proved, probable and possible reserves are 16, 12 and 25 years respectively. However, detailed

investigation will be carried out to prove the reserves, which are defined as probable and possible reserves. The salient features of the proposed mining in Nongtrai Limestone Block are as given in the following ***Table 3.5***:

Table 3.5: Salient features of the Proposed Limestone Quarry

Method of mining	Fully Mechanised Opencast mining (Drilling 115 mm dia), Shovel (4.5 m^3), Dumper (18 t) combination.
Mining leased area	100 hectares (excluding the residential complex)
On site and offsite infrastructure facilities	Mine Office Complex, Explosive magazine Crushing plant and Loading unit Sub-station for Electricity supply Residential complex for employees Conveyor belt
Geological reserves	
• Proved reserves	35.7 million tonnes
• Probable Reserves	35.84 million tonnes
• Possible Reserves	136.12 million tonnes
Mineable reserves (based on proved reserves only)	32.01 million tonnes
Command area (P1+P2+P3)	90.4 hectares
Ultimate pit depth	Up to 90 m RL
Pit Slope angle	Maximum 45º
Bench height	10 m
Statutory barrier width from the lease boundary	7.5 m
Life of the Mine	• Proved Mineable reserves - 16 years • Probable reserves - 12 years • Possible reserves - 25 years
ROM Limestone	800 tph
Method of cuts	Bench cut up to 10 m
Average Quality of Limestone Limestone	CaO 51.90% MgO 1.08% SiO_2 1.96% Al_2O_3 1.05% Fe_2O_3 0.60%
Annual limestone production	2.0 mpta of crushed limestone (-80 mm) ie 7,000 tonnes per day
Targeted commencement date of production	Middle of 2003 AD
Present owner of the land	Nongtrai village Durbar
Land Lease Period (applied)	35 years
Working hours	Two shifts 8 hour basis
No of employees	57

3.2 *CONCEPTUAL PLAN MINE DEVELOPMENT*

A tentative ultimate pit has been conceptualised based on the geological investigation done so far within the lease area. Once detailed investigations in the probable and possible reserves areas are completed, the ultimate pit limit within the lease area will need to be modified. Based on the above, development of mine for the first five years is as given below and is also summarised in ***Table 3.6.***

First year

It is proposed to open an access road from the 39th km-stone on the road south of the lease area, to the crushing plant site. Subsequently, a 20 m wide haul road is planned to be laid from the crusher plant and workshop sites to the top of the mine, with a gradient not exceeding 1:16 (6.25%), for access to the mining block. Developmental excavation for opening of benches and temporary stockpile near the crusher are also proposed to be taken up during this year. Other infrastructural activities such as site development, construction and erection of crushing plant, explosive magazine, etc. are also planned during this year. It is also anticipated to commence the construction of belt conveyor for transportation of crushed limestone to Bangladesh.

Second year

During first six months, it is proposed to develop the topmost bench with a floor of RL of 180 m. After sufficiently advancing the 180 m RL bench, a 50 m wide gullet of 250 m long is proposed to be developed with the floor RL of 170 m in non-cavernous zone bordering the northern limit of the cavernous zone. The bench in non-cavernous zone will be able to sustain the production requirement in case of slow advancement in the cavernous zone. By end of six months period, mine shall be geared up to produce at the full rate of production of 2.0 million tons per year. During later half of the year the 170m RL bench, besides being advanced into the cavernous zone is also proposed to be developed westwards up to 170 m contour. This will facilitate another access to the benches on the western side and reduce the total distance to the crusher. Total estimated excavation of limestone during the second year is 1.527 million tonnes.

Third Year

During the third year, it is proposed to push the second bench (170 m RL floor level) northwards and also day lighting the bench towards south. Third bench (160m RL floor level) too will be opened in the same manner as the 170 m RL bench and developing north and south. Limestone excavated during third year is estimated to be 1.95 million tonnes.

Fourth year

During the fourth year, the second and third benches (170 m RL & 160 m RL floors) floors will be pushed northwards and advanced up to lease boundary (leaving the statutory barrier of 7.5 m) on the east. The production envisaged during the year is estimated to be 2.05 million tonnes.

Fifth Year

It is proposed to advance second Bench (170m RL) bench westwards. The third bench (160 m RL) too is proposed to advance westwards only up to some extent. Fourth bench (150m RL) will be developed and a ramp is proposed to be developed from near the access of third bench (160m RL) to reach the fourth bench. The quantity expected during the fifth year is estimated to be 2.035 million tonnes.

Table 3.6 : Excavation Programme for first five years

Year of operation	Nature of operation	Limestone excavated (Tonnes)
1st	Development of haul roads & site clearance	-
2nd – First half	First half-Development of 2 benches, site construction activities	497,000
2nd - Second half	Production	1,030,000
3rd	Production	1,950,000
4th	Production	2,050,000
5th	Production	2,035,000

3.2.1 Stacking of Mineral rejects and Disposal of Waste

ML area is practically devoid of any overburden. Some of the clay, which is fragmented form of shale, is found to occupy the cavities in the lease area.

3.3 BLASTING

3.3.1 Burden, Spacing, Depth and Sub Grade Drilling

The mining method chosen is conventional drilling and blasting followed by loading. Based on the nature of the limestone deposit, the blast hole parameters proposed are as follows:

- Bench height : 10 m
- Burden x spacing : 3.5 x 4.5 m
- Diameter of hole : 115 mm
- Depth of hole (10% sub-grade drilling) : 11.0 m
- Total number of holes per blast : 104

3.3.2 Explosives

The types of explosives proposed are as under:

- Nitro-glycerine based (NG) gelatinous explosives. Major usage of this class will be as boosters;
- Ammonium Nitrate fuel Oil (ANFO) mixture. ANFO will be the chief column charge during the dry season ; and
- Slurry explosives (AN based), viz., Powergel, Acquadyne, Superdyne, etc during monsoon season mainly.

Under normal conditions, ANFO will be the main column charge for reasons of economy and safety. Free flowing prilled granulated ammonium nitrate will be mixed intimately with about 6.0 to 6.3% by weight of Diesel oil. The mixture so prepared at site will then be used as explosive agent with about 20 to 30% of base charge at the bottom of the hole. Deck charging will be preferred to spread the charge uniformly over the length of the blast hole. This will also reduce the generation of oversize boulders.

Secondary Blasting

Rock breaker is proposed for secondary breaking of the limestone boulders. In case of non-availability of breaker for a long time, hand held jackhammers are proposed to be used for secondary blasting. Besides, in the initial and development stage of mining, hand held jackhammers will be desired for acess / haul road development. As far as possible this operation will be kept to a bare minimum and whenever required and it will be carried out along with the primary blasting operations.

Explosive requirement and storage

1. Average weekly requirement of explosive requirement is envisaged as 7500 kg as per given break-up:
   - High explosive - 1500 Kg
   - ANFO - 6000 Kg.
2. Blasting accessories required per blast are:(1) Detonating cord – 2160 m;(2)Electrical detonators – 4 nos.; (3)Delay detonators(ms) – 220 nos.; (3) Exploder – 2 nos.
3. Storage of high explosives - it is proposed to construct a magazine of 20 tonnes capacity. The magazine will also have a detonator storage capacity of 10,000 in nos. and 10,000 m of detonating cord / excel shock tubes.
4. Storage of ANFO – it is proposed to construct a mixing shed (7 tonnes capacity) on the northern side of the lease boundary. A separate ammonium nitrate shed is proposed within the mine complex to store about 60 tonnes. Diesel oil will be drawn from the proposed HSD pump in the mine complex.

3.3.3 Equipment Details

It is proposed to deploy various mobile equipment at Nongtrai limestone mine, the details of which and the number of such equipment in the fleet are given in ***Table 3.7***

Table 3.7: List of Equipment

Equipment	Capacity	Number
Hydraulic Drills with compressor	115 mm dia., 405 HP,400 cfm compressor	1
Hydraulic Excavators	4.5 cum bucket,428 HP	2
Dump Trucks	31.75 tons (payload), 355HP	7
Bulldozer	405 HP	1
Rock Breaker	145 HP	1
Wheel loader	5 -6 m^3 bucket,430 HP	1
Grader	280 HP	1
Jack Hammers	-	2
Compressor for Jack Hammers	350 cfm	1
Water tanker	28 kl,355 HP	1
Explosives Van	-	1
Diesel Tanker	-	1
Mobile Crane	10 tonnes capacity	1
Mobile Maintenance Van / Pick-up Jeep	-	1
		1

Equipment	Capacity	Number
Jeeps (Diesel)	-	4
Ambulance	-	1

3.3.4 Crusher Details

It is proposed to set up a crushing unit just outside the lease area on the southern side. The run-of-mine (ROM) limestone of approximately 1000mm size will be fed to a two stage roller, which will crush the limestone to -80mm. It is proposed to operate the crusher in two shifts six days a week. A schematic diagram of the tentative flow sheet is given below as ***Figure 3.3***:

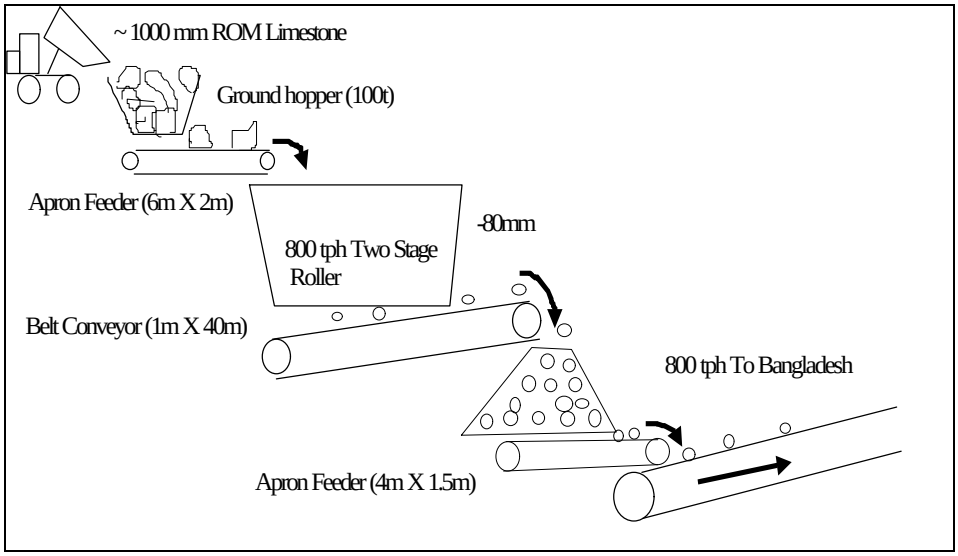


Figure 3.3 Schematic Diagram of the Tentative Flow Sheet

3.3.5 Belt Conveyor

It is proposed to install a main overland belt conveyor as shown in ***Figure 3.4*** from the crusher to Chhatak in Bangladesh where the cement plant is proposed to be located. The operations and maintenance of the conveying system will be looked after by the cement plant in Bangladesh. The conveyor will be installed with an overhead trolley for supervision and maintenance. Salient features of the belt conveying system are:

- Capacity: 800 tph;
- Belt speed: 3m / sec;
- Distance: 17 km approximately (7.2 km on the Indian side and 10.1 km on the Bangladesh side);
- Working hours: 2 shifts per day for 6 days a week;
- Elevation at the despatch point: 130m RL approximately; and
- Elevation at the border and beyond in Bangladesh: 15m RL.

Figure 3.4: View of proposed covered limestone Belt Conveyor

3.3.6 Power Requirement-Sources and Details

A total of about 2.2 MW of power requirement is envisaged for the crushing unit, belt conveyor drive on the Indian side, workshop & other infrastructural facilities, mine lighting, colony facilities, etc. It is proposed to source the main power from the Meghalaya State Electricity Board (MSEB). Though there is already an 11 kV rural feeder line of MSEB at village Pyrkan but MSEB sources have indicated that this line is not reliable and not capable for taking additional load. Therefore, for this purpose, a new overhead transmission line will need to be laid to transmit power (at 33 kV) from Cherrapunji feeder to the mine site. The distance will be approximately 38.5 km. A standby HSD based emergency DG set of 2.5 MW is also proposed.

3.3.7 Air Compressor-Pneumatic Equipment Details

List of pneumatic equipment to be used is presented below in ***Table 3.8.***

Table 3.8: List of Proposed Pneumatic Equipment

Equipment	*Capacity*	*Number*
Compressor for Jack Hammers	~ 350 cfm	1
Compressor with Hydraulic Drills	~ 303 cfm	2
Compressor for workshop	~ 125 cfm	1
Compressor for crushing plant	~ 125 cfm	1

3.3.8 Building Details

There would be buildings for utilities, storage of fuel oil, ANFO mix, explosive magazine, store room, office, workshop, first-aid ambulance room, employees facilities, canteen, rest room etc. Some of them are described as under:

Mine Office Complex

It is proposed to locate the mine office complex on the southwest corner and just outside the proposed mining lease area. General management activities will be performed from this office. All the areas such as offices, workshop, crushing plant, etc. will be installed with the latest computers networked with each other for information sharing, mine planning, equipment maintenance management, crushing plant performance, resource sharing, etc. The following facilities are proposed to be provided in the mine office complex.

- *Mine Office:* This will serve as the administrative office for the mine and supervision of the mining operations. The facilities will include time office, vocational training centre, mine planning & quality control cell, central stores, core library, etc.
- *HSD Storage:* Diesel storage and dispensing facilities will be provided within the mine office complex for vehicles and other machinery.
- *Maintenance Facilities:* Facilities will be provided to take care of the preventive and breakdown maintenance of all heavy earth moving

equipment. For maintenance work at the site itself, a well -equipped mobile maintenance van is proposed to be provided with facilities such as pneumatic air compressor, working table, washing pump and grease pump, oil pump for greasing and oil filling facilities. The maintenance shed is proposed to be equipped with overhead crane, welding machines and facilities for washing. The shed will also be designed with a compressor room, lube-oil room, battery charging room, etc.

Statutory Facilities

- *First Aid Station*: A first aid station will be provided with all necessary medical kit. All engineers and supervisors will be trained in first-aid treatment to take care of any emergency. An Ambulance is also proposed for this purpose.
- *Blasting Shelter*: Two portable blasting shelters will be provided in the mining area.
- *Canteen/Rest Shelter*: A good canteen-cum-rest shelter will be provided in the mine complex.
- *Ablution Block*: Appropriate number of Urinals & lavatories will be provided at the mine office, rest shelter and the workshop.
- *Vocational Training*: The vocational training centre will be well equipped with computer-based learning & simulation facilities for mine operations and maintenance. The engineers will be trained to impart training to other employees. All steps like conducting workshops, lectures, etc. will be planned to continuously update the skills of the employees.

Welfare Amenities

- *Residential Facilities*: The employees not belonging to the nearby areas will be provided with well-designed houses, having electricity and water connections. The residential complex will be well laid out with plantation and parks.
- *Medical and First Aid*: A well-equipped dispensary will be provided in the residential complex with full-time medical officer for the employees.
- *Recreational Facilities*: The employees and their family members will be provided with good recreational facilities in a guest house-cum-club proposed to be constructed within the residential complex. The club will be provided with indoor and outdoor games facilities, library, television, etc.

Other Facilities

The other facilities will include access to banking, co-operative society, etc.

3.3.9 Other infrastructure

Water Facilities

It is proposed to install a 37 kW pump, 100 m head & discharge rate of 20 litres / sec for meeting the water requirement, both for industrial and domestic usage. The water will be sourced from Phalangkaruh spring. Overhead water storage tank with adequate capacity will be provided both at the mine site as well as in the township area. Outlet points for water in the proposed mining

lease area will be provided at various places inside the mine office complex. One water sprinkler is also proposed for dust suppression as well as supply of water for any off-site work.

Lighting Arrangements

Adequate potable lighting arrangements will be made at the mine faces, along the crusher ramps, in and around the mines complex, magazine and colony.

Communication

Telephone facilities will be provided in the offices, workshop, crushing plant, colony, etc. For this purpose, it is proposed to install an Electronic Personnel Automatic Branch Exchange (EPABX) system of 50 lines capacity, expandable to 100 lines. Besides, for effective supervision, it is proposed to provide walkie-talkies sets for mine operations.

3.4 POLLUTION CONTROL MEASURES

3.4.1 Air Emissions and Control Measures

Crusher

To prevent the dust emission emitted from the stack of crusher plant, bag filter shall be provided by which dust emission shall be within the limit of 150 mg / Nm^3 prescribed by Meghalaya Pollution Control Board. The emission from the crusher will be controlled through 30-m stack height for wider dispersion of pollutants.

Emergency Power – DG Set Operation

It is proposed to provide one emergency DG set of about 2.5 MW as standby near the crusher. In case of power disruption from the main line from MSEB, the emergency DG set will be operated for running the crushing unit, belt conveyor, lighting, water pump, etc. It is proposed to provide adequate pollution control measures in-built in the system at the time of installation to restrict both SO_2 and NO_x emissions. Adequate pollution control measures for reduction of emissions will be provided as per under:

- Use of liquid fuel, resulting in particulate matter emission well below the Indian standard of 150 mg / Nm3;
- Use of low sulphur HSD fuel oil (with maximum 1% of Sulphur content) to restrict the SO_2 emission;
- Adequate stack height as per the stack height criteria of Central Pollution Control Board (CPCB) i.e.: $H = 14 (Q)^{0.3}$ where H is stack height in meters and Q is sulphur dioxide emission in kg / hour; and
- Adequate provision of silencers / mufflers to control the noise levels.

An emergency DG set of 100 KVA is also proposed catering to the proposed township area. The emergency DG set would be operational only in case of

power failure from the grid. The DG set will be provided with adequate stack height as per the following stack height criterion of CPCB:

$H = h + 0.2 (KVA)^{0.5}$, where H is the total height of stack in metres;
Where h is the total height of the building in metres where the generator is installed; & KVA is the total generator capacity of the set in KVA

3.4.2 Wastewater Generation, Treatment and Disposal

Wastewater is likely to get generated from the following sources:

- Domestic: Township, Mine Office, etc.
- Industrial: Workshop.

Wastewater from Township

The wastewater generation is likely to be about 40 kl per day from the township of about 20 families. Wastewater from individual houses will be led to septic tanks. Four to five septic tanks' overflow will be led to a soaking pit. The waste overflow water from the soaking pits will be led by underground drainage pipes to a sewerage treatment plant (STP). The sewage water is expected to consist of suspended (floating matter) and dissolved organic matter, which is biodegradable. The proposed STP's philosophy is a bar screen to trap large floating particles, an equalisation tank to take care of the flow fluctuations followed by a Activated Sludge Process (ASP) based treatment. The ASP will comprise of:

- An Aeration Tank where wastewater will be treated with the help of bacteria provided with sustained regular dosing of nutrients in the form of DI-ammonium phosphate;
- Low HP surface aerators to maintain required oxygen content in the Aeration Tank;
- Conical Clarifier for settling of impurities of wastewater from Aeration Tank; and
- Sludge Recirculation System to maintain proper Food: Micro-organism (F: M) ratio in the Aeration Tank.

The quality of outlet of the STP is expected to contain BOD content in less than 30 mg/L and total suspended solids less than 100 mg/L and will be reused in watering the green belt.

Wastewater from the Mine Area

The wastewater generation is likely to be of the order of 50 kl per day from the workshop and domestic usage. The wastewater will be led to pass through a bar screen followed by oil trap where oil content of wastewater will be recovered. From oil trap wastewater will pass through sedimentation tank followed by Activated Sludge Process (ASP) comprising of aeration tank provided with low HP surface aerators and sludge recirculation system. In the aeration tank, wastewater will be treated with the help of bacteria provided with sustained regular dosing of nutrients in the form of DI-ammonium phosphate. The wastewater from aeration tank will pass through clarifier for settling of the

solids. and the treated water will then be reused in watering the green belt. The so treated wastewater be subjected to maximum reuse /recycling. The treated wastewater will contain BOD less than 30 mg/L and total suspended solids less than 100 mg/L and will be reused for spraying on the haul roads and development of green belt. The left over treated wastewater if any will be discharged into nearby water body.

3.4.3 Solid Waste Generation and Disposal

The mine being devoid of overburden, there will be no solid waste generation as overburden. However, the solid waste generation will include sludge (approximately 0.1 to 0.15 tpd) from Activated Sludge Process based wastewater treatment plants, which being rich in Nitrogen and Phosphorus nutrient contents will be used as manure in plantations.

3.4.4 Project Cost

The anticipated capital outlay is given in ***Table 3.9***

Table 3.9: Capital Outlay Envisaged

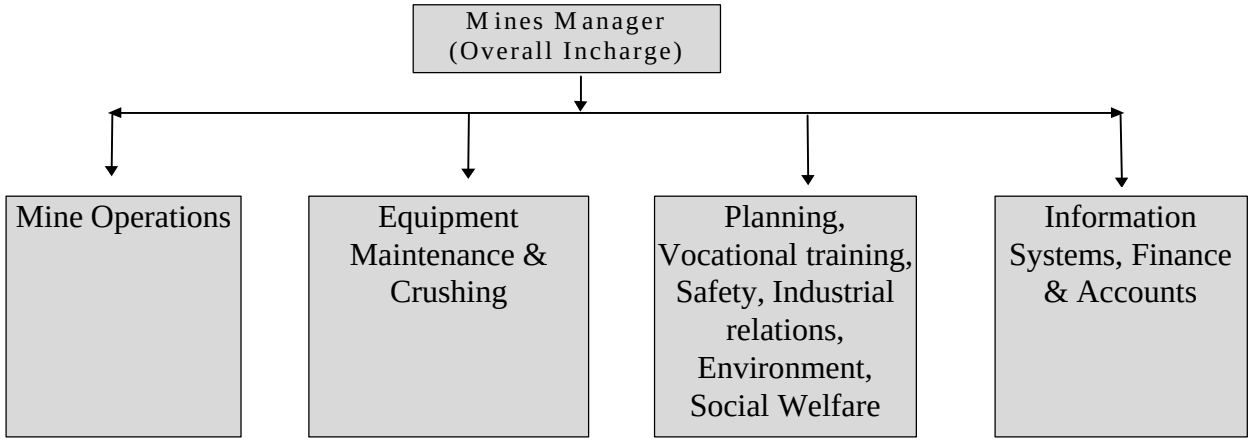
Item	Amount in Rs Million
Mining Equipment	174.24
Ancillary Facilities	41.12
Crushing Plant & facilities	128.00
Colony Facilities	36.04
Pre-Operative Expenses	36.00
Electricity OH transmission & distribution	36.00
Captive DG set [standby unit]	30.00
Pollution Control (Air, Water)	16.31
Belt Conveyor	440.0
Sub-total	937.71
Contingencies (@ 12.5%)	117.21
Total	1054.92
	Say around Rs 105 Crores

3.4.5 Commencement of Production

Anticipating the commissioning of the cement production by the year 2003, it is proposed to achieve full rate of production of limestone at Nongtrai limestone mine by the same time. The site development, procurement of machinery, installation of the crushing unit, setting up of township facilities, etc. is expected to take about 2 years time. As considerable limestone will be generated during the site developmental activities, and as such limestone will be dispatched to Bangladesh over a period of time, the commencement of production (or opening of mine) is expected to middle of 2002.

3.4.6 Organisation Management

A Manager (Mining) holding First Class Mine Managers Certificate of competency will head the Mining project. The Manager will be the overall in-charge of various mining activities including planning, operations, safety, environment, finance, administration and overall mine management. The proposed organisation chart is given below:



3.4.7 Number of Employees Envisaged

The manpower proposed for the Nongtrai Limestone Mine is given in ***Table 3.10***.

Table 3.10: Manpower Envisaged

S. No	Manpower (Standard Force)	Strength
1	Manager Mining (FCC)	1
2	Asst Manager (FCC / SCC) - one in each shift	2
3	Asst Manager (FCC) – planning & vocational training & safety	1
4	Asst Manager – Environment, industrial relations, social welfare	1
5	Asst Manager - Mechanical - in general shift for HEMM & crushing plant	1
6	Asst Manager - Electrical - for HEMM & crushing plant	1
7	Geologist - for exploration & quality control	1
8	Information systems administrator	1
9	Heavy Earth Moving Operators	19
10	Mechanics & Electrical assistants	12
11	Skilled assistants for blasting, store keeping, accounts, issuing, quality control, office administration, canteen, etc.	10
12	Unskilled staff for housekeeping, canteen & other services	6
13	Medical officer	1
	Total	**57**

Besides the above standard force, it is proposed to engage professional services for security, local labour on contract as and when needed for various contractual works.

3.4.8 Shift Operation

It is proposed to operate the mines in two shifts for production of limestone & crushing and one shift operation for breakdown maintenance for six days a week with Sunday being the weekly off-day. The timings of different shifts is as under:

- Shift I : 06.00 AM to 02.00 PM
- Shift II : 02.00 PM to 10.00 PM
- General Shift : 08.00 AM to 05.00 PM

3.5 RISK ASSESSMENT AND SAFETY MEASURES IN BLASTING

3.5.1 Risks Involved Due to Explosive Storage and Handling:

The risks involved in storage of explosives and its handling are:

- Accidental explosion due to adopting unsafe practises; and
- Poor blasting parameters leading to excessive ground vibrations, noise, air blast and fly rock during blasting.

Accidental Explosion Due to Adopting Unsafe Practices:

All activities involving storage, handling and transportation will be in accordance with the rules made under the Indian Explosive Act and conducted with proper licences and approval from concerned authorities. All blasting operations will be performed by competent persons taking adequate precautions to make the operation totally safe. A detailed code of procedures for storage, handling and use of explosives will be prepared and strictly followed. All the employees will be trained and made conscious of adopting safe practises as per the safety policy and procedures laid down by the company.

Poor Blasting Parameters Leading to Excessive Ground Vibrations, Noise, Air Blast and Fly Rock During Blasting

The frequency of blasting will be optimised by conducting blasting once a week and also adopting multi-row blasting using delay detonators. The blasting pattern, stemming column, charge per hole, etc. will be designed so as to control the fly rock and the ground vibrations. Non-electric shock tube initiation systems will be deployed to enhance safety of operations, better blasting control and reduce noise due to airblast. Depending on the actual experience once the excavation commences, blasting parameters can be changed suitably to adhere to strict safety measures.

3.5.2 Environment, Health and Safety Policy

Environment Policy

The environment policy right from mine preparation to its operations will be based on:

- Compliance of applicable regulatory requirements;

- Conservation of natural resources;
- Maintaining a safe working environment;
- Providing high environmental expertise and know-how; and
- Regular training and refresher courses so as to achieve continuous improvement of environment.

Health and Safety Policy

The company identifies safety and health of the personnel as integral part of every work aspect at every level. In addition to compliance with the statutory rules and regulations as the minimum acceptable, LMMPL will set internationally acceptable standards for practice and will intend to achieve the above by the following:

- Provide adequate and continuous training to all personnel;
- Prepare an over-all safety & health manual giving general requirements of leadership, planned inspections, job analysis & procedures, emergency preparedness, organisational rules, necessity and use of protective equipment, health control, etc.;
- Systematic evaluation & measurement of system performance at all operational levels and continuously update the over-all safety & health manual;
- Carrying out regular publicity campaigns effective personnel safety and health conscious; and
- To employ a person as in-charge for planning, training & safety and make him responsible for implementation of safety and health policy.

4 BASELINE ENVIRONMENT STATUS

4.1 INTRODUCTION

Baseline data on environment is important to understand region's existing physical, biological, cultural and social environmental characteristics. Information and data presented in this section is based on primary surveys and environmental quality monitoring and secondary data have been collected from various departments and from other studies available on the subject. The information on the baseline environmental conditions forms the basis to analyse the probable impacts of the proposed mining activities *vis-a-vis* the present background environmental quality of the study area.

The environmental monitoring for ambient air quality, water quality, soil quality, dust fall rate, noise levels, water quality, meteorology of the study area etc. was undertaken by ERM India by subcontracting a recognised Delhi based laboratory called M/s Netel Chromatographs. The monitoring was undertaken during the four seasons in the year 1999 – 2000 as per the details given below:

Table 4.1 : Calendar of Environmental Monitoring of the Study Area

S.N	Monitoring Period	Seasons	Details of monitoring
1	I June to 7 July 1999	Pre monsoon	Ambient air quality, continuous meteorology, dust fall, noise levels, soil quality and water quality
2	August, 1999	Monsoon	Water quality
3	19 November to 18 December, 1999	Post Monsoon	Ambient air quality, continuous meteorology, dust fall, noise levels , soil quality and water quality
4	2 February to 1 March 2000	Winter	Ambient air quality, meteorology, dust fall, noise levels , soil quality and water quality

4.2 THE STUDY AREA

An area of 10 km radius (aerial distance) from the mine site is marked as the impact zone of the mining activity (as shown in ***Figure 4.1***). The baseline information is collected for the identified study area, where mining lease area (ML) is considered as the core zone with respect to the peripheral zone. The study area is entirely rural and is sparsely populated area situated in the southern slopes of the Central Plateau of Meghalaya. It partially occupies the community development (CD) blocks of Shella Bholaganj and Mawsynram both under the district jurisdiction of East Khasi Hills. No human settlements occur within the core zone. The nearest human settlement from the core zone is at village Phalangkaruh, which is located at 1 km to the south of the ML area. The core zone is under the jurisdiction of village Nongtrai, which is about 2.5 km away from the lease area. The study area encompasses 56 villages. Villages like Shella Bazar and Pyrkan are within the radius of 2 km from the core zone. The nearest township is at Cherrapunji, and has been provided with the facilities of Modern Township including post and telegraph, bank, civil hospital and higher secondary school.

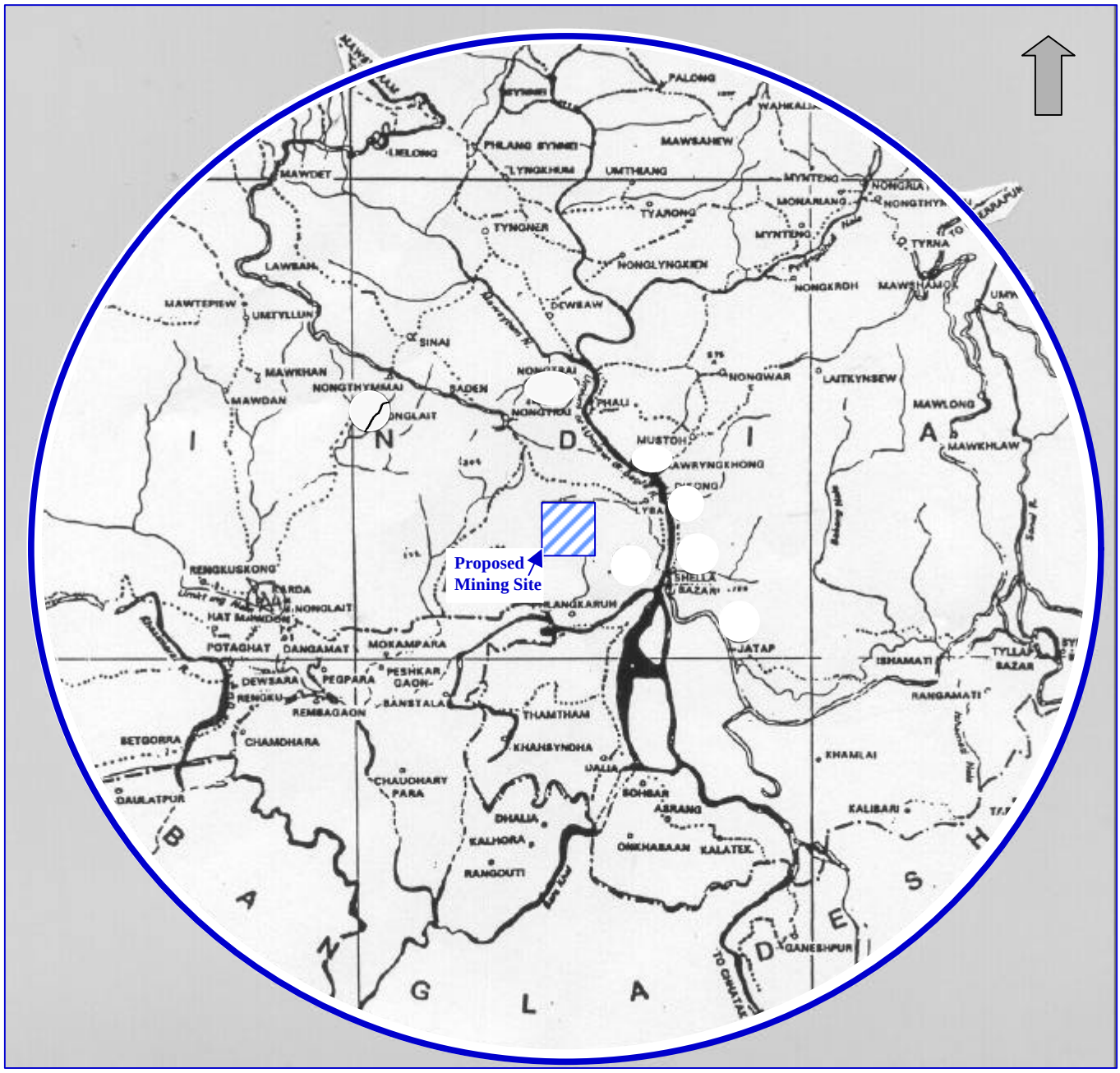


Figure 4.1: Study Area

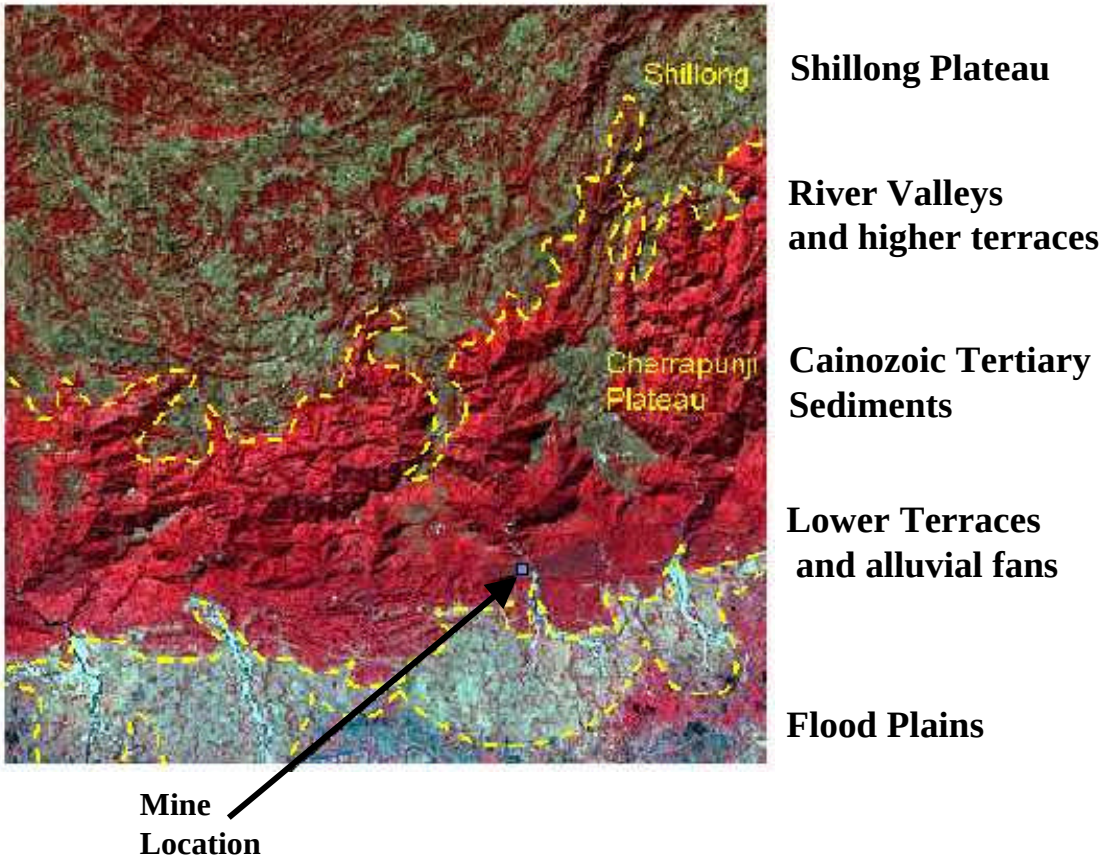


Figure 4.2: Regional Geomorphology

The industrial activities within the study area include the following:

1) Limestone quarrying in Ishamati and Shella across the River Umium to the east of the core zone.
2) *The Komorrah Limestone Quarry* situated near Bholaganj, was operated by Assam Bengal Cement Company Limited for about 26 years from November 1938 under a mining lease granted by the then Government of Assam. Limestone from this quarry was supplied to the Company's Chhatak Cement Factory in Sylhet (now in Bangladesh) by means of ropeway even after partition. Consequent to Indo-Bangladesh agreement of 1971, the quarry was revived for supplying limestone to the Chhatak Cement Factory in Bangladesh again by a joint public sector undertaking between the Meghalaya Industries Development Corporation Limited and the Economic Entrepreneurship Development Foundation, Calcutta with a paid up capital of Rs 10 lakhs. Each promoter contributed Rs. 5 lakhs to the Share Capital. Reportedly, a proven reserve of 7.5 million tonnes of limestone has been established for this quarry.
3) Limestone quarrying is also carried out on small scale in the hills all over the study area. Some of this limestone is exported to Bangladesh while some of it is baked in lime kilns for lime extraction. There are as many as 62 lime kilns in the Shella Bholaganj C D Block only.

The other major limestone quarrying and cement plant is *The Mawmluh-Cherra Limestone Quarry* which is located at about 17 km crowfly (which is about 56 km by road) to the northeast of the proposed site and comprises of two leases with a proved limestone reserve of 31.55 million tonnes. The quarry is captive to the cement factory of the *Mawmluh-Cherra Cements Limited,* (a Government of Meghalaya undertaking). The quarry was first started in January 1961.

4.3 PHYSICAL ENVIRONMENT

4.3.1 Physiography of the Area

The regional physiography of the area is defined on the basis of Digital Elevation Model (DEM), produced from Radarsat images for an area of 60 km x 60 km, using SPOT satellite imagery (Pan-chromatic and multi-spectral images), specially recorded for this project by M/s Furgo Miliu Consult BV, Netherland.

Topography and Geomorphology

The ML area is located of the southern edge of the Shillong Plateau, comprising the Khasi and Jaintia Hills. The following description relates to an area from approximately Shillong in the north to the floodplains of Surma River in the south. The following regional geomorphologic zones as shown in ***Figure 4.2***, can be distinguished (from low to high and from south to north):

- *Bangladeshi Plains (with Surma River south of the mine area):* A low lying alluvial plain, regularly flooded, braided and meandering rivers, levees, point bars, oxbow lakes, floodplains, back swamps, etc. Elevation lies between 5 and 50m amsl;

- *Footslopes and alluvial fans:* The transition from the plains to the hills and Shillong Plateau is characterised by a rapid rise in elevation and several alluvial fans. The

alluvial fans are deposited in the plains by the larger rivers coming from the Plateau. The elevations range between approximately 50 and 150m amsl;

- *Caenozoic sediments hills:* Caenozoic sediments, ranging from sandstone to shale and limestone, cover the southern edge of the Shillong Plateau. These sediments have been uplifted to elevations between 150 and 1,800m amsl. The major uplift has been taken place along east-west trending faults, including the Dauki fault system, and monoclines. There are indications in the study area, that more than a single east-west trending fault is involved in the uplift;

- *Shillong Plateau:* Further north, a massive crystalline rock complex can be recognised in the satellite images. This basement area has formed a high plateau at a level of 1,800m amsl and above. The basement is folded in wide, open folds and dissected by numerous faults and fractures and joints. The drainage pattern of the larger rivers is clearly structural controlled; and

- *Incised rivers:* As separate unit, the deeply incised river valley can be distinguished. A number of north south running rivers cut through the described topography and geomorphological units. A number of these rivers may represent an antecedent drainage pattern. However, some rivers or river branches show structural control. Structural control of the river courses is obvious in the basement area. Also in the Caenozoic sediments, structural features may have influenced the course of rivers. This is expressed in angular bends of the rivers or river branches.

Waterfalls and rapids are present in the larger north to south running rivers. These may indicate lithological differences or structural features. The major river east of the mine area is Umiam River having its source near Shillong.

Geological Setting of the Area

To the north, the study area is bound by the Archaean Basement of the Shillong Plateau. South of the Basement area, a sequence of Mesozoic to Caenozoic sediments are found. At and around the mine area, the major formations area the Langpar Formation, Shella Formation and Kopili Formation. The first two of these formations comprise alternating series of sandstone and limestone. The Kopili Formations mainly consists of alterations of thin sandstone and shale with rare thin limestone bands.

The SPOT satellite images show an extensive limestone covered area at the mine site, which forms a west to east running band of limestone on both sides of Umiam River. This limestone belongs to the Shella Formation and comprises the Prang and Umlatdoh limestones. This band can be followed for several kilometres to the west and east of the mine site. The width of this band is a little over 1 kilometre near the mine site. To the south, this limestone is bound by the thinly bedded Kopili Formation. The dip and strike measurements reported and an angular unconformity between the shales and limestone encountered in inclined boreholes, suggest that the boundary between the Shella Formation and Kopili Formation at the mine site may be formed by a fault.

To the west, however, the Kopili Formation is overlying the Shella Formation conformably. Here, the change in dip of the rocks indicates a southerly dipping monocline without faulting. East of Umian River, the Prang limestone signature can be followed for another few kilometres.

To the north of the mine area, a steep gradient is found. The terrain rises by several hundreds of metres. An alteration of limestone and sandstone bands is found on this escarpment. This higher part of the escarpment formed by the Langpar Formation. At the lower slopes of the escarpment, the Umlatdoh limestone is encountered in steep cliffs.

The Narpuh sandstone, separating the Umlatdoh and Prang limestones, is encountered north and east of the mine block. The lower part of the Narpuh sandstone appears to coincide partly with approximately west-north-west to east-south-east trending dark signature on the satellite images in the limestone area. To the west, the sandstone was not encountered in this zone. To North-west and north of the mine block, the sandstone is encountered, apparently dipping under the Prang limestone. To the east, along the Umian valley, as well as the Prang limestone – Narpuh sandstone contact as the Narpuh sandstone – Umlatdoh limestone contact is encountered. The Prang – Narpuh contact is encountered at approximately 77m RL at latitude of the centre of the mine block and the sandstone is gently dipping (approximately 15º) to the south-west. It is therefore difficult to explain why no sandstone is encountered in the boreholes in the mine block itself, unless there is an offset through faulting.

Geological setting of the Mine area

The mine and adjacent area is located in the zone of the Caenozoic sediment hills. The sediments generally dip towards the south. Therefore, the outcrops of the rocks largely follow the stratigraphic sequence from north to south. Differences in resistance to weathering and erosion of these rocks have caused differences in topography.

Apart from lithological causes of topographical differences, folding, faulting and different rates of uplift have caused further topographical differences within this zone on either side of the fold axis or fault. On the southern side, the mine block is bound by a fault, separating the limestones of the Shella formation from the shales, sand and siltstones of the Kopili Formation. Further to west, the Kopili Formation is conformably overlying the Shella formation in a monoclinal fold. Aparantly, the monocline passes into a fault to the east. Strong indications of east-west trending short faults in the Kopili Formation, south of the mine block have been found as well. A fault north of the mine block, along which a part of the Shella limestone has been uplifted, could be present as well. A steep scarp bounds the northern margin of the mine block. On the higher escarpment the village of Nongtrai is located. The top of the escarpment consists of sediments of the Langpar Formation: alternating sandstones and limestone bands. The sandstone forms relatively flat parts of the escarpment, where the limestone bands form the steeper parts.

Halfway the escarpment, a transtion to the Umlatdoh limestones of the Shella Formation is encountered. The Umlatdoh limestone is also found in the adjacent, lower and relatively flat area to the south. This would suggest a fault as the reason for the escarpment rather than differential erosion. All these faults (proven and

inferred) are short, local faults. A larger east-west trending fault is indicated on the regional geological map at approximately 2km north of the mine block.

Within a single fault block, several levels or "steps" can be recognised. Uplift of the fault blocks has been taken place in stages. After each stage of uplift, erosional forces have partly lowered the area. These stages can be recognised in erosional levels as found in the and around the mine area and as recognised by the digital elevation model (DEM). In and around the mine area, approximately 7 stages of uplift and erosional planation could be distinguished. Uplift is probably a still on-going process, while active incision and erosional action is evident in the heads of the gullies and valleys, including Phlangkaruh, on the southern margin of this unit.

Another characteristic of the geomorphology of the study area is that the area is largely covered by karstified limestone. Karst features displayed in the area include dissolution features of the limestone, like dissolution channels (runnels), caves, springs and depresssions.

4.3.2 Tectonic Region/Seismicity

The Shillong Plateau and the Khasi and Jaintia Hills form a part of the basement unit of Meghalaya. This basement unit is located between the Himalayan Frontal Fault (HFF) to the north and the Dauki Fault to the south. The underthrusting of the Indian Plate under the Asian Plate has caused the uplift of this relatively rigid unit and its surroundings. Further to north, the Himalaya and to the east the Indo-Burman Ranges are exponents of this underthrusting and uplift and large scale folding.

The uplift of the area is still on going. This is expressed by a high seismicity of the area. Magnitude 8.5 and 8.7 earthquakes have been reported in the area in the past 110 years. With regular intervals, lesser quakes and tremors are reported for the Indian-Bangladeshi border regions. From 1973 to present, 1,283 earthquakes have been reported in the area bound by latitudes 20^{o} and 30^{o}N and longitudes 86^{o} and 96^{o}E. In the area between latitudes 24^{o} and 26^{o}N and longitudes 90^{o} and 93^{o}E and during the same period, 67 earthquakes have been occurred. Within a radius of 100km from the mine area, 32 earthquakes have been reported for this period, the most recent on 9 November 2000 at 59km from the site with a magnitude of 4.2 (Richter Scale). The majority of these quakes had a magnitude between 4 and 5 Richter Scale. (Information: National Earthquake Information Centre, USGS).

The source zone of the earthquakes is relatively shallow, to approximately 40km depth. This is also shown clearly in the Source Zone Map of the Global Seismic Hazard Assessment Program (GSHAP) of the International Lithosphere Program (ILP). The source zone 3 on this map encompasses the Shillong Plateau (SP) which experienced a strong earthquake of magnitude 8.7 in 1897. The tectonics of the Shillong plateau is distinctly different from that of the regions to its north south and west, and hence a separate zone for the region. Peak Ground Accelerations (PGA) ranges for the study area between 0.20 and 0.25g. This places the area in seismic hazard zone III (out of four zones).

4.3.3 Sinkholes in the Study Area

There are numerous sinkholes present in the area. Closed depressions of simple form are exceedingly common in karst. Many terms as sinkhole, swallow hole and swallet

have been used for these loosely features. For more clarity, many have preferred the word doline. Doline are generally circular or oval in plan, with a range of forms; dish and bowl shaped, conical and cylindrical. Various classifications have been proposed for the various types of dolines. One such classification distinguishes among : 1. Collapse dolines; 2. Solution dolines; 3. Subsidence dolines; 4. Subjacent karst collapse dolines; and 5. Alluvial stream sink dolines.

The sinkholes encountered in the area fall in the categories solution dolines and collapse dolines. Solution dolines develop at solution favourable points, such as joint intersections. Solutes and some insoluble residues are removed down solution-widened joints and bedding planes. Once enlarged, rock fragments and residues will slide and fall down in them. The dolines of this type in the study area expose bedrock over all of the doline's surface. These dolines vary in size from a few metres to tens of metres in diameter. Their depth is generally less than 10m. However, the depth is difficult to establish as rockfall from the sides partly fills in most of the larger dolines.

The collapse dolines or collapse pits form a different category of sinkholes. The prime cause of this type of doline can be the collapse of the roof of a cave formed by underground solution. To begin with, the collapse pit will be vertically walled and may be angular in plan through joint guidance. The depth-width ratio exceeds the maximum likely in solution dolines of 1 to 3.5.

There are few possible causes for the development of a collapse pit:

- various forces are acting on the rock, such as gravity, permanent tectonic stresses in the rock and lithostatic load. Erosion causes decompression, which opens joints and permits rock fall on the surface and roof collapse underground;
- drainage of previously water-filled caves causes a sudden loss of roof and wall support and possible collapse; and
- tremors, earthquakes and also rock blasting may trigger collapse.

The largest sinkholes in the area are collapse pits. The obvious collapse pits are collapsed dome caves. The caves present in the area are dome caves as well. The Twin Sinkholes is a textbook example of a collapse pit. The highest point at the rim of the sinkholes lies at approximately 63m RL (by altimeter). The bottom of the sinkhole is at approximately 20m RL (by altimeter). The diameter is approximately 200m. The walls of the sinkhole are partly overhanging, still exhibiting the dome shape of the collapsed cave. At the floor of the sinkhole, a collapsed tunnel is present in the centre of the sinkhole.

A cave in the western edge of the sinkhole with an entrance at 39m RL leads to an intact dome cave at approximately 21m RL and below.

Some other large collapse pits have been identified northwest and west-northwest of the mine block. These structures are difficult to recognise due to their large shape and the fact that the collapsed roof and rock fall from the sides have partly filled in the collapse pit. A potential evolution of these structures that explains their present morphology has been described. These structures are only found in an east-west zone northwest of the mine block, just below the Nongtrai escarpment. These

collapse pits clearly belong to a long passed tectonic phase with a subsequent relatively long period of tectonic rest.

Rejuvenation of the karst will occur as a result of a negative movement in the base level, for example by uplift of the area. Since there is always tendency for (underground) water to find lower routes through the karst rocks, uplift may result in a new (lower) level of caves. Subsequent erosinal denundation of the uplifted area may trigger the formation of collapse pits over the former caves at the higher level. The northern large collapse features are clearly related to such an old stage of uplift and erosion. The present caves occur all on almost perfect east-west line, indicating the present active stage of cave formation as a result of one of the younger uplift phases.

Geometry of sub-surface channels, cavities and sinkholes

The only sinkhole in which water is encountered is the cave joining the Twin Sinkholes. Water is encountered at various places at low levels inside the cave. In all cases, the water level is 16m RL. The water level at the springs feeding Phlangkaruh southeast of the Twin Sinkholes is 8m RL. The hydraulic connection between the water in the cave and the springs has been established by three tracer tests.

The tracers took approximately 9 to 10 hours to emerge from the springs. This is a much longer time than expected on the basis of distance and water flow speed inside the cave. This indicates that the way the water travels to the springs is highly tortuous. This tortuousity factor may be as high as 5.

The cave is partly filled with sand (quartz sand) and pebble (rounded shale fragments) dunes. These dunes have a height to 28m RL. Fresh plant remains on the top of the dunes indicate that during the rainy season the water overflows these dunes. The water level inside the cave may, therefore, rise by at least 12m during the rainy season.

The largest dome of the cave has a diameter of at least 100m and is approximately 20m high. Deeper inside the cave, there are deep and steep funnels and high and narrow triangular galleries to over 20m high. Stalactites and stalagmites are present, although the stalactites prevail. This indicates that the cave is probably regularly filled with flowing water. The stalactites are concentrates along larger joints in the cave ceilings. Water is dripping from the ceiling, even during the dry season. Therefore, shallow vadose water must still be present between the estimated ceiling level (approximately 50m RL) and the ground level (approximately 70m RL). The water percolates through joints and cracks to lower levels like the cave river.

This cave is filled with large, loose blocks fallen from the ceiling. Also, a large fallen stalactite is encountered, which is not yet covered by new calcite. This indicates a relatively recent event that has caused the fall. Probably, this could be related to the 1950 heavy earthquake.

Another cave is explored from the Border Road, just south of the mine block. The entrance is at 45m RL and the cave is explored to a depth of 38m RL. Some tens of metres from the entrance, a deep north-south running gully is encountered, which could not be further explored. Although no water is visible, it seems logical that this gully carries water during the rainy season and possibly also connects to the

Phlangkaruh springs. The higher part of the cave exhibits as well stalactites as stalagmites, indicating that the higher part never gets filled with flowing water.

A third cave visited is located east of the mine block. The entrance of this cave is located at 64m RL. Some tens of metres after the entrance, this cave bifurcate into a branch in downward direction and a higher located gallery. No evidence of flowing water is encountered, which was also not expected due to the high elevation. The cave contained impressive stalactite and stalagmite formations.

Only a short stretch, several hundreds of metres long, was investigated by geophysical means. This stretch ran along the Shella Nongtrai road from west of the Twin Sinkholes to a point just east of the sinkholes. The objective of these measurements was to test whether the technique applied (resistivity imaging) was feasible under the local circumstances and with the local equipment available. The results (interpretation by induced polarisation modelling) indicated a cavern in this stretch. The resistivity values indicate an air-filled cavern of at least 20m wide and more than 10m high between 15 and 30m below the road level, i.e. approximately 15 to 30m RL. As this level is well above the spring levels of Phlangkaruh springs, this cavity may be a part of the underground system connecting to the western spring.

It is recommended to investigate the sub-surface of the mine block in detail by geophysical means. However, although the resistivity imaging technique has proven to be very useful in the area (and also in other studies aiming at identifying underground caves), it would require an extensive logistic operation to execute such study over the entire mine block, due to the difficult accessibility of the terrain. Possibly a reconnaissance by a different technique as for example a gravimetric technique should be carried out over the area, identifying anomalous zones. Subsequently, resistivity imaging could be applied in those zones. In any case, this will not be an exercise that can be completed with a matter of weeks.

4.3.4 Hydrology

The hydrology of the area has been studied in order to be able to assess the impact of the mining activities on the water quantity and water quality of the spring fed Phlangkaruh River. The techniques applied comprise the study of the hydrological patterns of the area by means of satellite imagery, the DEM and tracer tests to study the hydraulic connectivity of various waters encountered, the interpretation of flow and discharge measurements carried in the area in the year 1999 and 2001, and the setting up of a water balance for the area.

Water flow routes and water quantity

Regional and local catchment areas have been defined on the basis of the satellite images and the DEM. On a regional scale, a number of large rivers drain the southern part of the Shillong Plateau and a large part of the Caenozoic to Tertiary sediment hills. The Umian catchment area at the mine site latitude has an acreage of approximately 358km^2. On the southern margin of the hills, between the lower basins of the larger rivers, a series of small, independent catchment areas form a separate drainage system. The Phlangkaruh basin is one of these sub-catchements. The catchment comprises approximately 5.2km^2.

Flow routes

Apart from Phlangkaruh river, there is no clear surface water drainage pattern in the area. On the Nongtrai escarpment, some spring-fed river flows can be followed and these flows disseminate and dissolve as soon as the lower limestone area is entered. This indicates sinking streams. The precipitation on the karstified limestone forms no obvious surface drainage. Therefore, infiltration rates may be assumed to be very high or complete.

The water percolating into the limestone, will follow cavities along joints and bedding planes and form a kind of phreatic and highly variable (as well in time as location) "water-table". The term water-table is not very correct in this context, as the system is highly anisotropic and no actual regional piezometric level exists. The subcutaneous flow will tend to follow the bedding dip and the strike of the joints. The flow direction is therefore generally south to south-easterly. Vertical movement of the water to greater depths occurs through 1. shaft flow, where open shafts or funnels connect to caves or larger cavities at greater depths; 2. vadose trickles, the water descend through solution widened joints and reach caves as fast drips of streamlets; and 3. vadose seepage, that feed slow drips in caves below and that may take months to respond to rainfall events. Vadose trickles and seepage are observed in the Twin Sinkhole caves.

The flow of water in the caves occurs in the form of cave rivers or streams. Flow velocities are comparable to those of surface streams. The cave streams may loose water to lower levels again through the same three vertical flow components as described above. Loss of the water of the Twin Sinkholes cave river through a network of joints connecting to the Phlangkaruh springs has been proven by tracer tests.

Tracer tests

Seven fluorescent dye tracer tests have been carried out. Three tracing tests have been carried out on various days inside the Twin Sinkhole cave. The dyes came out from Phlangkaruh spring after approximately 9 to 10 hours. The discharge continued for at least the next 24 hours. The water flow velocity inside the cave is estimated to be 7 cm per second during the tests. The long time before the tracer came out and the long period of dye discharge indicates a tortuous pathway.

One dye tracing test is carried out at a swallow hole inside a limestone quarry at far western limit of this part of the Prang limestone at 4.7km (crow's flight) west-north-west of the Phlangkaruh spring. A fifth tracer is released at approximately 4.8km west north-west from the Phlangkaruh spring in a spring on the Nongtrai escarpment. The sixth and seventh tracers are also released at a spring, 4.6km from the Phlangkaruh spring on the Nongtrai escarpment, but slighly further east.

The uranine from the swallow hole is found back after little less than three days in westernmost Phlangkaruh spring. The fifth tracer is never found back and this stream probably drains to the valley west of the study area. The sixth tracer from the Nongtrai spring is not observed to submerge. Repetition of this tracer test with Rhodamine indicates that the tracer does not come out of the higher Phlangkaruh springs, but from a seep a few hundred metres downstream. This is probably the reason why the sixth tracer is not observed to re-appear.

The tracer from the swallow hole in the western part of the area has followed a relatively shallow route through the vadose system flowing south-east to the Phlangkaruh springs, while the water from the Nongtrai spring has reached a deeper flow system, probably through caves and cavities, first flowing south and then forced by the Kopili Formation into a easterly direction. This easterly flow may have been enhanced by the presence of sandstone bands and / or east-west trending faults in the Kopili Fomration.

This way, the length of the hydrogeological Phlangkaruh catchement area was estblished to be at least 4.7km and it has been proven that the Prang limestone is being recharged by springs from the Langpar Formation in the Nongtrai area.

All these observations point in the direction that the Phlangkaruh spring is actually an overflow spring. The groundwater system can be divided into a vadose system between the ground surface and probably some tens of metres. The absolute level of this system is related to the local topography and the dip of the bedding planes of the limestone. This system sustains the plant growth in the area. The deeper rooting evergreen trees (up to some tens of metres) always have access to this water, indicating this vadose water body does not get depleted during the dry season. The trickles of water inside the caves also indicate the presence of this vadose water during the dry season. However, the saturated storage volume of the vadose water, and the level at which this water is encountered, varies with the seasons. During the dry season, the "water-table" drops to below the rooting depth of the seasonal shrubs, which wither at the end of the dry season.

The vadose system connects to a localised system of cave streams at greater depth. Active caves have only been found in the southern (downstream) part of the study area. In the downstream portion, the water level in these caves was observed to be 16m RL during the dry season and may be expected to be as high as at least 28m RL. This system is by far the largest conduit of the majority of the waterflow in the area (i.e. during the rainy season).

Flow and discharge measurements

In August 1999, CSME have carried out flow and discharge measurements in Phlangkaruh river. The combined flow from the springs amounted to approximately $1m^3/sec$. At regular stations further downstream, the flow increased first to over $3m^3/sec$ and to over $4m^3/sec$. This increase can easily be attributed to additional inflow from overland-flow and through-flow from the adjacent shale hills. However, between station D and E, the flow discharge increases sharply to over $16m^3/sec$. Considering the catchment area of point E, between point D and E, and considering the maximum 24 hours rainfall observed in the mine area and assuming 100% run-off, the additional water from run-off and through-flow from the adjecent shale hills could not explain this large increase.

The Rhodamine dye tracer test in one of the Nongtrai springs has indicated that the water from this source may follow a relatively deep route first through the limestone to the south, and being forced by the Kopili Formation to flow either west or east at a lower level. The tracer is observed to appear exactly between stations D and E. This indicates an additional inflow of water at a lower level than the springs. During the rainy season, this additional inflow is significantly higher than the spring flow.

During the dry season, the flow between point D and E increased from approximately 0.2 to 0.3m^3/sec. The additional inflow of 0.1m^3/sec was more than expected on the basis of the estimated dry season flow of the Nongtrai spring alone. Also other springs, like the ones occurring at a lower level at the escarpment contribute to this flow.

It should therefore, be concluded that the most significant inflow of water in Phlangkaruh river occurs at a lower level than the springs and that the springs have only a limited contribution to the river flow. The spring flow is most significant for the upper few hundreds of metres of the Phlamgkaruh stream.

Water balance

In order to quantify some aspects of the water flow and storage in the area, a water balance has been set up for the Phlangkaruh springs catchment area.

The following factors have been considered:

- Precipitation;
- Evapotranspiration;
- Surface run-on;
- Surface run-off;
- Spring flow; and
- Change in saturated storage volume.

Groundwater inflow and outflow into and out of the basin area has not been considered. To the south, the basin is bound by the relatively impervious Kopili Formation. To the north, all groundwater processes appear to occur in a level well above the study area as shown by the spring levels in the Nongtrai area. To the west and east, the area is bound by valleys, along which no significant springs are encountered.

The water balance has been set up using monthly figures for the precipitation. The monthly potential evapotranspiration has been calculated, from which the "actual" monthly evapotranspiration has been derived. The evapotranspiration has been calculated by the Priestly-Taylor method on the basis of the monthly figures for average temperature, average net radiation, the latent heat of water vaporisation, the gradient of the saturated water vapour pressure curve and the psychrometric constant. The actual evaporation has been estimated with the help of the Turc-equation for catchment areas. A check is made by applying the Blaney-Criddle equation. The figures from both methods matched very well. The calculated "actual" evapotranspiration also matched very well with the observed precipitation.

The water balance calculations indicated a water surplus for the area from the month of March till October. The largest surplus is found in June. During this period, first the saturated storage volume is recharged and the subsurface water flow increases. Spring flow will reach its maximum after the saturated storage volume has been fully recharged and all other water surplus is discharged through the springs. From November till February, the recharge is lower than the evapotranspiration and spring discharges combined. In this period, the saturated storage volume is depleted:

the vadose zone water levels drop and the shallow rooting shrubs and plants whither.

The water balance calculations have been checked on the measured spring flow in August 1999. The total spring is flow then amounted to approximately 1,000 litres per second. The calculated average spring flow for August is, according to the water balance calculations approximately 850 litres per second. For September, this figure is 1,050 litres per second. The slight underestimation may be attributed to the fact that the water balance gives a monthly average and to the fact that it is quite common that the "actual" evapotranspiration is being over-estimated.

Downstream Uses and Users of Water

The main water use of the water from Phlangkaruh is the washing, bathing, cooking and drinking water supply for Phlangkaruh Village. The valley is too steeply incised to apply the water for irrigation of the fields on the valley slopes. Water is only abstracted for drinking water supply and cooking. Washing and bathing finds mainly place at various points in the river itself.

Domestic use: The average domestic water use may be estimated at 30 litres per capita per day for rural areas in India. The population of Phlangkaruh is estimated at 120 persons This brings the downstream water use at 3600 liters per day. However, a major part of the water use is in-stream. Only a few litres per capita per day are abstracted for cooking and drinking. The amount of water abstracted can be estimated to be 5 litres per person per day, amounting to a total of approximately 600 litres per day.

A few scattered settlements are present in the shale hills. The people occupying these settlements abstract their water mainly from local seeps in the shale hills and not from Phlangkaruh.

Livestock water use: There is very little livestock present in the area. The livestock comprises a few heads of cattle, some goats and pigs. An average water consumption of the water by livestock can be estimated at 30 litres per head livestock per day. *Agricultural use*: Phlangkaruh river is too deeply incised to utilise its water for irrigation of the fields on the valley slopes or the beetle nut gardens without rams or pumps. Instead, the beetle nut gardens north of Phlangkaruh Village are irrigated by water from one of the springs on the Nongtrai escarpment. A system of plastic and bamboo pipelines is fed by the springs and transported by gravity to the beetle nut gardens over a distance of 2.0 to 2.4km. The fall in elevation is from approximately 275m RL at the spring to approximately 45m RL at the lowest point at the beetle nut gardens. The spring discharge is estimated not more than 20 litres per second during the dry season and approximately half is abstracted by the irrigation system. It may be assumed that at least half of the water is lost through leakages before it reaches the beetle nut gardens. This would yield approximately 400,000 litres per day for irrigation, which could support the irrigation of 20 to 40 hectares. The insignificant looking spring flow at the Nongtrai escarpment therefore contributes enormously to the dry season water supply of the agriculture in the Phlangkaruh area. This system is completely independent from the spring flow of the Phlangkaruh springs.

Another piped system, applying a large diameter GI pipeline, taps water from another spring at the Nongtrai escarpment. However, as well the spring flow as the

tapped water flow to the west and out of the study area. More abstraction systems exist at the Nongtrai springs, but all for more local use.

Some 900 metres downstream (crow's flight) from the Phlangkaruh springs, a small earth-dam has been constructed in Phlangkaruh river to retain water during the dry season and for agricultural and domestic use.

The proposed mine comprises a 1km^2 area to a maximum depth of 90m RL. Assuming all rainwater falling on the mine area will be intercepted and discharged off, this would have some influence on the recharge of the vadose groundwater volume. A maximum of approximately 18% reduction (the percentage of the catchment area occupied by the mine) in the vadose zone recharge could be expected. However, as no vegetation will be utilising this vadose zone water, it will have no impact on the plant growth. Assuming the water entering the mine will be discharged into Phlangkaruh after treatment, the stream flow will not be influenced either.

The spring flow into Phlangkaruh is fed by a deeper groundwater system. As shown in the Twin Sinkholes cave and the cave found in the geophysical profile, this system is present at depth between approximately 15 and 30m RL. This major system is well below the maximum mining depth of 90m RL. Therefore, no negative impact on the spring flow into Phlangkaruh is foreseen.

Probably the most important inflow of water into Phlangkaruh has its origin on the Nongtrai escarpment, well outside (north-west) of the mining block. The flow route of this water is west of and south of the mining block. No influence of the mining activities on this water route may be expected.

The only potential negative impact of the mining activities on the groundwater regime and the Phlangkaruh river is very difficult to assess i.e. influence of the mining activities on the caves and cavities due to drainage of these or disturbance of these conduits by for example blasting. It can not be foreseen how these activities may, for example, cause the underground collapse of important conduits, in or outside the mining block.

Karstic landscapes are particularly sensitive to environmental degradation. Stresses induced by mankind in karstic terrane result in environmental problems that are much more acute than those which would occur in terranes underlain by either crystalline or clastic rock. As shown by the tracer tests, karst features in the area like swallow holes, caves etc. have direct connections to the springs feeding Phlangkaruh river. This means that any contaminant easily spreads through the underground flow system to Phlangkaruh river. This makes the hydrological system extremely vulnerable to contamination.

Karst areas are notorious for their potential sources of groundwater contamination. Sinkhole dumping is only one way of contaminating a karstic groundwater supply. Leaky septic systems, sewage lines, or effluent from faulty sewage-treatment facilities introduce coliforms and other disease-bearing organisms into the karst system. Chemicals, herbicides, or sludge applied to land overlying carbonate rock will enter the aquifer through diffuse infiltration and contaminate springs and wells as will runoff from feed lots. Chemicals introduced in this fashion may

hydrocarbons, heavy metals, and others. Particulate matter from excavations will also alter the chemical and discharge characteristics of karstic aquifers.

The potential source of contaminants into the karst aquifer during the mining will be through the mine itself. Leakage from machines (hydrocarbons), chemicals and even explosives are other potential sources of contamination. The deeper the mine is excavated, the closer following sources of contamination are to the main groundwater system:

- The waste disposal and sewage system of the mine offices and staff camp. Leakages in the sewage system or improper sewage treatment will result in a rapid contamination of the groundwater system. Sinkholes and excavated parts of the mining area are areas where garbage and household waste may be disposed off and contaminate the groundwater system;
- Sludge disposal from the water treatment plant could be a source of groundwater contamination and increased silt load.; and
- Many abandoned quarries are turned into waste pits or landfills. In karst areas, this is a sure way to contaminate the groundwater system.

For these reasons, degradation of the groundwater and surface water quality can not be excluded unless stringent measures are taken to prevent the above mentioned sources of contamination.

4.3.5 Landuse

Landuse patterns reflect the topography, soil characteristics and proximity to the river, which dictates water availability for irrigation. In Meghalaya state, the land belongs to the people and not to the state.

The Nongtrai Limestone Block is located on predominantly undulating to rolling country to the west of the Umium River, with a small portion of the eastern boundary extending into the flood plains. A large portion of the study area is covered with dense growth of vegetation, however, the site has not been considered or classified as reserved or protected forest land by the Department of Forest, Government of Meghalaya or Government of India. The surrounding land has some of the area as consecrated forests (Law Kyntang) set apart purposely for the religious performances of the village.

The core zone is practically devoid of any soil cover. This area is not arable and hence does not support agriculture. The land is mostly rocky and the rock is wholly limestone. The adjoining areas surrounding the core zone have almost similar structural features.

4.3.6 Climate

The climate of the study area is sub tropical type where seasons can be classified as summer (March - April), pre monsoon (May – mid June); peak monsoon (mid June - October); post monsoon (October – November) and winter (December - February).

Meteorology

The nearest India Meteorological Department (IMD) station is located at Cherrapunji (1313 m above mean sea level), which is about 15 km (crowfly) to the Northeast of the proposed mine site. The western, northern and eastern area has hilly topography whereas to the south of the mine site, the area is dominated by flood plains of Bangladesh. The data on surface meteorological parameters like wind speed, wind direction, temperature, rainfall, relative humidity, weather phenomena etc are procured from this IMD for 5-year period (i.e. 1986-1990). Available Climatological Table (1951 to 1980) for Cherrapunji has also been considered to understand the meteorology of the region.

The other nearest meteorological station is located in Bangladesh at Sylhet (11 m above mean sea level), which is about 40 km to the Southeast of the proposed mine site and data for various meteorological parameters are procured from Bangladesh Meteorological Department (BMD) for 10 years (1989 to 1999). The other available meteorological data (from an existing study) is Sunamganj, Bangladesh, which is located at about 15 km to the south of the proposed mine site.

The summary of the meteorological information for Cherrapunji stations is given as under:

Table 4.2: Meteorological Information* for Cherrapunji (Climatological Table 1951-80)

Month	Daily Temp (º C)		Relative Humidity (%)		Mean Wind Speed m/sec	Prevailing Wind Direction	Rainfall total
	Min	Max	Mor.	Eve.			(mm)
January	7.2	15.7	65	78	1.5	SW	19.8
February	9.1	17.5	64	71	2.1	SW	30.3
March	12.9	20.9	68	70	2.6	SW	228.0
April	14.9	22.4	80	81	2.8	SW	695.3
May	16.2	22.6	87	88	2.7	SW	1461.2
June	17.6	22.6	94	93	2.5	SW	2857.4
July	18.2	22.6	95	94	2.6	SW	2689.2
August	18.3	23.1	94	93	2.3	SW	1811.1
September	17.9	23.4	89	91	2.2	SW	1073.2
October	15.9	22.6	79	87	1.5	NE	527.0
November	12.4	20.0	71	82	1.3	NE	61.8
December	8.7	17.2	68	80	1.2	NE	11.4
Annual Avg.	14.1	20.9	80	84	2.1	-	-
Total Annual	-	-	-	-	-	-	11465.7

* *Based on morning (0830 am) and evening (0530 pm) readings in a day except that of Rainfall.*

Table 4.3: Meteorological Data* for Cherrapunji (Lat 25º 15 'N; Long 91º, 44' E) for 1986 – 1990

Month	Frequency of Foggy days	Daily Temp (ºC)		Relative Humidity (%)		Mean Wind Speed m / sec	Prevailing Wind Direction	Max Wind Speed m / sec	Monthly Rainfall in mm							Nos. of Days with Total Cloud Cover (Oktas)				
Avg. 1986 – 1990		Max	Min	Max	Min				1986	1987	1988	1989	1990	Total Avg.	Max. 24-Hourly	0	1-2	3-5	6-7	8
January	3	18.6	6.2	97	14	1.2	NE	3.8	12.3	41.2	23.4	56.1	19.0	30.5	42.1	12	7	10	2	0
February	2	19.6	7.2	98	26	1.6	SW	6.1	0	20.2	89.8	235.0	73.0	83.6	113.6	0	1	14	0	13
March	4	23.6	10.4	98	13	2.1	SW	11.1	55.8	288.2	174.1	34.0	186.0	147.6	68.3	9	5	9	6	2
April	3	23.6	11.4	100	30	2.8	SW	8.3	323.3	822.7	418.2	2016.0	2059.3	1127.9	786.2	3	4	11	7	5
May	7	23.8	16.6	100	40	1.7	SW	6.1	82.2	729.4	4967.8	1174.7	1428.1	1676.4	659.8	0	6	12	10	5
June	12	28.8	16.8	100	54	1.7	SW	10.0	1614.0	3934.0	3045.9	3249.5	3277.4	3024.2	957.0	0	2	5	11	12
July	22	25.4	17.8	100	67	2.1	SW	11.1	2264.8	5456.8	5219.1	6271.6	2850.5	4412.6	963.4	0	0	3	8	20
August	18	26.2	17.8	100	57	1.7	SW	12.2	1691.8	2194.6	6172.3	1184.6	1125.3	2473.7	667.1	0	1	6	10	14
September	11	26.4	14.8	100	54	1.7	SW	10.0	1195.2	2117.0	1918.7	1559.1	1649.5	1687.9	661.0	0	1	6	11	13
October	4	25.8	14.8	100	31	1.3	NE	7.8	772.1	144.1	1102.1	1253.7	1386.0	931.6	642.8	5	7	9	6	4
November	4	24.2	12.8	99	11	1.3	NE	9.5	257.7	70.3	406.6	58.0	29.5	164.4	209.1	9	7	10	3	1
December	2	19.0	6.8	100	18	1.2	NE	3.9	2.8	76.4	201.2	5.0	1.9	57.5	201.2	14	6	8	3	0
Annual Avg.	92	23.8	12.8	99	35	1.7	-	8.3	689.3	132.4.6	1978.4	1424.75	1173.7	-	-	-	-	-	-	-
Annual Total	-	-	-	-	-	-	-	-	8272	15895	23740	17097	14085	15818	-	52	47	103	77	86

**** Based on morning (0830 am) and evening (0530 pm) readings in a day except that of Rainfall***

As per the 5-years data (1986 to 1990), the clouds at Cherrapunji are low which prevail in the area throughout the year. The Oktas of cloud cover ranging from 3 to 8 prevail in months of May to October. The low clouds (0 to 1000 m from surface) resulting into high foggy conditions during monsoon seasons i.e. May to September. The foggy conditions also prevail during non-monsoon i.e. October to March. The incidences of thunder prevail during April to September.

The average annual rainfall (1986 to 1990) at Cherrapunji station has been observed to be 15,818 mm. The heaviest 24 hours rainfall during this period has been observed to be 963.4 mm on 5 July 1988. The average rainfall during 1951 to 1980 at Cherrapunji has been observed to be 11465.7 mm with the heaviest 24 hours rainfall of 985.5 mm observed on 13 September 1974.

Meteorological Information for Sylhet Meteorological Station of BMD for 1989 to 1999 is as under:

Table 4.4: Meteorological Data* for Sylhet (Lat 24º 54'; Long 91º, 53') for 1989 - 1999

Month	Frequency of Foggy days	Daily Temp (ºC)		Relative Humidity (%)		Mean Wind Speed	Prevailing Wind Direction	Max Wind Speed	Monthly Rainfall in mm										
Avg. 1989 – 1999		Min	Max	Max	Min	m/sec		m/sec	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	Average 1989- 1999
January	14	13.7	25.5	100	36	1.4	E	8.6	6	2	10	0	35	23	10	2	1	7	0	9
February	13	14.9	27.2	100	27.9	1.7	E	9.6	33	45	55	55	149	43	29	76	27	15	0	48
March	10	18.4	30.4	100	22.9	1.8	E,W	10.1	11	176	60	172	96	514	80	257	111	239	49	160
April	8	21	31.3	100	34.6	1.9	E	17.7	312	574	405	129	261	326	176	252	170	548	207	305
May	3	22.8	31.1	100	47.6	1.9	E	22.8	453	546	1063	544	587	342	327	759	347	366	731	551
June	2	24.4	31.2	100	54.5	1.6	E	17.7	370	551	1203	661	1099	584	941	518	796	858	472	732
July	1	25.1	31.5	100	54.3	1.4	E	14.2	1342	596	351	901	1174	757	874	745	681	1245	775	858
August	1	25.2	32	99.8	55.1	1.4	E,S	7.1	665	582	437	374	471	573	832	745	486	665	503	576
September	4	24.5	31.6	100	56.5	1.3	E	6.1	1081	1023	781	549	702	227	423	379	946	313	253	607
October	6	22.9	31.2	100	47.9	1.4	E	22.8	524	216	173	203	153	145	79	281	31	90	344	204
November	8	18.9	29.5	99.8	39	1.4	E	7.6	34	40	3	3	2	4	102	0	23	42	0	23
December	11	14.5	26.6	99.2	35.8	1.5	E	7.1	1	3	79	0	0	0	0	0	18	0	0	9
Annual Avg.	81	20.5	29.9	99.9	42.7	1.6	-	12.6	402.7	362.8	385	299.3	394.1	294.8	322.8	334.5	1818.5	365.7	277.8	-
Annual Total	-	-	-	-	-	-	-	-	4832	4354	4620	3591	4729	3538	3873	4014	3637	4388	3334	4083

* *Based on morning (6 am) and evening (6 pm) readings in a day except that of Rainfall.*

At Sylhet the foggy days prevail during winter ie from November to April. The average annual rainfall (1989 to 1999) observed is approx. 4080 mm. The heaviest 24 hours rainfall of 290 mm occurred on 13 April 1998 during 1989 to 1999.

Meteorological Information for area near Sunamganj is as under:

Table 4.5: Meteorological Data* for Sunamganj

Month	Daily Temp (ºC)		Relative Humidity (%)		Mean Wind Speed m/sec	Prevailing Wind Direction*	Rainfall (mm)
	Min	Max	Max	Min			
January	13.4	25.1	93	67	4.6	SE	24
February	13.9	26.8	88	57	5.1	E	42
March	17.4	30.6	83	51	4.6	NE	65
April	21.8	32.8	87	63	7.6	NE	192
May	22.4	32.1	93	79	3.6	E	696
June	24.6	30.8	96	82	3.1	SE	1370
July	25.3	31.2	97	83	6.2	S	594
August	24.3	31.6	95	84	2.6	NE	531
September	24.6	30.8	95	85	4.6	NE	655
October	22.4	30.2	96	84	4.1	NE	274
November	17.1	28.7	93	75	4.1	E	7
December	14.1	26.4	95	73	2.6	NE	6
Annual Avg.	20.1	29.8	93	75	4.4	-	371.4
Annual Total	-	-	-	-	-	-	4456

**Based on morning (6 am) and evening (6 pm) readings in a day except that of Rainfall.*

At Sunamganj, the annual rainfall observed is approx. 4456 mm.

Meteorological information has also been collected in the study area near the mine site during pre monsoon, post monsoon and winter seasons for a month. To collect the site-specific data, the meteorology station was established at Shella (near core zone). The methodology adopted for monitoring surface observations were as per the standard norms laid down by Bureau of India Standards (BIS) and India Meteorology Department (IMD).

Meteorological measurements were recorded at the selected station for monitoring of wind speed, wind direction, rainfall, ambient air temperature, relative humidity and cloud cover. On line weather monitoring system of Dyna lab make (model D2 2000) was installed at a central location in Shella Bazar, near ambient air quality (AAQ) station -*A1* at top of a building height. Cloud cover was recorded by manual observation. Summary of meteorological data generated near the proposed mine site area is as under:

Table 4.6: Meteorological Data* for Site (Lat 25º 12'; Long 91º, 37')

Season	Daily Temp (ºC)		Relative Humidity (%)		Mean Wind Speed m/sec	Prevailing Wind Direction	Max Wind Speed m/sec	Monthly Rainfall in mm	
	Max	Min	Max	Min				Total	Max. 24-Hourly
Pre monsoon	37.0	25.0	96	62	1.0	NE	4.1	620.0	112.3
Post monsoon	32.4	13.7	86	12	1.3	NE	4.2	14.0	8.0
Winter	29.9	9.3	95	9	1.3	NE	4.2	6.0	4.0

**Based on hourly data collected round the clock during the study period*

Wind direction also recorded during various seasons and are presented as windrose diagram in ***Figure 4.3 A to C***.

Based on the above tables, it may be concluded that the daily maximum and minimum temperatures recorded at site are mostly different than those recorded at Cherrapunji by IMD, however, these are more in line with that of Sylhet and Sunamganj locations in Bangladesh. The wind directions recorded at the site using continuous data logger, when compared with the Cherrapunji data, these are found to be inconsistent.

The Cherrapunji being at an elevation of 1313 m amsl and the mine site area at an elevation of 20 to 140 m amsl, the meteorology of the area around the mine site is mostly different than that of Cherrpunji, however it is more in line with that of Sylhet and Sunjamganj which are at an elevation level of 11 to 15 m amsl. The annual rainfall recorded at the site is in concurrence with that of recorded rainfall at Sylhet and Sunamganj. As per annual rainfall maps of IMD, the area adjoining the mine site receives 4000 mm of annual rainfall and 320 mm of 24-hour maximum rainfall .

This rainfall in the mine site area is more in concurrence with that of Sylhet and Sunamganj than with Cherrapunji.

Based on the above analysis, it is clear that the meteorology of the mine site area has least concurrence with that of Cherrapuji, however, it is more in line with that of Sylhet and Sunamganj.

4.3.7 Ambient Air Quality

To make an assessment of baseline ambient air quality, air monitoring study was carried out during pre-monsoon, post monsoon and winter season. The locations of the ambient air quality monitoring stations were established after studying the predominant wind direction, topographical parameters, vegetation, receptors' sensitivity, etc in the study area and also the relative location of the core zone (mine site).

The sampling stations locations are given in ***Table 4.7*** and the same are also shown in ***Figure 4.4***.

Table 4.7: Locations of Ambient Air Quality Monitoring Stations

Sl No	Locations	Station No	Direction from Mining Lease Area	Arial Distance from Mining Lease Area
1	Shella Bazar	A1	East	1.5
2	Jatap	A2	South East	3.0
3	Pyrkan	A3	East East South	1.0
4	Karda (Kyrdoh)	A4	West	4.5
5	Nonglait	A5	North West	3.5
6	Nongtrai	A6	North	2.0
7	Mawryngkhong	A7	North East	1.5
8	Disong	A8	East East North	1.5

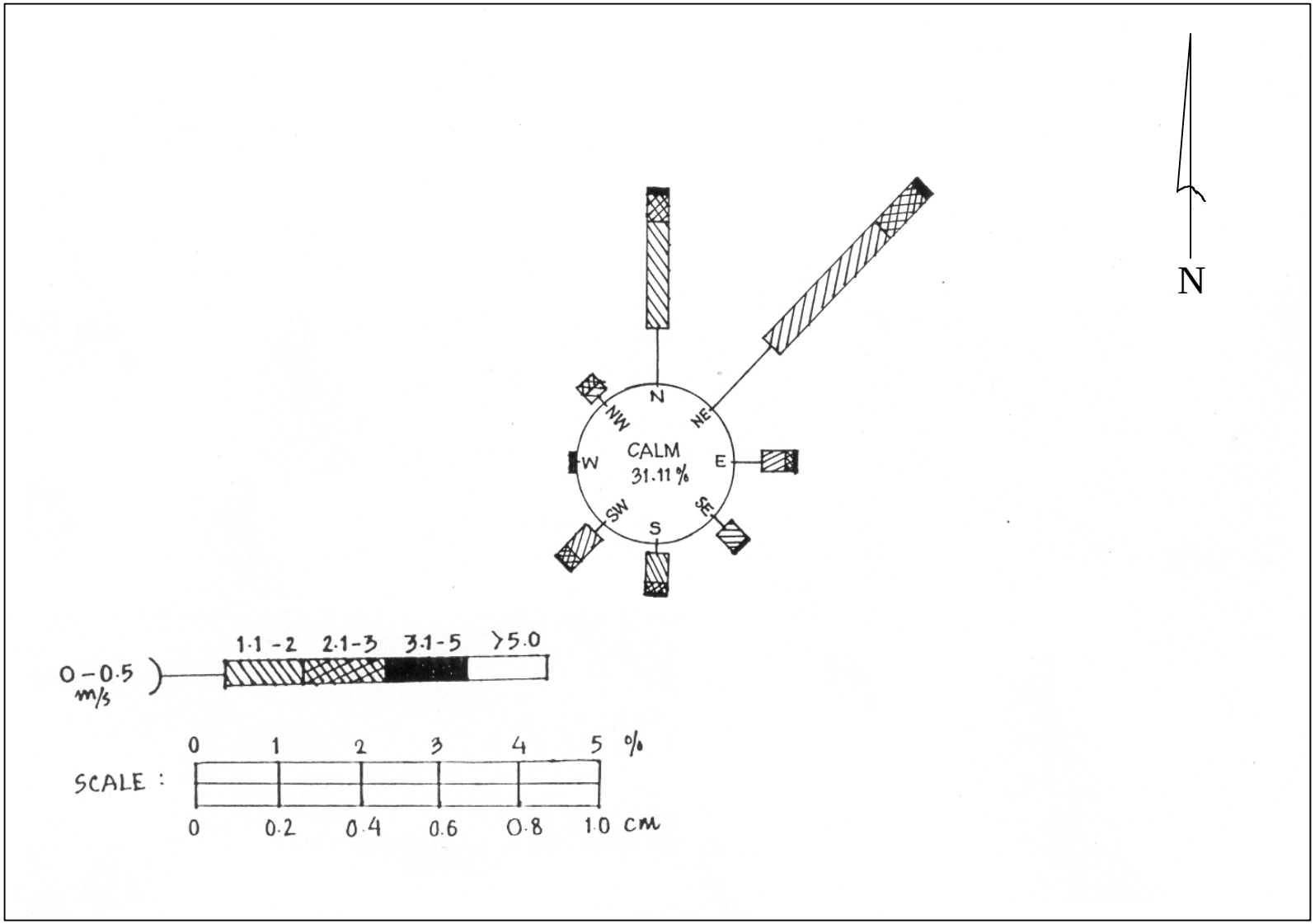


Figure 4.3A Windrose for the month of June

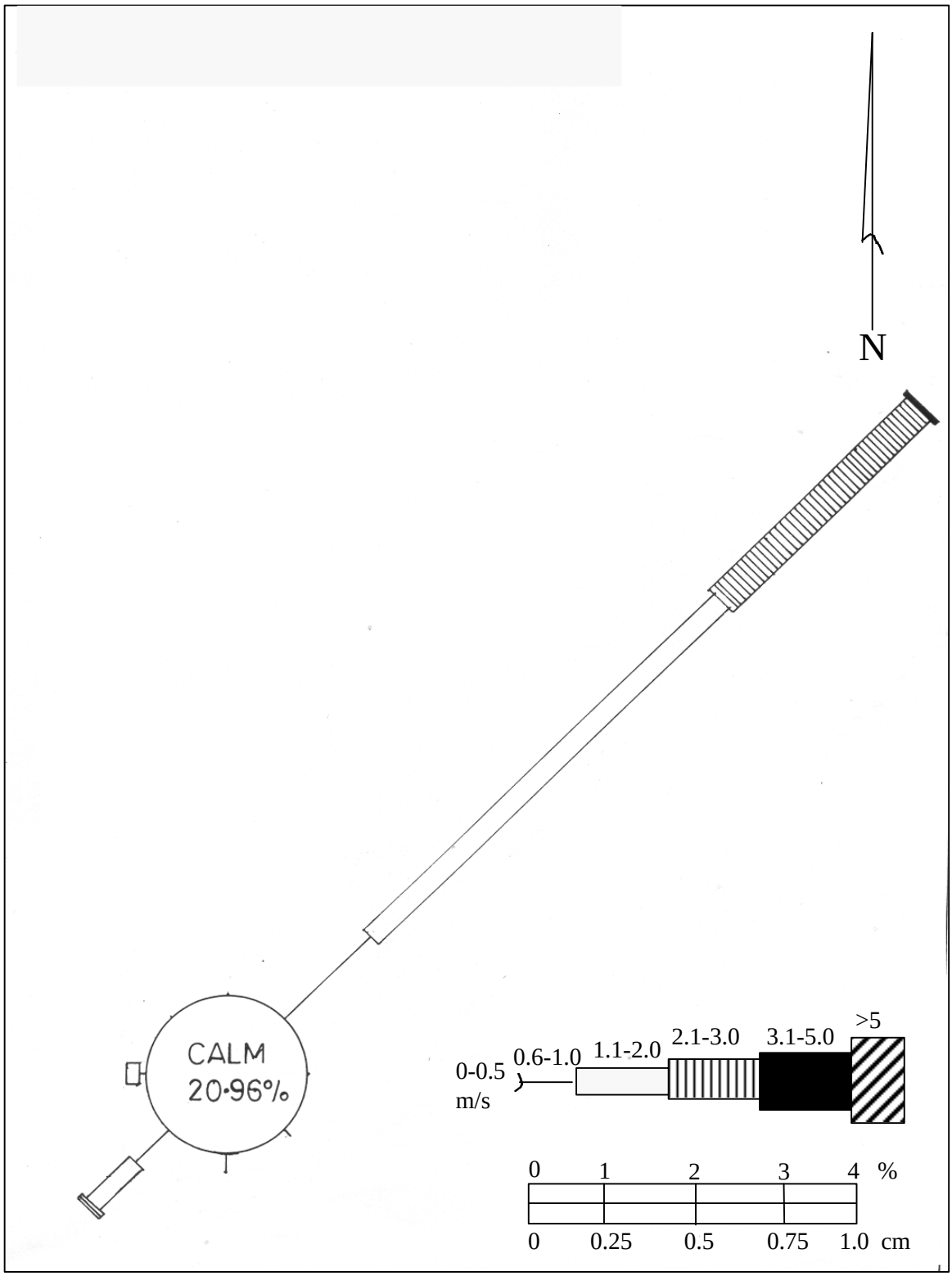


Figure 4.3B: Windrose for the month of November - December

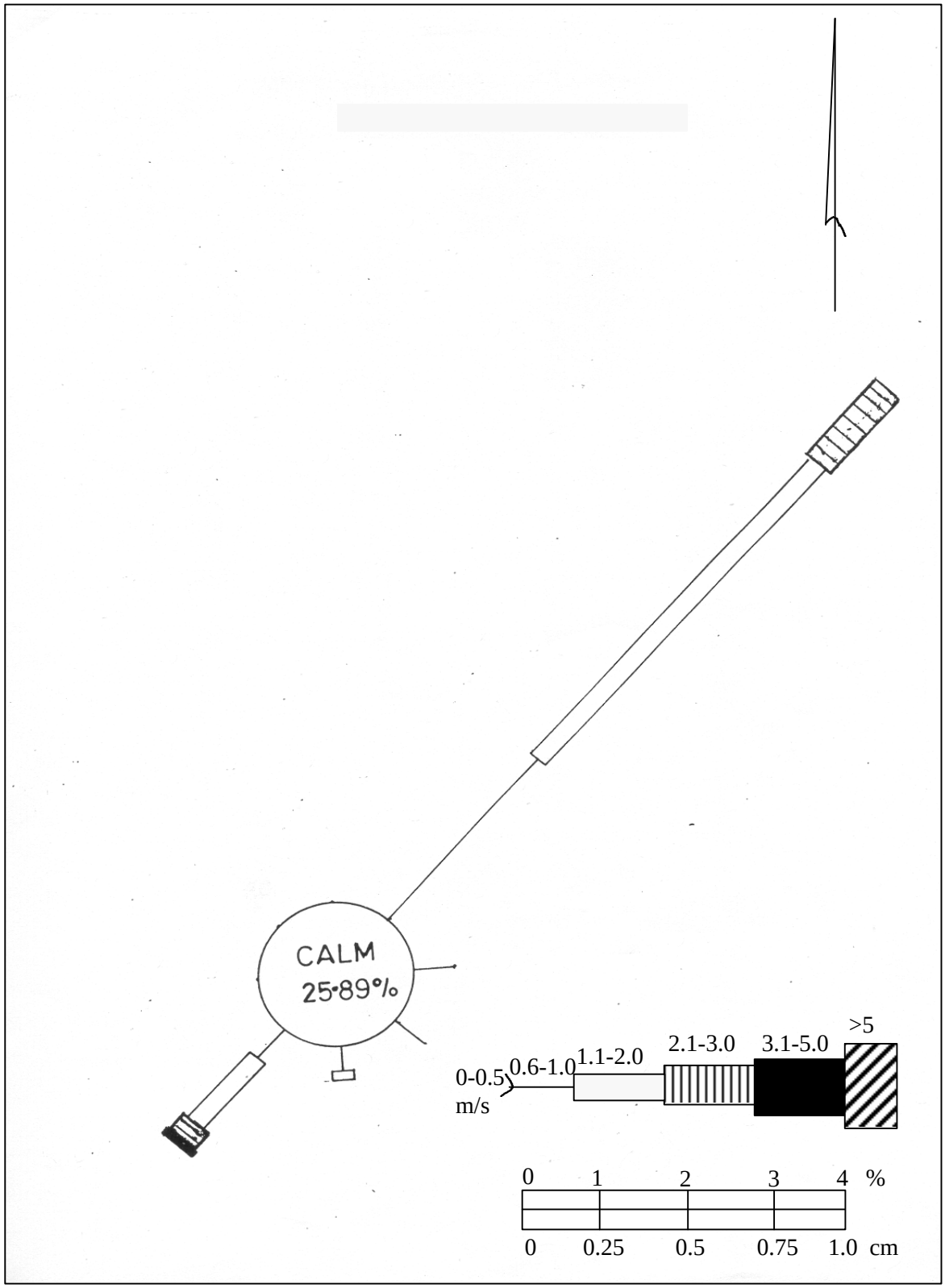


Figure 4.3C: Windrose for the month of February

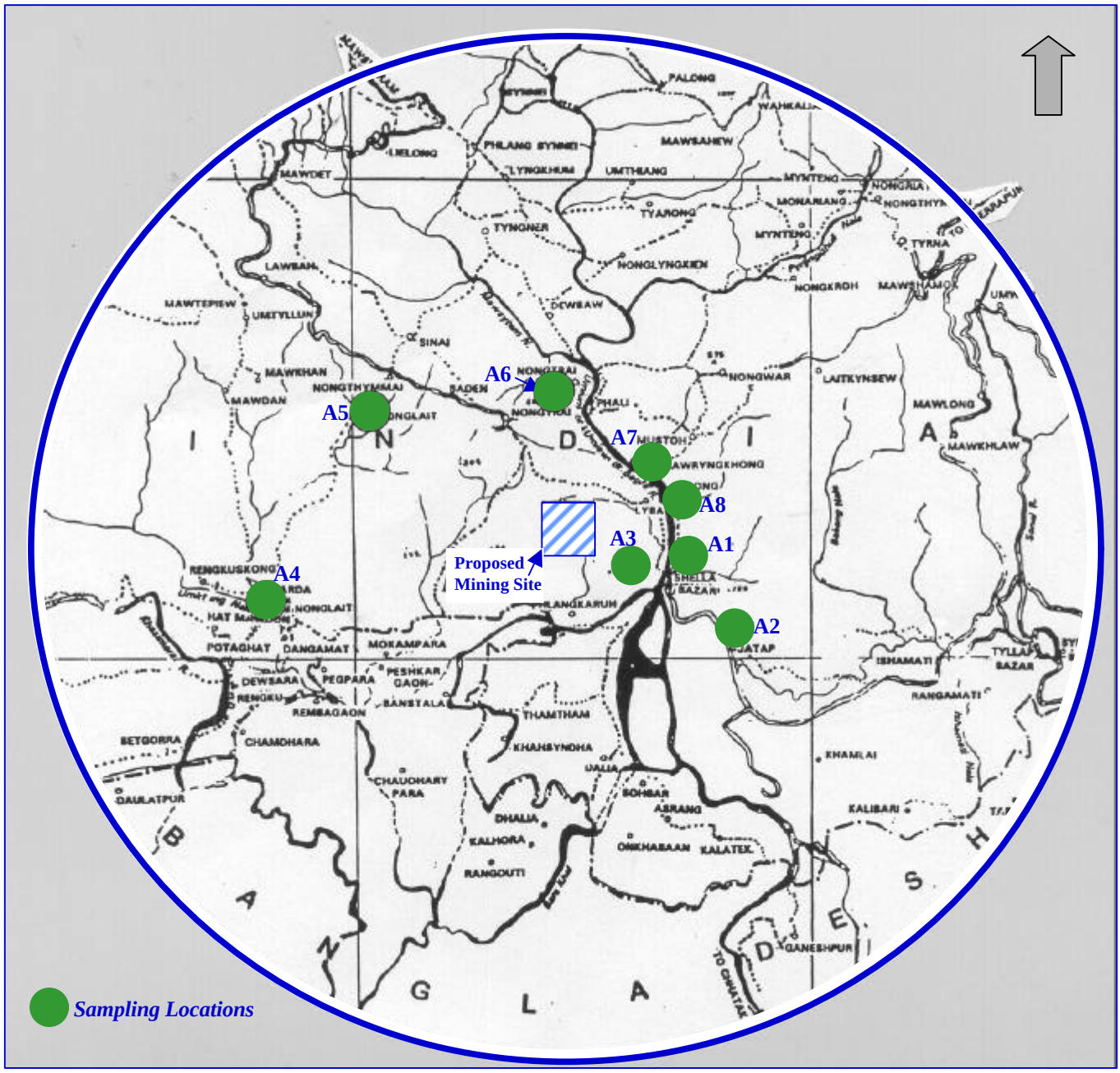


Figure 4.4: Ambient Air Sampling Locations

Description of Sampling Locations

Location A1: Shella Bazar

The location has been selected to assess the air quality levels in the core zone area of the proposed plant site. As the site is an open non-arable fallow land, therefore no residential buildings in the vicinity. The sampler was placed in the village located towards east of the proposed mining site at a distance of about 1.5 km on top of the terrace of two story building and is free from any obstructions. The location was away from the village road and did not experience any frequent vehicular movement. The primary source of background levels of air pollutants could be the commercial and domestic activities.

Micro meteorological monitoring instrument and sensors as well as dust fall collection apparatus were also installed on top of the building.

Location A2: Jatap

The village is located towards southeast ie up wind direction of the proposed mining site at a distance of about 3.0 km from the core zone. The sampler was placed on the terrace of one storey building. The major activity in the adjacent areas of the village is operation of lime kiln and the local limestone quarries. Cultivated land surrounds the location on one side. The village is very well connected to Cherrapunji and Shillong, by road.

Location A3 : Pyrkan

The village is located in the east east south (EES) direction from the proposed mining site, at a distance of about 1.0 km. The site was just opposite to Shella Bazar on the right bank of river Umium. The sampler was placed on the top of a single storey building. There is no activity in the area barring trading of limestone and further up the hill, there are some limestone quarries. The village is connected to Nongtrai, Mawsynram & Shillong by road. However, it is connected by boats to Shella.

Location A4 : Karda (Kyrdoh)

The village is located in the west and at a distance of about 4.5 kms from the proposed mining site. The sampler was placed on the top of a single storey building. There was no activity in the village except market days, once in every 4 days when petty business dealings occured. The village is well connected to state capital Shillong via Nongtrai, Mawsynram by road.

Location A5 : Nonglait

Nonglait near Nongthymai was identified as one of the ambient air quality monitoring station for crosswind direction. The sampler was placed on the top of a single storey building. The site is in the north west direction at a distance of approximately 3.5 km from the proposed mining site. The village has no major activity and is located on the highway joining Hat Mowdon to Mawsynram.

Location A6 : Nongtrai

The village is located towards north of proposed mining site at a distance of about 2.0 km. The sampler was placed on the top of a single storey building. The village is primarily residential and is located near the highway joining Hat Mowdon and Mawsynram.

Location A7 : Mawryngkhong

The village is located towards north east of the proposed mining site at a distance of about 1.5 km. The sampler was placed on the top of a single storey building. There was no major activity in the village.

Location A8 : Disong

Disong is very close to and in between Mawryngkhong and Shella Bazar. It is in the east-east-north direction from the proposed mine site, at a distance of about 1.5 km. The sampler was placed on the top of a single storey building. The village has no major activity.

Sampling and Testing Methodology

The air samples were collected for the following air quality determinants:

- Suspended Particulate Matter (SPM);
- Respirable Suspended Particulate Matter (RSPM);
- Oxides of Nitrogen (NO_x);
- Sulphur Dioxide (SO_2);
- Carbon Monoxide (CO); and
- Hydrocarbon(HC).

Sampling schedule: 24 hourly samples for SPM, RSPM, SO_2, and NO_x were collected from each station, by continuous monitoring for 24 hours whereas CO and HC were analysed based on grab samples taken into the myller bags at a frequency of twice a week for four weeks.

The sampling and analysis of ambient air quality parameters was carried out as per the procedures detailed in relevant Parts of IS-5182 (Indian Standards for Ambient Air Quality Parameters). Brief of these testing procedures are given in ***Table 4.8.***

Table 4.8 Procedure For Determining Various Air Quality Parameters

Parameters	Testing Procedure
RSPM	Gravimetric method using respirable dust sampler
SPM	Gravimetric method using respirable dust sampler IS:5182
NO_x	Absorption in dilute NaOH for colorimetric estimation with sulphanilamide and N(1-Naphthyl) Ethylene Diamine Dihydrochloride and Hydrogen Peroxide (IS:5182, 1975, Part V)
SO_2	Absorption in Sodium Tetra Chloromercurate followed by colorimetric estimation using p-Rosaniline Hydrochloride and Formaldehyde (IS:5182 Part II, 1969)
CO	GC-FID method IS: 5182 (Part XVII)

Parameters	Testing Procedure
HC	GC- FID method IS: 5182 (Part X)

Existing Ambient Air Quality

The summary of air quality during pre-monsoon, post-monsoon and winter seasons is given in ***Table 4.9*** and is being compared with the national ambient air quality standards prescribed by Central Pollution and Control Board (CPCB) for industrial and residential, rural and other area.

On perusal of the ***Table 4.9*** it is evident that all monitored values in various seasons are well within the limits presented by central Pollution Control Board for residential, rural and other areas. The results are summarised below:

SPM: The highest SPM concentration (99 µg / m^3) in the ambient air was recorded at Nongtrai (A4) during pre-monsoon season while lowest SPM concentration (27 µg / m^3) was found to be at Disong (A8) during pre-monsoon season on the rainy day. Average SPM concentration values monitored in various seasons varied from 37 to 76 µg / m^3. All monitored values of SPM are well below the specified limit of 200 µg / m^3 for residential, rural and other areas.

RSPM: The highest RSPM concentration was observed 85.6 µg / m^3 at Jatap (A2) during post monsoon season whereas lowest RPM concentrations was observed 8.6 µg / m^3 at Disong(A8) during pre-monsoon season on the rainy day.The average RSPM concentration in the ambient air ranged from 10.8 to 73.2 µg / m^3 during all three seasons. However, all monitored values of RPM are well below the specified limit of 100 µg / m^3 for residential, rural and other areas.

SO_2: The highest SO_2 concentration was found to be 7.8 µg / m^3 at Shella Bazar (A1) during pre-monsoon season whereas lowest SO_2 concentration was found to be 3.2 µg / m^3 at Disong (A8) during winter season. Average SO_2 concentration varied from 3.8 to 6.4 µg / m^3. All monitored values of SO2 are quite low and well below the specified limit of 80 µg / m^3 for residential, rural and other area.

NO_x: The highest NO_x concentration was found to be 14.5 µg / m^3 at Jatap (A2) during pre-monsoon season whereas lowest NO_x concentration was found to be 5.0 µg / m^3 at Disong (A8) during winter season. Average values of NO_x for all seasons ranged between 7.4-11.6 µg / m^3 . All the monitored values are quite low and well below the specified limit of 80 µg / m^3 for residential, rural and other areas.

CO: All monitored values of CO during various seasons range between 320 to 540 µg / m^3 . All monitored values of CO are quit low and well below specified limit of 2000 µg / m^3 for residential, rural and other areas.

HC: The monitored values of HC in ambient air during all seasons range between 79 to 216 µg / m^3. No limit is specified by CPCB for HC in ambient air.

Based on the above discussions, it may be concluded that air quality of the area is less susceptible with respect to seasonal variations. The variation is mainly contributed by local residential and commercial activities.

Table 4.9: Detailed Ambient Air Quality in the study area

	Shella Bazar (A1)			Jatap(A2)			Pyrkan(A3)			Karda (A4)			Nonglait (A5)			Nongtrai (A6)			Mawryngkhong (A7)			Disong (A8)		
	I	II	III	I	II	III	I	II	III	I	II	III	I	II	III	I	II	III	I	II	III	I	II	III
SPM Concentration																								
Maximum	84.0	83.7	83.9	79.0	93.0	85.9	68.0	66.5	88.3	52.0	62.0	65.0	90.0	76.2	66.9	99.0	83.3	69.4	65.0	68.7	71.9	54.0	64.2	69.4
Minimum	34.0	53.0	54.3	42.0	57.4	47.9	36.0	48.6	62.5	30.0	42.5	39.8	31.0	49.3	53.7	38.0	60.8	55.6	32.0	45.4	46.7	27.0	44.1	40.4
Average	55.0	69.5	70.6	58.0	80.0	73.8	50.0	59.1	76.4	37.0	51.7	52.3	51.0	63.6	58.7	73.0	71.1	61.1	43.0	59.4	59.5	38.0	55.4	58.2
98%tile	82.0	83	83.0	79.0	92.9	85.6	68.0	66.2	87.5	51.0	61.4	63.7	89.0	75.5	66.3	99.0	82.6	68.6	64.0	68.0	71.2	53.0	63.9	68.7
RSPM Concentration																								
Maximum	14.7	75.3	78.9	14.3	85.6	79.6	13.3	61.3	83.3	12.1	55.5	61.9	15.3	68.7	64.4	16.7	74.5	66.2	12.8	64.3	66.9	12.4	58.7	66.3
Minimum	11.4	48.0	51.1	10.4	52.6	46.7	10.5	44.8	61.2	9.3	38.0	39.8	9.8	47.3	51.7	11.0	57.3	51.8	10.2	42.3	45.5	8.6	40.4	39.1
Average	12.7	64.1	67.2	12.6	73.2	69.8	11.9	54.5	72.6	10.8	46.8	51.0	12.1	58.2	56.2	14.0	65.9	58.0	11.4	54.6	57.1	10.8	50.7	55.8
98%tile	14.6	74.7	78.1	14.2	85.2	79.5	13.2	61.1	82.5	12.0	55.1	60.8	15.2	68.1	63.7	16.7	74.2	65.6	12.7	63.5	66.5	12.4	58.4	65.7
SO2 Concentration																								
Maximum	7.8	6.4	4.8	6.1	7.4	4.8	5.8	6.1	4.7	6.1	5.1	4.3	5.9	6.4	4.3	6.0	6.1	4.4	6.2	6.3	4.3	6.0	6.1	4.3
Minimum	4.8	5.3	4.1	4.8	5.1	4.5	4.4	4.7	4.1	4.8	4.2	3.7	4.4	5.3	3.8	4.8	4.8	3.7	4.8	4.7	3.6	4.8	4.5	3.2
Average	5.9	6.1	4.5	5.6	6.4	4.6	5.2	5.6	4.4	5.3	4.7	4.0	5.3	5.7	4.1	5.4	5.5	4.1	5.6	5.6	4.0	5.2	5.5	3.8
98%tile	7.6	6.4	4.8	6.1	7.4	4.8	5.8	6.1	4.7	6.1	5.1	4.3	5.9	6.3	4.3	6.0	6.1	4.4	6.2	6.2	4.3	6.0	6.1	4.3
NOx Concentration																								
Maximum	14.5	12.5	12.7	12.8	12.9	12.7	10.1	12.4	12.0	9.6	9.8	9.5	12.4	10.1	11.4	13.7	10.5	11.4	9.7	10.4	11.4	9.7	10.8	12.1
Minimum	6.6	9.3	9.5	7.8	8.9	9.5	7.8	8.6	7.6	6.5	8.6	5.1	6.6	9.1	6.4	7.5	8.2	7.6	6.8	8.8	6.3	7.6	8.8	5.0
Average	10.6	10.8	10.9	9.8	11.6	11.4	9.0	10.5	10.5	7.5	9.2	7.4	8.9	9.6	9.0	10.0	9.6	9.4	8.5	9.7	9.3	8.5	9.9	8.3
98%tile	14.2	12.4	12.7	12.4	12.9	12.6	10.1	12.3	12.0	9.4	9.8	9.5	12.0	10.1	11.4	13.5	10.5	11.2	9.7	10.4	11.2	9.6	10.7	11.8
CO Concentration																								
Maximum	492	511	540	526	536	525	423	430	511	469	458	494	458	459	518	526	490	528	435	411	501	423	389	435
Minimum	389	432	496	423	432	494	343	381	471	412	395	467	377	346	481	446	460	489	332	340	421	320	340	393
Average	443	473	519	475	475	510	382	411	493	445	426	480	418	411	498	486	475	509	378	380	479	353	364	419
98%tile	489	508	540	523	535	524	420	429	510	468	455	493	456	457	516	525	490	527	432	409	500	415	387	434
HC Concentration																								
Maximum	190	193	197	196	164	169	170	178	192	124	138	146	157	164	172	216	183	193	124	160	172	118	145	170
Minimum	111	142	164	134	128	145	111	143	167	85	104	133	98	111	157	163	159	171	92	112	150	79	98	143
Average	139	166	181	171	140	158	139	160	180	106	121	140	121	144	164	187	173	184	107	134	162	91	124	160
98%tile	180	192	197	195	161	169	169	176	192	123	138	146	154	163	172	214	183	192	123	157	172	115	145	170

Note: 1. Unit:µg / m3 (microgram / m3)

I - Pre-monsoon season

II - Post - monsoon season

III - Winter season

4.3.8 Dustfall

Dust fall measurements were also carried out at two locations, namely, Shella Bazar and Nongtrai as per IS: 5182 part-I. The results of dust fall measurement are presented in ***Table 4.10***. It is evident that dust fall is always higher at Nongtrai in comparison to Shella Bazar. Highest dust fall is recorded during winter season at both locations whereas lowest in pre-monsoon season.

Table 4.10. Dust fall near the Mine Area

	Shella Bazar			Nongtrai		
	I	**II**	**III**	**I**	**II**	**III**
Dust Fall rate (MT/km2/month)	0.0957	0.1107	0.1264	0.1051	0.1198	0.1309
Heavy Metal	NIL	NIL	NIL	NIL	NIL	NIL

Note : I- Pre monsoon season, II- Post monsoon season & III- Winter season

4.4 NOISE QUALITY

Noise in general is sound, which is composed of many frequency components of various loudness distributed over the audible frequency range. The most common and universally accepted scale is the *A weighted Scale* which is measured as dB (A). This is more suitable for audible range of 20 to 20,000 Hz.

Investigation criteria

A preliminary reconnaissance survey has been undertaken to identify the major noise generating sources in the area. Noise levels were recorded for 10 minutes in every clock hour for a continuous 24-hour period at 15 locations in the study area. The environment setting of noise monitoring locations are given in ***Table 4.11*** and depicted in ***Figure 4.5***.

Table 4.11: Details of Noise Level Monitoring Locations

Sr No	Locations	Direction wrt Plant Site	Distance wrt Plant Site, Km	Details of the Surroundings
1.	Phlankaruh	S	1-1.5	The location has been selected to assess noise levels near the mine site in residential area.
2.	Nongtrai	N	2	The location has been selected to assess noise levels near the mine site in residential area.
3	Kyrdoh	W	4.5	The location has been selected to assess noise levels in the residential area.
4	Tham Tham	S	3.0	The location has been selected to assess noise levels in a residential area with light vehicular movement.. Monitoring point is selected near the market area characterised with heavy

Sr No	Locations	Direction wrt Plant Site	Distance wrt Plant Site, Km	Details of the Surroundings
				vehicular traffic and crowd.
5	Jatap	SE	3.0	The location has been selected to assess noise levels in the traffic area and mining activities
6.	Nonglait	NW	3.5	The location has been selected to assess noise levels in the residential area. The location has been selected to assess noise levels near a hospital. A village road passes nearby.
7.	Mustoh	ENE	2.5	The location has been selected to assess noise levels in the residential area.
8.	Pyrkan	EES	1.0	The location has been selected to assess noise levels in the residential area.
9	Mawryngkhong	NE	1.5	The location has been selected to assess noise levels in a residential area..
10	Hat Mawdon	WWS	5	The location has been selected to assess noise levels in a residential area with light vehicular movement.
11	Disong	EEN	1.5	The location has been selected to assess noise levels in a residential area with light vehicular movement.
12	Nongwar	NE	3.5	Residential houses surround the monitoring point with vehicular movement along the highway.
13	Shella Bazar	E	1.5	The location has been selected to assess the noise levels in the commercial area The monitoring pt. Is located near the state highway and shops during market day
14	Shella Bazar	E	1.5	The location has been selected to assess the noise levels in the area without commercial activities.
15	Mine Lease Area	Core	0.0	The location has been selected to assess the noise levels in the mining area and thereby determine a baseline status.

Assessment Criteria

Leq is the equivalent continuous sound level that is equivalent to the same sound energy as the actual fluctuating sound measured in the same period. This is necessary because sound from noise source often fluctuates widely during a given period of time. This is calculated from the following:

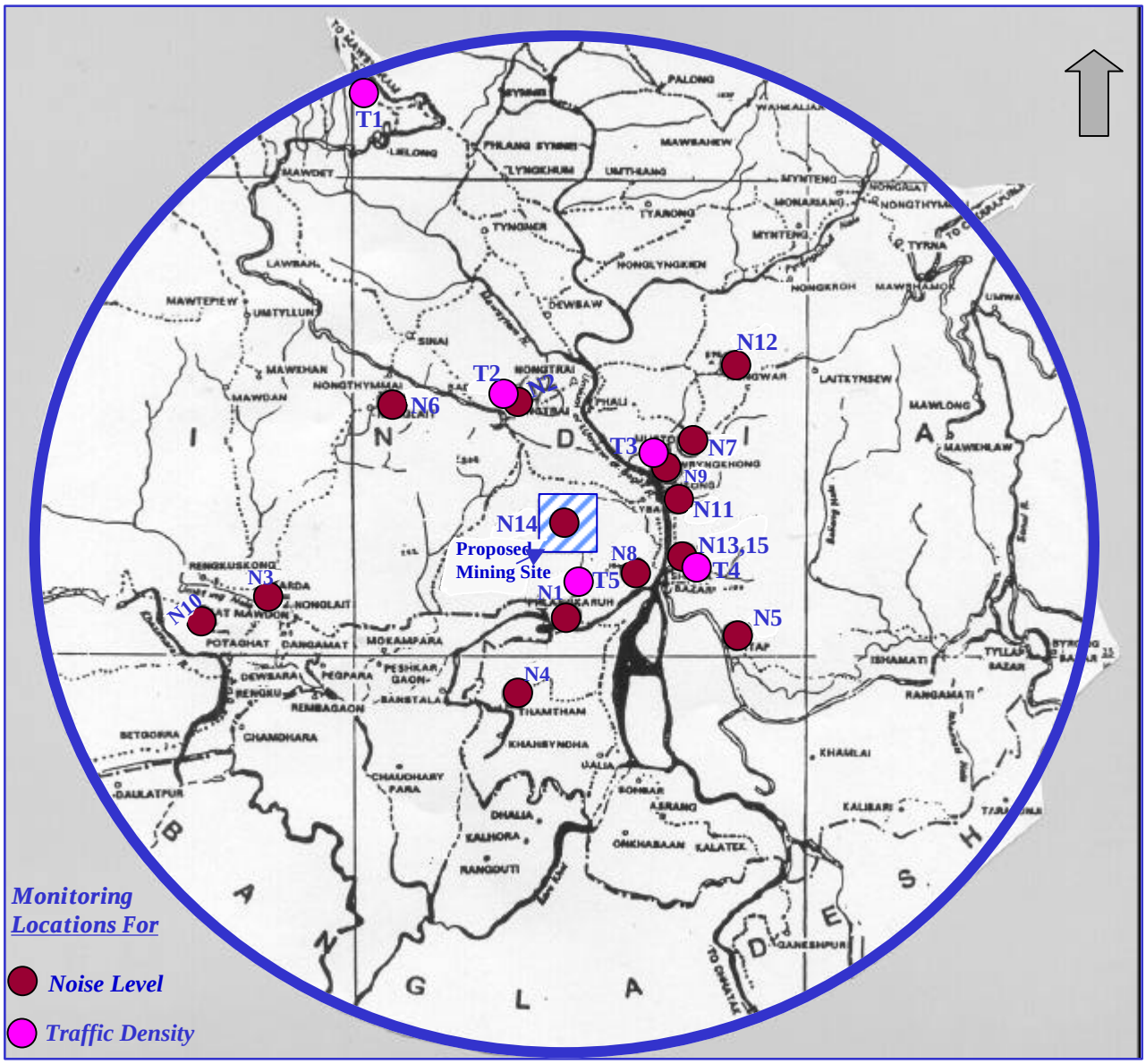


Figure 4.5: Noise Level & Traffic Density Monitoring Locations

L_{day} is defined as the equivalent noise level measured over a period of time during day (6 am to 10 pm).

L_{night} is defined as the equivalent noise level measured over a period of time during night (10 pm to 6 am).

A noise rating developed by *Environment Protection Agency, USEPA* for specification of community noise from all the sources is the Day-Night Sound Level, (L_{dn}).

Day-Night Sound Level (L_{dn}):

The noise rating developed for community noise from all sources is the Day-Night Sound Level (L_{dn}). It is similar to a 24 hr equivalent sound level except that during night time period (10 pm to 6 am) a 10 dB (A) weighting penalty added to the instantaneous sound level before computing the 24 hr average.

$$L_{eq} = 10\log\frac{1}{T}\sum_{i=1}^{N} Ti(10)^{\frac{Li}{10}}$$

$where T = total\ time\ of\ sampling,$

$Ti = Time\ duration\ of\ ith\ phase,$

$N = number\ of\ phases,\ and$

$Li = L_{eq}\ for\ the\ ith\ phase$

This night time penalty is added to account for the fact that noise during night when people usually sleep is judged as more annoying than the same noise during the day time.

The L_{dn} for a given location in a community may be calculated from the hourly L_{eq}'s, by the following equation.

$$L_{dn} = 10 \log \{1/24[16(10^{Ld/10}) + 8\ (10^{(Ln+10)/10})]\}$$

Where, L_d is the equivalent sound level during the day time (6 am to 10 pm) and L_n is the equivalent sound level during the night time (10 pm to 6 am).

4.4.2 Existing Noise Environment

The noise level monitored during the three seasons are given in ***Table 4.12*** in the form of L_{day}, L_{night}, and L_{dn} and compared with the standard prescribed by CPCB.

On perusal of ***Table 4.12,*** it is found that maximum L_d was observed to be 70.9 dB(A) at Jatap (N5) during post monsoon season while minimum noise L_d was observed to be 50.6 dB(A) at Phlangkaruh (N1) during pre monsoon season. L_n was observed to be 58 dB(A) at Nongtrai (N2) during pre monsoon season while minimum noise L_n was observed to be 42.6 dB(A) at Kyrdoh (N3) during winter season. Seasonal variation and exceeded values of noise level are mainly attributed to the local domestic activities.

Table 4.12: Equivalent Noise Levels in the study area

S.N	Station	CPCB norms L_{eq}(dBA)		Day Time Leq (L_d) (dBA)			Night Time Leq (L_n) (dBA)			Day – night Leq (L_{dn}) (dBA)		
		Day Time	Night Time	I	II	III	I	II	III	I	II	III
1	Phlangkaruh (N1)			51	50.6	64.2	45	46.3	49.9	53	53.7	62.3
2	Nongtrai (N2)	Industrial area : 75	Industrial area : 70	60	59.8	63.9	58	52.2	47.9	64	60.8	62.4
3	Kyrdoh (N3)			54	70.5	64.9	47	48.3	42.6	55	68.6	63.0
4	Thamtham (N4)			53	51.3	61.7	47	44.9	46.6	53	53.0	60.3
5	Jatap (N5)			66	70.9	64.7	61	47.2	51.5	68	69.0	63.7
6	Nonglait (N6)	Commercial area : 65	Commercial area : 55	52	70.3	64.2	46	48.2	49.5	54	68.4	62.9
7	Mustoh (N7)			54	53.5	63.6	48	46.1	48.4	56	54.6	62.1
8	Pyrkan (N8)			53	70.3	67.4	46	45.9	48.8	54	68.3	65.6
9	Mawryngkhong(N9)			48	64.1	63.9	45	50.7	50.8	51	63.1	62.9
10	Hatmawdan (N10)			58	65.9	68.6	46	48.4	51.0	57	64.3	66.9
11	Disong (N11)			51	55.4	63.4	50	46.5	48.9	56	55.8	62.1
12	Nongwar (N12)			57	60.2	64.5	53	45.2	49.9	60	58.9	63.2
13	Shella Bazar (Mkt day) (N13)			67	70.9	68.9	48	48.4	47.5	65	69.0	67.0
14	Mine site (N14)			56	55.3	64.4	48	52.8	49.1	57	59.7	63.0
15	Shella Bazar (N15)			56	65.9	67.4	50	45.5	50.2	58	64.0	65.8

Note : I- Pre monsoon season, II- Post monsoon season & III- Winter season

4.5 TRAFFIC DENSITY

Primarily there are two main road arterial roadways that connect various parts of the study area. Two-lane motorable all season road originating from the Mawsynram leads to Hat Mowdon terminating near the boarder post south west of the study area. While another road originates from Cherrapunji and terminates at Shella, east of the site. The site area is presently approached from the southern portion through a motorable road known as border road, that branches from Mawsynram– Hat Mowdon. Apart from this major roadways the study area is criss-crossed with several rural road networks. Traffic movements with respect to heavy motor vehicles, light motor vehicles and two wheelers were recorded in 24 hourly basis at five locations. Assessments of these sources were based on the surveys for traffic density around the proposed mining lease area. The locations of the sampling points as shown in ***Figure 4.5*** and the assessment criteria are mention in the ***Table 4.13*** below

Table 4.13 Locations for Traffic Density

Sl No.	Road	Location	Direction wrt to site	Details of the Surrounding
1`	Mawsynram- Hat Mowdon (T1)	Mawsynram	NW	Nearest major highway
2	Do (T2)	Nongtrai	N	Assess traffic density in boarder road
3	Cherra- Shella(T3)	Mawkhlan	NE	Proximity to Cherrapunji township
4	Do (T4)	Shella Bazar	E	Important business centre
5	Border Road(T5)	39 Pillar Stone	S	Nearest metal road from site

Existing Traffic Volumes

Observations on vehicular movement were recorded for 24 hours and average frequency of the traffic movement was recorded during monitoring period (refer to ***Table 4.14***).

Table 4.14 Summary of Existing Traffic Volumes (24 hourly basis)

Sl no	Traffic density	Sampling Locations				
		Mawsynram Road	Nongtrai	Mawkhlan	Shella Bazar	39 Pillar Stone
Total number of vehicles						
1	Pre-monsoon season	700	23	22	27	23
2	Post – monsoon season	789	35	31	35	31
3	Winter season	852	49	50	47	44
Heavy Motor vehicles (%)						
1	Pre-monsoon season	65.6	17.4	63.6	33.4	69.6
2	Post – monsoon season	66.3	60.0	71.0	34.3	87.1
3	Winter season	66.8	69.4	76.0	38.2	88.6
Light motor Vehicles(%)						
1	Pre-monsoon season	31.3	73.9	36.4	44.3	30.4
2	Post – monsoon season	31.9	34.3	19.3	54.3	9.7
3	Winter season	32.2	30.6	20.0	59.7	9.1
Two & three Wheelers (%)						
1	Pre-monsoon season	3.1	8.7	-	22.2	-

Sl no	Traffic density	Sampling Locations				
		Mawsynram Road	Nongtrai	Mawkhlan	Shella Bazar	39 Pillar Stone
2	Post – monsoon season	1.8	5.7	9.7	11.4	3.2
3	Winter season	1.0	0.0	4.0	2.1	2.3

4.6 WATER QUALITY

Reconnaissance survey was undertaken and monitoring locations were finalised based on:

- Location of water courses; and
- Location of residential areas representing different activities / likely impact areas.

The samples collected were examined for physio-chemical, heavy metals and bacteriological parameters in order to assess the effect of industrial and other activities on surface and ground water. The samples were collected and analysed as per the procedures specified in '*Standard Methods for the Examination of Water and Waste Water*' published by American Public Health Association (APHA) as per guidelines of Bureau of Indian Standards' IS:10500 - 1991 specifications.

Grab water samples were collected from 15 identified locations during the study period in pre-monsoon, monsoon season, post-monsoon and winter season to assess the existing water quality in the study area. The details of the water sampling locations are shown in the ***Table 4.15*** and also marked in the ***Figure 4.6***.

Table 4.15 Details of Water Quality Monitoring Stations

Station	Approx. Distance from the mine site (km)	Direction from mine site	Particulars
W1	4.5	NW	Mawsynram Nadi
W2	6.0	NE	Pryringithull Nala
W3	1.5	NE	Umium River, near Maweyngkong
W4	1.5	E	Upstream of Umium River, near Shella Bazar
W5	2.0	SE	Downstream of Umium River, near Shella Bazar
W6	3.5	S	Further Downstream of Umium River, near Dalia
W7	2.5	SE	Nala near Jatap
W8	6.0	ESE	Nala near Ishamati
W9	1.0	NW	Fotsgnet stream water
W10	2.0	N	Nala near Nongtrai
W11	1.1	S	Stream 1 near 39km milestone
W12	1.2	S	Stream 2 near 39 Km milestone
W13	1.3	S	Stream 3 furlong ahead of 39 Km milestone
W14	1.4	S	Stream 4 Furlong ahead of 39 km milestone
W15	1.5	S	Downstream of Phalangkaruh river

The results of water quality in the area during the four seasons namely: pre monsoon, monsoon, post monsoon and winter seasons are summarised in ***Table 4.16.***

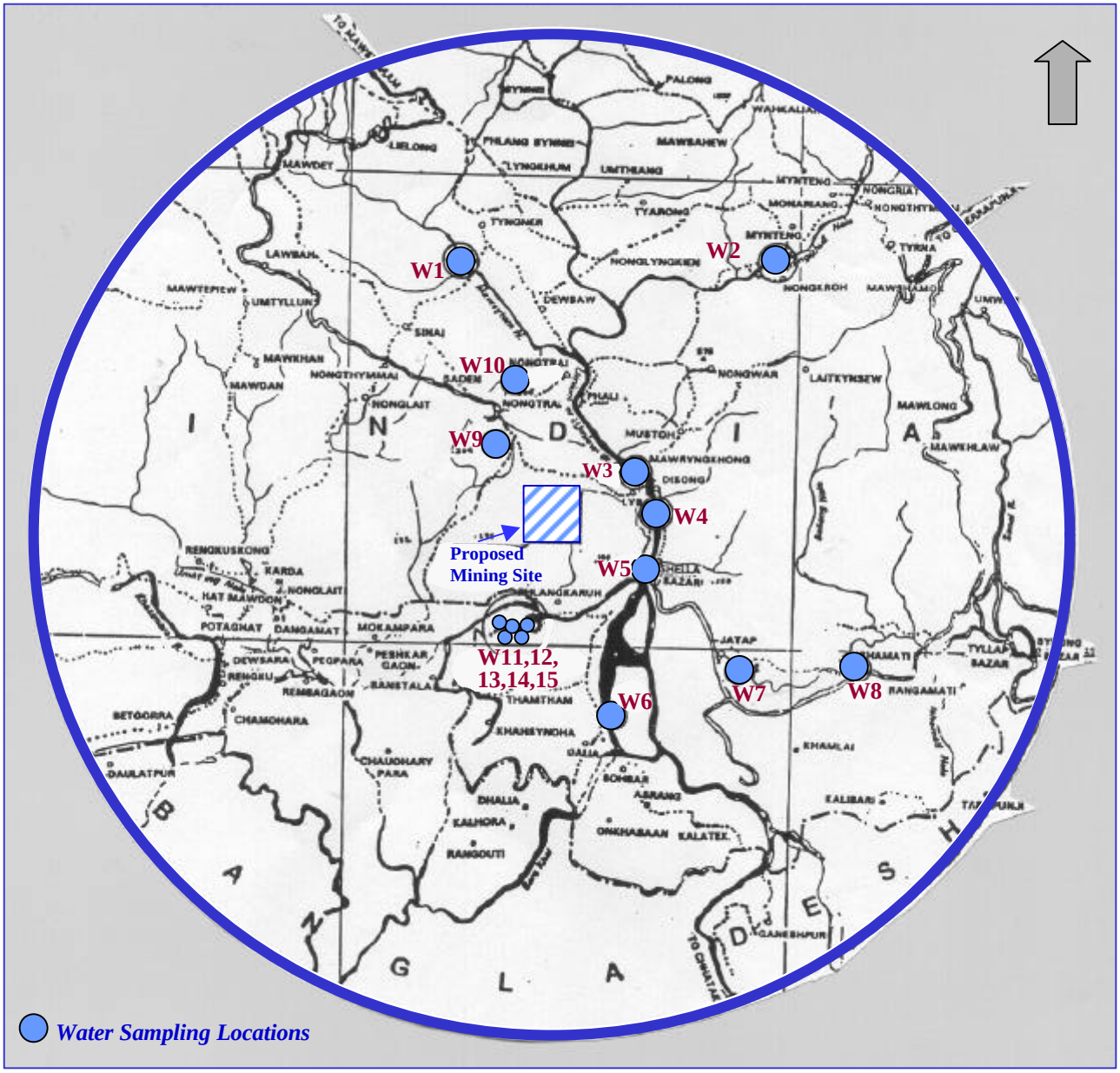


Figure 4.6: Water Sampling Locations

Table 4.16: Water Quality of the Study Area

	Colour, Cobalt Units				Odour				Turbidity				pH Value				Total Hardness as $CaCO_3$ (mg/l)			
	I	**II**	**III**	**IV**	**I**	**II**	**III**	**IV**	**I**	**II**	**III**	**IV**	**I**	**II**	**III**	**IV**	**I**	**II**	**III**	**IV**
W1	<10	<10	<10	< 10	Unob	Unob	Unob	Unob	5	7	5	5	7.6	7.8	7.6	7.9	20.6	22.1	35.3	26.78
W2	<10	<10	<10	< 10	Unob	Unob	Unob	Unob	8	10	8	7	6.6	6.3	7.8	6.6	18.2	15.2	98.0	20.15
W3	<10	<10	<10	< 10	Unob	Unob	Unob	Unob	7	8	7	6	6.4	6.7	7.8	7.0	23.5	21.1	92.12	23.54
W4	<10	<10	<10	< 10	Unob	Unob	Unob	Unob	4	6	4	5	7.3	7.6	7.6	7.8	15.68	21.5	29.40	26.9
W5	<10	<10	<10	< 10	Unob	Unob	Unob	Unob	3	9	3	4	6.1	7.0	7.0	7.2	17.9	22.8	27.44	30.25
W6	<10	<10	<10	< 10	Unob	Unob	Unob	Unob	7	10	7	8	6.4	6.8	7.1	7.0	19.8	23.1	11.76	27.37
W7	<10	<10	<10	< 10	Unob	Unob	Unob	Unob	6	12	6	8	7.3	7.4	6.6	7.5	43.12	36.8	21.56	40.2
W8	<10	<10	<10	< 10	Unob	Unob	Unob	Unob	7	10	7	9	6.3	6.6	7.8	6.7	12.2	14.1	64.68	14.22
W9	<10	<10	<10	< 10	Unob	Unob	Unob	Unob	3	4	3	5	7.6	7.4	8.0	7.8	25.4	26.9	43.12	30.5
W10	<10	<10	<10	< 10	Unob	Unob	Unob	Unob	8	10	4	9	6.4	7.0	7.6	7.3	3.92	11.54	35.28	14.4
W11	<10	<10	<10	< 10	Unob	Unob	Unob	Unob	8	8	8	7	7.7	7.0	7.8	7.3	82.32	76.96	98.00	83.60
W12	<10	<10	<10	< 10	Unob	Unob	Unob	Unob	7	13	7	9	7.7	7.3	7.8	7.5	70.56	77.80	92.12	79.4
W13	<10	<10	<10	< 10	Unob	Unob	Unob	Unob	6	13	11	10	7.8	7.2	7.7	7.4	84.28	81.63	90.16	92.16
W14	<10	<10	<10	< 10	Unob	Unob	Unob	Unob	8	11	8	9	8.1	7.9	7.9	8.0	62.72	69.74	90.16	83.31
W15	<10	<10	<10	< 10	Unob	Unob	Unob	Unob	5	10	5	7	7.8	7.7	7.9	7.6	78.4	80.72	80.24	85.55

Note : I- Premonsoon season, II-Monsoon season, III- Postmonsoon season & IV- Winter season
Unob - Unobjectionable

Table 4.16: Water Quality of the Study Area

	Iron as Fe(mg/l)				Chlorides as Cl(mg/l)				Residual Free Chlorine(mg/l)				Total Suspended Solids(mg/l)				Dissolved Solids(mg/l)				Calcium as Ca(mg/			
	I	**II**	**III**	**IV**	**I**	**II**	**III**	**IV**	**I**	**II**	**III**	**IV**	**I**	**II**	**III**	**IV**	**I**	**II**	**III**	**IV**	**I**	**II**	**III**	**I**
W1	0.32	0.38	0.30	0.25	5.14	5.52	4.00	6.1	<0.005	< 0.005	< 0.005	< 0.005	3.3	3.9	2.1	4.0	34	44	23	40	4.71	4.85	3.93	6
W2	0.22	0.30	0.21	0.18	3.92	3.55	4.00	4.5	<0.005	< 0.005	< 0.005	< 0.005	5.5	6.2	4.1	5.8	30	28	60.4	34	3.44	3.27	14.13	4
W3	0.46	0.54	0.27	0.34	7.7	7.1	4.2	7.2	<0.005	< 0.005	< 0.005	< 0.005	40	4.4	1.8	2.0	1.6	55	42	45	3.92	3.92	6.29	6
W4	0.60	0.71	0.16	0.32	7.7	8.2	5.9	7.9	<0.005	< 0.005	< 0.005	< 0.005	44	3.5	1.5	4.0	1.2	50	50	48	2.36	6.17	7.08	8
W5	0.84	0.76	0.29	0.45	6.4	7.7	5.2	7.0	<0.005	< 0.005	< 0.005	< 0.005	36	4.2	3.5	4.4	4.0	47	25	40	6.28	7.11	7.08	1
W6	0.76	0.62	0.44	0.47	1.3	5.14	2.1	3.5	<0.005	< 0.005	< 0.005	< 0.005	33	6.8	5.6	5.5	3.3	40	40	35	2.36	6.07	3.93	7
W7	0.38	0.60	0.30	0.25	8.99	8.2	2.99	8.5	<0.005	< 0.005	< 0.005	< 0.005	3.8	7.8	3.9	6.5	60	56	55	65	3.14	3.86	6.29	4
W8	0.20	0.32	0.32	0.18	6.4	6.4	5.00	6.2	<0.005	< 0.005	< 0.005	< 0.005	4.1	7.4	4.3	7.0	30	34	98.5	50	3.14	3.27	21.21	3
W9	0.32	0.36	0.44	0.34	3.85	3.55	3.05	4.25	<0.005	< 0.005	< 0.005	< 0.005	1.2	1.3	1.0	2.0	40	32	60.5	65	7.07	6.55	10.21	7
W10	0.46	0.38	0.30	0.35	NIL	1.7	3.79	2.0	<0.005	< 0.005	< 0.005	< 0.005	6.4	8.2	4.1	9.0	10	17	59.5	30	1.57	2.8	9.43	3
W11	0.16	0.26	0.21	0.22	5.14	5.44	4.96	5.67	<0.005	< 0.005	< 0.005	< 0.005	102	6.5	5.2	7.0	7.1	94	112	115	9.43	16.97	29.07	1
W12	0.30	0.32	0.27	0.31	6.42	7.11	5.86	6.95	<0.005	< 0.005	< 0.005	< 0.005	104	10	6.5	9	8.2	120	110	120	24.35	23.91	32.21	2
W13	0.24	0.21	0.34	0.18	3.84	4.97	3.96	3.5	<0.005	<0.005	<0.005	<0.005	94	10	5.1	11.0	8.0	102	98	112	25.9	26.22	31.42	3
W14	0.28	0.28	0.36	0.20	7.06	7.8	4.06	5.67	<0.005	<0.005	<0.005	<0.005	96	8.8	2.5	9.0	3.8	108	100	110	22.0	23.13	23.57	2
W15	0.26	0.26	0.32	0.23	7.7	6.04	4.16	5.95	<0.005	<0.005	<0.005	<0.005	100	8.2	3.0	7.0	3.2	104	102	115	25.1	25.9	31.42	2

Note : I- Premonsoon season, II-Monsoon season, III- Postmonsoon season & IV- Winter season

Table 4.16: Water Quality of the Study Area (Contd...)

	Magnesium as Mg (mg/l)				Copper as Cu (mg/l)				Sulphate as SO_4 (mg/l)				Nitrate as NO_3 (mg/l)				Fluoride as F (mg/l)				Phenolic c	
	I	**II**	**III**	**IV**	**I**	**II**	**III**	**IV**	**I**	**II**	**III**	**IV**	**I**	**II**	**III**	**IV**	**I**	**II**	**III**	**IV**	**I**	**II**
W1	1.90	2.17	3.80	2.38	<0.05	< 0.05	< 0.05	< 0.05	<1.0	2.5	<1.0	<1.0	<0.01	< 0.01	< 0.01	< 0.01	0.38	0.35	0.40	0.36	<0.001	< 0
W2	2.17	1.43	0.48	2.1	<0.05	< 0.05	< 0.05	< 0.05	<1.0	< 1.0	< 1.0	< 1.0	<0.01	< 0.01	< 0.01	< 0.01	0.3	0.32	0.32	0.31	<0.001	< 0
W3	3.32	2.38	1.43	1.77	<0.05	< 0.05	< 0.05	< 0.05	<1.0	1.9	<1.0	<1.0	<0.01	< 0.01	< 0.01	< 0.01	0.42	0.47	0.40	0.39	<0.001	< 0
W4	0.95	0.96	2.85	1.42	<0.05	< 0.05	< 0.05	< 0.05	<1.0	< 1.0	< 1.0	< 1.0	<0.01	< 0.01	< 0.01	< 0.01	0.38	0.35	0.39	0.34	<0.001	< 0
W5	NIL	0.48	2.38	0.98	<0.05	< 0.05	< 0.05	< 0.05	<1.0	< 1.0	< 1.0	< 1.0	<0.01	< 0.01	< 0.01	< 0.01	0.38	0.32	0.37	0.34	<0.001	< 0
W6	0.95	1.38	0.47	2.1	<0.05	< 0.05	< 0.05	< 0.05	<1.0	2.51	<1.0	3.5	<0.01	< 0.01	< 0.01	< 0.01	0.38	0.38	0.32	0.36	<0.001	< 0
W7	8.57	6.11	1.43	7.9	<0.05	< 0.05	< 0.05	< 0.05	<1.0	< 1.0	< 1.0	< 1.0	<0.01	< 0.01	< 0.01	< 0.01	0.52	0.48	0.48	0.41	<0.001	< 0
W8	0.94	1.16	2.85	1.2	<0.05	< 0.05	< 0.05	< 0.05	<1.0	< 1.0	< 1.0	< 1.0	<0.01	< 0.01	< 0.01	< 0.01	0.30	0.34	0.33	0.32	<0.001	< 0
W9	1.43	1.84	4.28	2.5	<0.05	< 0.05	< 0.05	< 0.05	<1.0	< 1.0	< 1.0	< 1.0	<0.01	< 0.01	< 0.01	< 0.01	0.46	0.44	0.48	0.43	<0.001	< 0
W10	NIL	NIL	2.85	NIL	<0.05	< 0.05	< 0.05	< 0.05	<1.0	< 1.0	< 1.0	< 1.0	<0.01	< 0.01	< 0.01	< 0.01	<0.30	0.32	0.31	0.31	<0.001	< 0
W11	14.3	7.93	6.17	8.5	<0.05	< 0.05	< 0.05	< 0.05	<1.0	< 1.0	< 1.0	< 1.0	<0.01	< 0.01	< 0.01	< 0.01	0.55	0.50	0.56	0.49	<0.001	< 0
W12	2.38	4.19	2.84	5.00	<0.05	< 0.05	< 0.05	< 0.05	<1.0	1.76	<1.0	<1.0	<0.01	< 0.01	< 0.01	< 0.01	0.38	0.34	0.37	0.35	<0.001	< 0
W13	4.76	3.79	2.84	3.76	<0.05	< 0.05	< 0.05	< 0.05	<1.0	1.54	<1.0	1.5	<0.01	< 0.01	< 0.01	< 0.01	0.32	0.40	0.34	0.35	<0.001	< 0
W14	1.90	2.73	7.60	3.10	<0.05	< 0.05	< 0.05	< 0.05	<1.0	1.68	<1.0	1.55	<0.01	< 0.01	< 0.01	< 0.01	0.40	0.42	0.42	0.40	<0.001	< 0
W15	3.81	3.73	1.89	4.1	<0.05	< 0.05	< 0.05	< 0.05	<1.0	< 1.0	< 1.0	1.4	<0.01	< 0.01	< 0.01	< 0.01	0.46	0.40	0.45	0.42	<0.001	< 0

Note : I- Premonsoon season, II-Monsoon season, III- Postmonsoon season & IV- Winter season

Table 4.16: Water Quality of the Study Area (Contd...)

	Mercury as Hg (mg/l)				Cadmium as Cd (mg/l)				Selenium as Se (mg/l)				Arsenic as As (mg/l)				Cynaide as CN (mg/l)			
	I	**II**	**III**	**IV**	**I**	**II**	**III**	**IV**	**I**	**II**	**III**	**IV**	**I**	**II**	**III**	**IV**	**I**	**II**	**III**	**IV**
W1	<0.001	< 0.001	< 0.001	< 0.001	<0.002	< 0.002	< 0.002	< 0.002	<0.01	< 0.01	<0.01	< 0.01	<0.001	< 0.001	< 0.001	< 0.001	<0.002	< 0.002	< 0.002	< 0
W2	<0.001	< 0.001	< 0.001	< 0.001	<0.002	< 0.002	< 0.002	< 0.002	<0.01	< 0.01	< 0.01	< 0.01	<0.001	< 0.001	< 0.001	< 0.001	<0.002	< 0.002	< 0.002	< 0.
W3	<0.001	< 0.001	< 0.001	< 0.001	<0.002	< 0.002	< 0.002	< 0.002	<0.01	< 0.01	< 0.01	< 0.01	<0.001	< 0.001	< 0.001	< 0.001	<0.002	< 0.002	< 0.002	< 0.
W4	<0.001	< 0.001	< 0.001	< 0.001	<0.002	< 0.002	< 0.002	< 0.002	<0.01	< 0.01	< 0.01	< 0.01	<0.001	< 0.001	< 0.001	< 0.001	<0.002	< 0.002	< 0.002	< 0.
W5	<0.001	< 0.001	< 0.001	< 0.001	<0.002	< 0.002	< 0.002	< 0.002	<0.01	< 0.01	< 0.01	< 0.01	<0.001	< 0.001	< 0.001	< 0.001	<0.002	< 0.002	< 0.002	< 0.
W6	<0.001	< 0.001	< 0.001	< 0.001	<0.002	< 0.002	< 0.002	< 0.002	<0.01	< 0.01	< 0.01	< 0.01	<0.001	< 0.001	< 0.001	< 0.001	<0.002	< 0.002	< 0.002	< 0.
W7	<0.001	< 0.001	< 0.001	< 0.001	<0.002	< 0.002	< 0.002	< 0.002	<0.01	< 0.01	< 0.01	< 0.01	<0.001	< 0.001	< 0.001	< 0.001	<0.002	< 0.002	< 0.002	< 0.
W8	<0.001	< 0.001	< 0.001	< 0.001	<0.002	< 0.002	< 0.002	< 0.002	<0.01	< 0.01	< 0.01	< 0.01	<0.001	< 0.001	< 0.001	< 0.001	<0.002	< 0.002	< 0.002	< 0.
W9	<0.001	< 0.001	< 0.001	< 0.001	<0.002	< 0.002	< 0.002	< 0.002	<0.01	< 0.01	< 0.01	< 0.01	<0.001	< 0.001	< 0.001	< 0.001	<0.002	< 0.002	< 0.002	< 0.
W10	<0.001	< 0.001	< 0.001	< 0.001	<0.002	< 0.002	< 0.002	< 0.002	<0.01	< 0.01	< 0.01	< 0.01	<0.001	< 0.001	< 0.001	< 0.001	<0.002	< 0.002	< 0.002	< 0.
W11	<0.001	< 0.001	< 0.001	< 0.001	<0.002	< 0.002	< 0.002	< 0.002	<0.01	< 0.01	< 0.01	< 0.01	<0.001	< 0.001	< 0.001	< 0.001	<0.002	< 0.002	< 0.002	< 0.
W12	<0.001	< 0.001	< 0.001	< 0.001	<0.002	< 0.002	< 0.002	< 0.002	<0.01	< 0.01	< 0.01	< 0.01	<0.001	< 0.001	< 0.001	< 0.001	<0.002	< 0.002	< 0.002	< 0.
W13	<0.001	< 0.001	< 0.001	< 0.001	<0.002	< 0.002	< 0.002	< 0.002	<0.01	< 0.01	< 0.01	< 0.01	<0.001	< 0.001	< 0.001	< 0.001	<0.002	< 0.002	< 0.002	< 0.
W14	<0.001	< 0.001	< 0.001	< 0.001	<0.002	< 0.002	< 0.002	< 0.002	<0.01	< 0.01	< 0.01	< 0.01	<0.001	< 0.001	< 0.001	< 0.001	<0.002	< 0.002	< 0.002	< 0.
W15	<0.001	< 0.001	< 0.001	< 0.001	<0.002	< 0.002	< 0.002	< 0.002	<0.01	< 0.01	< 0.01	< 0.01	<0.001	< 0.001	< 0.001	< 0.001	<0.002	< 0.002	< 0.002	< 0.

Note : I- Premonsoon season, II-Monsoon season, III- Postmonsoon season & IV- Winter season

Table 4.16: Water Quality of the Study Area (Contd...)

	Lead as Pb (mg/l)				Zinc as Zn (mg/l)				Anionic detergents as MBAS(mg/l)				Chromium as Cr^{+6} (mg/l)				Polynuclear Aromatic hydrocarbons as PAH (mg/l)			
	I	**II**	**III**	**IV**	**I**	**II**	**III**	**IV**	**I**	**II**	**III**	**IV**	**I**	**II**	**III**	**IV**	**I**	**II**	**III**	**IV**
W1	<0.001	< 0.001	< 0.001	< 0.001	<0.001	< 0.001	< 0.001	< 0.001	NIL	NIL	NIL	NIL	<0.001	< 0.001	< 0.001	< 0.001	NIL	NIL	NIL	NIL
W2	<0.001	< 0.001	< 0.001	< 0.001	<0.001	< 0.001	< 0.001	< 0.001	NIL	NIL	NIL	NIL	<0.001	< 0.001	< 0.001	< 0.001	NIL	NIL	NIL	NIL
W3	<0.001	< 0.001	< 0.001	< 0.001	<0.001	< 0.001	< 0.001	< 0.001	NIL	NIL	NIL	NIL	<0.001	< 0.001	< 0.001	< 0.001	NIL	NIL	NIL	NIL
W4	<0.001	< 0.001	< 0.001	< 0.001	<0.001	< 0.001	< 0.001	< 0.001	NIL	NIL	NIL	NIL	<0.001	< 0.001	< 0.001	< 0.001	NIL	NIL	NIL	NIL
W5	<0.001	< 0.001	< 0.001	< 0.001	<0.001	< 0.001	< 0.001	< 0.001	NIL	NIL	NIL	NIL	<0.001	< 0.001	< 0.001	< 0.001	NIL	NIL	NIL	NIL
W6	<0.001	< 0.001	< 0.001	< 0.001	<0.001	< 0.001	< 0.001	< 0.001	NIL	NIL	NIL	NIL	<0.001	< 0.001	< 0.001	< 0.001	NIL	NIL	NIL	NIL
W7	<0.001	< 0.001	< 0.001	< 0.001	<0.001	< 0.001	< 0.001	< 0.001	NIL	NIL	NIL	NIL	<0.001	< 0.001	< 0.001	< 0.001	NIL	NIL	NIL	NIL
W8	<0.001	< 0.001	< 0.001	< 0.001	<0.001	< 0.001	< 0.001	< 0.001	NIL	NIL	NIL	NIL	<0.001	< 0.001	< 0.001	< 0.001	NIL	NIL	NIL	NIL
W9	<0.001	< 0.001	< 0.001	< 0.001	<0.001	< 0.001	< 0.001	< 0.001	NIL	NIL	NIL	NIL	<0.001	< 0.001	< 0.001	< 0.001	NIL	NIL	NIL	NIL
W10	<0.001	< 0.001	< 0.001	< 0.001	<0.001	< 0.001	< 0.001	< 0.001	NIL	NIL	NIL	NIL	<0.001	< 0.001	< 0.001	< 0.001	NIL	NIL	NIL	NIL
W11	<0.001	< 0.001	< 0.001	< 0.001	<0.001	< 0.001	< 0.001	< 0.001	NIL	NIL	NIL	NIL	<0.001	< 0.001	< 0.001	< 0.001	NIL	NIL	NIL	NIL
W12	<0.001	< 0.001	< 0.001	< 0.001	<0.001	< 0.001	< 0.001	< 0.001	NIL	NIL	NIL	NIL	<0.001	< 0.001	< 0.001	< 0.001	NIL	NIL	NIL	NIL
W13	<0.001	< 0.001	< 0.001	< 0.001	<0.001	< 0.001	< 0.001	< 0.001	NIL	NIL	NIL	NIL	<0.001	< 0.001	< 0.001	< 0.001	NIL	NIL	NIL	NIL
W14	<0.001	< 0.001	< 0.001	< 0.001	<0.001	< 0.001	< 0.001	< 0.001	NIL	NIL	NIL	NIL	<0.001	< 0.001	< 0.001	< 0.001	NIL	NIL	NIL	NIL
W15	<0.001	< 0.001	< 0.001	< 0.001	<0.001	< 0.001	< 0.001	< 0.001	NIL	NIL	NIL	NIL	<0.001	< 0.001	< 0.001	< 0.001	NIL	NIL	NIL	NIL

Note : I- Premonsoon season, II-Monsoon season, III- Postmonsoon season & IV- Winter season

Table 4.16: Water Quality of the Study Area (Contd...)

	Mineral oil (mg/l)				Pesticides (mg/l)				Radioactive materials (Alpha emitters)				Radioactive materials (Beta emitters)			
	I	**II**	**III**	**IV**	**I**	**II**	**III**	**IV**	**I**	**II**	**III**	**IV**	**I**	**II**	**III**	**IV**
W1	<0.5	< 0.5	< 0.5	< 0.5	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL
W2	<0.5	< 0.5	< 0.5	< 0.5	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL
W3	<0.5	< 0.5	< 0.5	< 0.5	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL
W4	<0.5	< 0.5	< 0.5	< 0.5	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL
W5	<0.5	< 0.5	< 0.5	< 0.5	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL
W6	<0.5	< 0.5	< 0.5	< 0.5	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL
W7	<0.5	< 0.5	< 0.5	< 0.5	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL
W8	<0.5	< 0.5	< 0.5	< 0.5	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL
W9	<0.5	< 0.5	< 0.5	< 0.5	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL
W10	<0.5	< 0.5	< 0.5	< 0.5	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL
W11	<0.5	< 0.5	< 0.5	< 0.5	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL
W12	<0.5	< 0.5	< 0.5	< 0.5	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL
W13	<0.5	< 0.5	< 0.5	< 0.5	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL
W14	<0.5	< 0.5	< 0.5	< 0.5	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL
W15	<0.5	< 0.5	< 0.5	< 0.5	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL

Note : I- Premonsoon season, II-Monsoon season, III- Postmonsoon season & IV- Winter season

Table 4.16: Water Quality of the Study Area

	Alkalinity as $CaCO_3$ (mg/l)				Aluminium as Al (mg/l)				Manganese as Mn (mg/l)				Boron as B (mg/l)				Total Coliforms (MPN/100ml)			
	I	**II**	**III**	**IV**	**I**	**II**	**III**	**IV**	**I**	**II**	**III**	**IV**	**I**	**II**	**III**	**IV**	**I**	**II**	**III**	**IV**
W1	25.7	30.9	30.9	35	<0.006	< 0.006	< 0.042	< 0.006	<0.042	< 0.042	< 0.002	< 0.042	<0.002	< 0.002	NIL	0.002	NIL	NIL	NIL	NIL
W2	22.4	21.8	51.5	24.5	<0.006	< 0.006	< 0.006	< 0.006	<0.042	< 0.042	< 0.042	< 0.042	<0.002	< 0.002	< 0.002	< 0.002	NIL	1	NIL	NIL
W3	37.5	40.8	31.2	45	<0.006	< 0.006	< 0.006	< 0.006	<0.042	< 0.042	< 0.042	< 0.042	<0.002	< 0.002	< 0.002	< 0.002	NIL	NIL	NIL	NIL
W4	30.9	35.3	41.2	38.5	<0.006	< 0.006	< 0.006	< 0.006	<0.042	< 0.042	< 0.042	< 0.042	<0.002	< 0.002	< 0.002	< 0.002	NIL	NIL	NIL	NIL
W5	27.75	34.2	40.1	37.5	<0.006	< 0.006	< 0.006	< 0.006	<0.042	< 0.042	< 0.042	< 0.042	<0.002	< 0.002	< 0.002	< 0.002	NIL	2	NIL	NIL
W6	25.4	30.5	30.5	32.5	<0.006	< 0.006	< 0.006	< 0.006	<0.042	< 0.042	< 0.042	< 0.042	<0.002	< 0.002	< 0.002	< 0.002	2	2	2	2
W7	51.5	45.8	30.6	52.5	<0.006	< 0.006	< 0.006	< 0.006	<0.042	< 0.042	< 0.042	< 0.042	<0.002	< 0.002	< 0.002	< 0.002	1	NIL	1	1
W8	20.6	22.2	72.1	25.1	<0.006	< 0.006	< 0.006	< 0.006	<0.042	< 0.042	< 0.042	< 0.042	<0.002	< 0.002	< 0.002	< 0.002	NIL	NIL	NIL	NIL
W9	30.9	31.4	51.5	36.3	<0.006	< 0.006	< 0.006	< 0.006	<0.042	< 0.042	< 0.042	< 0.042	<0.002	< 0.002	< 0.002	< 0.002	NIL	NIL	NIL	NIL
W10	10.3	15.4	61.8	20.5	<0.006	< 0.006	< 0.006	< 0.006	<0.042	< 0.042	< 0.042	< 0.042	<0.002	< 0.002	< 0.002	< 0.002	NIL	3	NIL	4
W11	92.7	82.4	108.4	90.5	<0.006	< 0.006	< 0.006	< 0.006	<0.042	< 0.042	< 0.042	< 0.042	<0.002	< 0.002	< 0.002	< 0.002	2	2	2	3
W12	90.55	92.7	105.6	100.5	<0.006	< 0.006	< 0.006	< 0.006	<0.042	< 0.042	< 0.042	< 0.042	<0.002	< 0.002	< 0.002	< 0.002	3	NIL	3	NIL
W13	87.55	91.6	95.2	98.5	<0.006	< 0.006	< 0.006	< 0.006	<0.042	< 0.042	< 0.042	< 0.042	<0.002	< 0.002	< 0.002	< 0.002	NIL	NIL	NIL	NIL
W14	82.4	84.6	92.3	90.5	<0.006	< 0.006	< 0.006	< 0.006	<0.042	< 0.042	< 0.042	< 0.042	<0.002	< 0.002	< 0.002	< 0.002	NIL	NIL	NIL	NIL
W15	87.55	88.1	95.98	96.5	<0.006	< 0.006	< 0.006	< 0.006	<0.042	< 0.042	< 0.042	< 0.042	<0.002	< 0.002	< 0.002	< 0.002	NIL	NIL	NIL	NIL

Note : I- Premonsoon season, II-Monsoon season, III- Postmonsoon season & IV- Winter season

On perusal of the *Table 4.16*, following observations may be made.

Surface Water Quality

Umium River

All together 4 water samples (W3 to W6) were collected from Umium river at various locations upstream and downstream with respect to the proposed mine lease area.

During pre monsoon season, pH of the Umium river water was found to be slightly acidic (6.1 – 6.4) except at up stream of Umium river, near Shella Bazar where pH was observed to be 7.3. Fluorides were reported in all the water samples and the value ranges from 0.38 mg/l to 0.42 mg/l. The only water sample collected from Umium river near village Dalia (W6) reported coliform contamination. The likely source of this bacteriological contamination was due to the proximity to residential area.

During the monsoon season pH of the Umium river water was found to be in the range of 6.7 to 7.0 except at upstream of Umium river, near Shella Bazar where pH was observed to be 7.6. Fluorides were reported in all the water samples and the value ranges from 0.32 mg/l to 0.47 mg/l. The water samples collected from down stream of Umium River near Sella Bazar (W5) and village Dalia (W6) reported coliform contamination. The likely source of this bacteriological contamination was due to the proximity to residential area.

During the Post-monsoon season pH of the Umium river water was found to be in the range of 7.0 to 7.8. Fluorides were reported in all the water samples and the value ranges from 0.32 mg/l to 0.40 mg/l. The water samples collected from down stream of Umium River near village Dalia (W6) reported coliform contamination. The likely source of this bacteriological contamination was due to the proximity to residential area.

During the winter season pH of the Umium river water was found to be in the range of 7.0 to 7.8. Fluorides were reported in all the water samples and the value ranges from 0.32 mg/l to 0.39 mg/l. The water samples collected from down stream of Umium River near village Dalia (W6) reported coliform contamination. The likely source of this bacteriological contamination was due to the proximity to residential area.

Results shows that the quality of water is less susceptible to the seasonal variation.

Fotsgnet Stream

One sample (W9) was collected and results shows that the pH was found to be in the range of 7.4 to 8.0 during all the four seasons. Fluorides were reported in all four season and the varied from 0..43 mg/l to 0.48 mg/l. Coliform contamination was not observed in any season.

Other streams

The results of water quality analysis of the nalahs, streams and rivers (sampling locations W1, W2, W7, W8 and W10) collected show that the pH in the water samples collected from above said nalahs, stream and rivers ranged between 6.3 to 7.9 during all four seasons. Bacteriological contamination has been reported only at W7 during pre-monsoon season, W2, & W10 during monsoon season, W7 during post-monsoon season and W7 during winter season.

Springs Water Quality

Phalangkaruh Springs

As one of the source of water for the Phlangkaruh River is the water springs coming out near the mine site. These streams meet together and form one stream that ultimately meets with Phlangkaruh River. One of the water sample was collected from stream 1(W11), stream 2(W12) and stream 3 (W13) while one water sample (W14) was collected from stream 4 (combined stream of stream 1, 2,& 3). One another water sample (W15) was also collected downstream from the meeting of stream 4 at Phlangkaruh River.

Water samples collected from sampling locations W11, W12, W13 and W14 were alkaline in nature and pH values ranged between 7.0 to 8.1 during all four seasons. pH was always higher in water sampling location W14 and ranged between 8.0 to 8.1. The pH of water sample (W15) from the downstream of the Phalangkaruh river was found to be between 7.0 to 7.9 due to the dilution effect. Bacteriological contamination has been reported only at W11 & W12 during pre-monsoon seasonW11 during monsoon season W11 &W12 during post-monsoon season and W11 during winter season.

The levels of the Total Alkalinity (as $CaCO_3$) recorded at the origins and downstream of the Phalangkaruh river were found to be in the range of 82.4 to 108.5 mg/l, indicating that the waters are slightly alkaline. Fluorides (as F) have been recorded in all the water samples collected from the springs of Phalangkaruh river and values ranged between 0.32 to 0.56 mg/l.

General

The overall study of the water samples collected from the study area reveals that none of the parameters tested are above the permissible standards of IS10500: Drinking Water Standards. The alkalinity of the water sample is on the higher scale in the nearby areas to the mining area.

4.7 SOIL AND LAND CAPABILITY

The entire plateau is devoid of soil while the slopes although have some soil cover but does not show prolific structures. High rainfall, hilly geography and nature of substrata are responsible for the loss of soil layer in the entire area. The soil at the mining site is found in gullies and crevices and cracks, which characterise the area. At places dense growth of grasses and shrubs, wild

banana, and undergrowth have helped in retaining the soil whose thickness rarely exceeds 50 cm.

As per the earlier studies, three soil types viz., in crevices, from hill slopes and from foot hills. As per their study, soil is characterised as sandy clay loam in texture in the cervices and sandy loam in the foothills. The soil reaction was near neutral to alkaline in all three types with pH ranging from 6.93 to 7.86. The soil in cervices was reported rich in organic carbon, total nitrogen and available phosphorous.

Representative soil samples were collected from various locations during pre-monsoon season, post-monsoon and winter season (refer to ***Figure 4.7***) at sub surface level for studying soil characteristics and chemistry. The locations of the soil samples are provided in the ***Table 4.17*** below.

Table 4.17 Locations of Soil sampling Stations

Sample	Location
S1	Shella Bazar (lower), 1.5 km east of the lease area
S2	Phlankaruh, 1.0km south of the lease area
S3	Shella Bazar (upper), 1.5-2.0 km east of the lease area
S4	Nongwar, 1.5-2.0 km east of the lease area
S5	Nonglait, 3km North east of the lease area
S6	Pyrkan, 3km west of the lease area
S7	Mines lease area
S8	Mines lease area
S9	Karda, 4 km west- west south of the lease area
S10	Mawryngkhong, 1km north east of the lease area
S11	Nongtrai (lower), 2 km north east of the lease area
S12	Nongtrai (upper), 2.5 km north east of the lease area
S13	Mawdet , 6km north west of lease area

The above defined soil samples were collected from the cultivated areas, cervices at the site and hill slopes and results are given in ***Table 4.18*** during pre monsoon, post monsoon and winter season. The results are compared with the standard soil classification provided in the ***Table 4.19.***

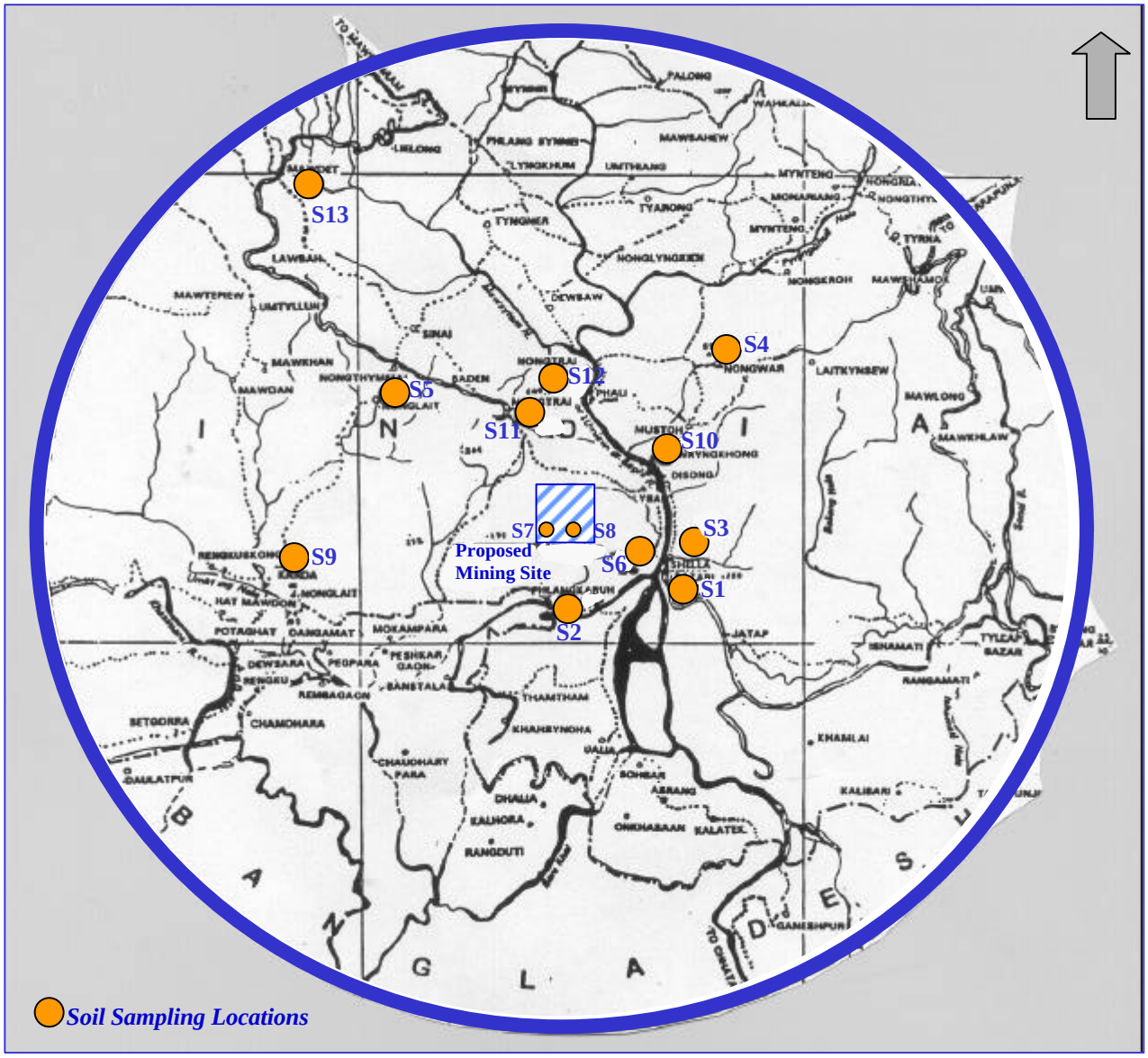


Figure 4.7: Soil Sampling Locations

Table 4.18: Soil Quality of the Stydy Area

Parameter	Appearance			Texture			Gravel, %			Sand, %			Silt & Clay, %		
	I	**II**	**III**	**I**	**II**	**III**	**I**	**II**	**III**	**I**	**II**	**III**	**I**	**II**	**III**
Shella Bazar (lower)(S1)	Brownish	Brownish	Brownish	Loamy	Loamy	Loamy	15	8.36	10	75	82.30	74	10	9.35	16
Phlankaruh(S2)	Greyish Brown	Greyish Brown	Greyish Brown	Sandy Clay. Loam	Sandy Loam	Sandy Clay. Loam	44.8	34.9	39.5	21.4	57.9	22.2	33.8	7.3	38.5
Shella Bazar (upper (S3)	Greyish Brown	Greyish Brown	Greyish Brown	Sandy Loam	Sandy Loam	Sandy Loam	9.5	29.33	6.4	78.0	58.92	80.0	12.5	11.75	14.7
Nongwar(S4)	Buff Colour	Buff Colour	Buff Colour	Loamy	Loamy	Loamy	6.8	5.2	5.0	82.5	79.5	77.6	10.7	15.1	17.3
Nonglait(S5)	Light Yellowish	Light Yellowish	Light Yellowish	Loamy	Loamy	Loamy	11.2	10.3	13.0	84.0	84.7	79.6	4.8	5.1	7.5
Pyrkan(S6)	Dark Brown	Dark Brown	Dark Brown	Loamy	Loamy	Loamy	7.5	8.2	2.2	84.1	81.1	85.3	8.4	10.5	12.5
Mines lease area (S7)	Light Brown	Light Brown	Light Brown	Loamy	Loamy	Loamy	11.2	10.3	7.3	70.1	69.6	70.5	18.7	20.2	22.3
Mines lease area(S8)	Dark Brown	Dark Brown	Dark Brown	Sandy Loam	Sandy Loam	Sandy Loam	26.8	27.3	27.0	46.7	48.6	46.5	23.6	24.1	26.5
Karda(S9)	Brown	Brown	Brown	Sandy	Sandy	Sandy	2.6	4.9	2.1	87.3	83.9	85.4	10.1	11.3	12.5
Mawryngkhong(S10)	Greyish Brown	Greyish Brown	Greyish Brown	Loamy	Loamy	Loamy	7.3	8.4	9.5	84.3	82.3	80.0	8.7	9.4	10.5
Nongtrai (lower)(S11)	Greyish Brown	Greyish Brown	Greyish Brown	Sandy Loam	Sandy Loam	Sandy Loam	32.8	34.9	28.9	61.5	57.9	60.1	5.7	7.3	11.0
Nongtrai (upper)(S12)	Greyish Brown	Brownish	Brownish	Sandy Loam	Sandy Loam	Sandy Loam	28.5	29.3	25.1	60.9	58.9	61.5	10.6	11.8	13.4
Mawdet (S13)	Blackish	Blackish	Blackish	Sandy Clay. Loam	Sandy Clay. Loam	Sandy Clay. Loam	42.5	41.3	39.5	20.7	23.5	22.0	36.8	35.2	38.5

Note : I- Pre monsoon season, II- Post monsoon season & III- Winter

Table 4.18: Soil Quality of the Stydy Area (Contd…)

Parameter	Organic Matter, %			Plasticity Limit, %			Bulk Density, gm/cm³			Moisture Retention Capacity, %			Wilting Coefficient			Nitrogen, lbs/acre		
	I	II	III	I	II	III	I	II	III	I	II	III	I	II	III	I	II	III
Shella Bazar (lower)(S1)	0.68	0.60	0.65	8.3	22.6	8.5	1.3	1.5	1.1	34	42.5	36.0	22.2	19.5	23.5	58.0	20.1	59.5
Phlankaruh(S2)	0.5	0.63	0.55	11.7	8.4	12.4	1.2	1.4	1.3	40.0	31.2	42.5	19.3	23.6	20.7	13.0	43.2	15.4
Shella Bazar (upper (S3)	0.6	0.67	0.62	25.5	24.6	25.8	1.1	1.6	1.1	44.0	39.5	44.2	23.5	25.1	24.3	1.3	10.7	13.5
Nongwar(S4)	0.44	0.54	0.5	27.3	27.7	28.1	1.3	1.6	1.5	32.8	35.2	36.5	16.4	18.5	17.1	9.0	11.5	12.6
Nonglait(S5)	0.47	0.51	0.49	11.1	12.1	11.6	1.4	1.6	1.5	40.0	43.5	42.5	19.3	22.3	20.5	Nil	Nil	Nil
Pyrkan(S6)	0.6	0.63	0.65	25.0	26.1	25.8	1.3	1.6	1.5	44.0	47.2	46.5	11.4	14.3	13.4	Nil	Nil	Nil
Mines lease area (S7)	0.48	0.52	0.55	30.0	32.3	33.5	1.4	1.0	1.1	56	54.6	55.5	37.8	36.5	37.5	13	15.7	16.5
Mines lease area(S8)	0.6	0.58	0.63	37.5	38.7	37.8	1.3	1.1	1.1	44.0	46.3	45.3	35.9	36.9	37.8	22	25.2	24.5
Karda(S9)	0.61	0.63	0.62	20.0	22.6	23.5	1.5	1.3	1.4	34	33.2	34.5	21.7	20.5	21.9	Nil	8.3	9.5
Mawryngkhong(S10)	0.63	0.60	0.64	21.4	22.6	21.8	1.5	1.5	1.5	40	42.5	44.1	18.5	19.5	18.7	Nil	20.1	21.5
Nongtrai (lower)(S11)	0.65	0.63	0.67	7.4	8.4	8.8	1.4	1.4	1.4	30.0	31.2	32.5	22.3	23.6	22.5	10.0	43.2	38.5
Nongtrai (upper)(S12)	0.70	0.67	0.68	25	24.6	25.5	1.3	1.6	1.5	37.6	39.5	24.6	22.0	25.1	24.5	Nil	10.7	11.5
Mawdet (S13)	0.70	0.69	0.72	16.7	15.7	16.8	1.3	1.3	1.3	36.0	38.2	37.5	15.1	16.2	15.7	Nil	10.2	11.5

Note : I- Pre monsoon season, II- Post monsoon season & III- Winter

Table 4.18: Soil Quality of the Stydy Area (Contd…)

Parameter	Phosphorus, lbs/acre			Potassium, lbs/acre			Sodium Adsorption Ratio			pH (1:10 suspension)			Calcium as Ca, mg/gm			Magnesium as Mg, mg/gm		
	I	II	III	I	II	III	I	II	III	I	II	III	I	II	III	I	II	III
Shella Bazar (lower)(S1)	19.6	16.7	20.5	89.0	90.4	90.0	0.014	0.006	0.085	7.5	7.7	6.5	0.0032	0.160	0.038	0.0109	0.0136	0.0234
Phlankaruh(S2)	18.6	17.2	19.0	92.6	90.1	93.5	0.032	0.009	0.15	7.2	6.5	6.6	0.0042	0.169	0.092	0.0143	0.054	0.0096
Shella Bazar (upper (S3)	17.9	21.5	19.3	94	89.3	94.5	0.17	0.004	0.35	7.1	6.3	5.1	0.0002	0.092	0.0015	Nil	0.145	0.005
Nongwar(S4)	16.7	18.2	17.9	93.6	90.3	94.5	0.0404	0.0346	0.044	7.7	6.7	6.3	0.0016	0.006	0.0045	0.0038	0.0049	0.0018
Nonglait(S5)	18.3	19.9	18.7	82.9	84.1	85.1	0.0379	0.0312	0.028	7.2	8.4	6.8	0.0016	0.005	0.0057	0.0029	0.0037	0.0025
Pyrkan(S6)	18.9	17.5	18.5	95.7	97.6	96.3	0.034	0.0278	0.025	7.9	6.7	6.5	0.0024	0.004	0.0048	0.0121	0.0132	0.0118
Mines lease area (S7)	16.6	17.5	18.5	85.3	82.1	85.0	0.0131	0.0101	0.011	8.5	6.0	6.8	0.326	0.432	0.395	0.0155	0.0236	0.0175
Mines lease area(S8)	17.3	16.3	17.5	82.5	80.3	83.1	0.0153	0.0134	0.0087	7.9	7.6	7.9	0.262	0.321	0.297	0.0253	0.0281	0.0261
Karda(S9)	18.5	17.6	18.7	90.1	91.3	92.5	0.0153	0.013	0.0061	7.2	6.3	7.0	0.0152	0.026	0.020	0.0222	0.012	0.018
Mawryngkhong(S10)	17.6	16.7	17.5	89.3	90.4	91.5	0.0113	0.0064	0.0064	7.1	7.7	7.8	0.03	0.160	0.110	0.005	0.0136	0.012
Nongtrai (lower)(S11)	18.4	17.2	18.0	91.3	90.1	92.5	0.0171	0.0087	0.0099	7.4	6.5	7.0	0.046	0.169	0.096	0.0034	0.054	0.041
Nongtrai (upper)(S12)	19.9	21.5	20.5	90.8	89.3	92.0	0.016	0.0041	0.0058	7.4	6.3	7.5	0.034	0.092	0.08	0.011	0.145	0.019
Mawdet (S13)	19.6	21.2	20.3	95.4	93.2	96.7	0.0204	0.0157	0.019	7.0	6.4	7.6	0.025	0.041	0.035	0.0243	0.032	0.028

Note : I- Pre monsoon season, II- Post monsoon season & III- Winter

Table 4.18: Soil Quality of the Stydy Area (Contd…)

Parameter	Sodium as Na, mg/gm			Chlorides as Cl, %			Sulphates as SO_4, %			Carbonates, %			Bicarbonates, %			Total Alkalinity, meq/100gm		
	I	**II**	**III**	**I**	**II**	**III**	**I**	**II**	**III**	**I**	**II**	**III**	**I**	**II**	**III**	**I**	**II**	**III**
Shella Bazar (lower)(S1)	0.0012	0.0019	0.015	0.0032	0.0027	0.0036	BDL	BDL	BDL	BDL	BDL	BDL	0.0251	0.0412	0.26	0.412	0.686	0.493
Phlankaruh(S2)	0.0031	0.0029	0.035	0.0019	0.0304	0.0028	BDL	BDL	BDL	BDL	BDL	BDL	0.0125	0.021	0.126	0.206	0.343	0.207
Shella Bazar (upper (S3)	0.0017	0.0014	0.20	0.0039	0.0324	0.0043	BDL	BDL	BDL	BDL	BDL	BDL	0.0251	0.0132	0.0268	0.412	0.216	0.510
Nongwar(S4)	0.0021	0.0026	0.003	0.0025	0.0027	0.0024	BDL	BDL	BDL	BDL	BDL	BDL	0.0251	0.0124	0.0261	0.412	0.216	0.361
Nonglait(S5)	0.0018	0.002	0.002	0.0026	0.0048	0.0031	BDL	BDL	BDL	BDL	BDL	BDL	0.0125	0.0126	0.0135	0.206	0.208	0.254
Pyrkan(S6)	0.0029	0.0026	0.002	0.0020	0.0028	0.0027	BDL	BDL	BDL	BDL	BDL	BDL	0.0251	0.0206	0.0244	0.412	0.343	0.345
Mines lease area (S7)	0.0054	0.0048	0.005	0.0045	0.0049	0.005	BDL	BDL	BDL	BDL	BDL	BDL	0.0502	0.061	0.051	0.824	0.91	0.857
Mines lease area(S8)	0.0058	0.0056	0.006	0.0032	0.0038	0.0035	BDL	BDL	BDL	BDL	BDL	BDL	0.0628	0.073	0.064	1.03	1.45	1.1
Karda(S9)	0.0021	0.002	0.002	0.0045	0.002	0.0035	BDL	BDL	BDL	BDL	BDL	BDL	0.0125	0.007	0.014	0.206	0.105	0.171
Mawryngkhong(S10)	0.0015	0.0019	0.002	0.0032	0.0027	0.0030	BDL	BDL	BDL	BDL	BDL	BDL	0.0377	0.0412	0.0402	0.618	0.686	0.641
Nongtrai (lower)(S11)	0.0027	0.0029	0.003	0.0032	0.0304	0.0313	BDL	BDL	BDL	BDL	BDL	BDL	0.0377	0.021	0.035	0.618	0.343	0.509
Nongtrai (upper)(S12)	0.0012	0.0014	0.001	0.0038	0.0324	0.0345	BDL	BDL	BDL	BDL	BDL	BDL	0.0377	0.0132	0.030	0.618	0.216	0.428
Mawdet (S13)	0.0032	0.003	0.003	0.0038	0.0034	0.0036	BDL	BDL	BDL	BDL	BDL	BDL	0.0125	0.0125	0.020	0.206	0.206	0.215

Note : I- Pre monsoon season, II- Post monsoon season & III- Winter

Table 4.18: Soil Quality of the Stydy Area (Contd…)

Parameter	Iron as Fe, mg/gm			Copper as Cu, mg/gm			Zinc as Zn, mg/gm			Manganese as Mn, mg/gm			**Boron as B, mg/gm**		
	I	**II**	**III**	**I**	**II**	**III**	**I**	**II**	**III**	**I**	**II**	**III**	**I**	**II**	**III**
Shella Bazar (lower)(S1)	0.0116	0.023	0.0165	0.0002	0.0001	0.00034	0.00097	0.00107	0.00093	0.00003	0.000033	0.000048	BDL	BDL	BDL
Phlankaruh(S2)	0.016	0.0163	0.025	0.0011	0.0003	0.0020	0.00102	0.00110	0.00135	0.00013	0.00031	0.00018	BDL	BDL	BDL
Shella Bazar (upper (S3)	0.0174	0.0299	0.198	0.0002	0.0004	0.00031	0.00095	0.00104	0.00096	0.00031	0.000031	0.00037	BDL	BDL	BDL
Nongwar(S4)	0.0116	0.0214	0.0207	0.0002	0.0002	0.00023	0.00086	0.00095	0.00092	0.00014	0.00016	0.00017	BDL	BDL	BDL
Nonglait(S5)	0.016	0.0091	0.01	0.0002	0.0002	0.00020	0.00091	0.00088	0.00089	0.00021	0.00022	0.00020	BDL	BDL	BDL
Pyrkan(S6)	0.0174	0.0104	0.0145	0.001	0.0009	0.00090	0.00101	0.00105	0.00106	0.00017	0.00021	0.00019	BDL	BDL	BDL
Mines lease area (S7)	0.013	0.019	0.0385	0.0011	0.0012	0.00117	0.00106	0.00109	0.00105	0.00019	0.0002	0.00020	BDL	BDL	BDL
Mines lease area(S8)	0.003	0.005	0.007	0.0011	0.0098	0.0110	0.00108	0.00112	0.0013	0.00019	0.0002	0.00019	BDL	BDL	BDL
Karda(S9)	0.0048	0.021	0.015	0.0004	3E-04	0.0156	0.00099	0.001	0.0010	0.00003	4E-05	0.00004	BDL	BDL	BDL
Mawryngkhong(S10)	0.034	0.023	0.020	0.0002	0.0001	0.00015	0.00103	0.00107	0.00108	0.00002	3.3E-05	0.000028	BDL	BDL	BDL
Nongtrai (lower)(S11)	0.027	0.0163	0.0173	0.0003	0.0003	0.00030	0.00099	0.00110	0.00115	0.00029	0.00031	0.00030	BDL	BDL	BDL
Nongtrai (upper)(S12)	0.0103	0.0299	0.031	0.0028	0.0004	0.00034	0.00097	0.001	0.00100	0.00003	3E-05	0.000027	BDL	BDL	BDL
Mawdet (S13)	0.0114	0.0113	0.015	0.0006	0.0005	0.00050	0.00084	0.00084	0.00084	0.00022	0.00024	0.00021	BDL	BDL	BDL

Note : I- Pre monsoon season, II- Post monsoon season & III- Winter

Table 4.19: Standard Soil Classification

Sr No	Soil Tests	Classification
1	PH	< 4.50 extremely acidic 4.51-5.00 very strongly acidic 5.01-5.50 strongly acidic 5.51-6.00 moderately acidic 6.01-6.50 slightly acidic 6.51-7.30 neutral 7.31-7.80 slightly alkaline 7.81-8.50 moderately alkaline 8.51-9.00 strongly alkaline 9.01 very strongly alkaline
2	Salinity Electrical Conductivity (mmhos / cm) (1 mmho / cm = 640 ppm)	upto 1.00 average 1.01-2.00 harmful to germination 2.01-3.00 harmful to crops (sensitive to salts)
3	Organic Carbon	upto 0.2 : very less 0.21-0.4 : less 0.41-0.5 : medium 0.51-0.8 : on an average sufficient 0.81-1.0 : Sufficient >1.0 : more than sufficient
4	Nitrogen (kg / ha)	Upto 50 very less 51-100 less 101-150 good 151-300 better above 300 sufficient
5	Phosphorus (kg / ha)	upto 15 very less 16-30 less 31-50 medium 51-65 on an average sufficient 66-80 sufficient above 80 more than sufficient
6	Potassium (kg / ha)	0 very less 120-180 less 181-240 medium 241-300 average 301-360 better above 360 more than sufficient

Presentation of Results

Mining site Area

The soils in and around mine sites (S7 & S8) during all three seasons, have been reported to be loamy and sandy loam in texture . pH of soils varied from 6.0 to 8.5. Nitrogen content varied from 13.0 to 25.2 lbs / acre, falling under the category of very less. Similarly, the Potassium level varied from 80.3 to 85.3 lbs / acre, falling under the category very less. Phosphorus content varied from 16.3 to 18.5 lbs / acre, falling under the category of less. The levels of organic

matter in the soil varied from o.48 to 0.63% falling under the category of sufficient. Sulphates, Carbonates and Boron were found below detection limit.

Commercial area

The texture of soil at Shella Bazar (S1 & S3) varied from loamy to sandy loam and pH value ranged between 5.1 to 7.7. Nitrogen content varied in the range of 20.1 to 59.5 lbs / acres at S1, while 1.3 to 13.5 lbs / acres at S3 and to be under the category of less to very less respectively. Similarly, the Potassium level varied from 89.0 to 90.4 lbs / acres at S1 while 89.3 to 94.5 lbs / acres at S3 and to be under the category of low. Phosphorus was within the level of 16.7 to 20.5 lbs / acres at S1 and 17.9 to 21.5 lbs / acres at S3 and to be under the category of on an average less. The level of organic matter in the soil was observed in the range of 0.60 to 0.68 % and to be under the category of average sufficient. Sulphates, Carbonates and Boron were found below detection limit

Phlangkaruh River Bed

The soil at Phlangkaruh (S2) was colected on the bank of Phlangkaruh river and was observed to be sandy clay loam to sandy loam in texture & slightly acidic to neutral in nature. Nitrogen content ranged from 13.0 to 43.2 lbs / acres, and covered under the category of very less during pre monsoon and winter season while less in post monsoon season. Similarly, the Potassium level ranged from 90.1 to 93.5 lbs / acres and covered under the category of low. Phosphorus ranged from 17.2 to 19.0 lbs / acres and covered under the category of less. The level of organic matter in the soil was observed to be 0.5 to 0.63 % and covered under the category of on an average sufficient. Sulphates, Carbonates and Boron were found below detection limit

Rural Surrounding

The soil at Nongwar and Mawryngkhong and Pyrkan (S4, S10 and S6) were collected to establish the rural soil quality of the region. Soil at all locations were found to be loamy and alkaline in nature. Nitrogen content ranged from 9.0 to 12.6 lbs / acres in Nongwar and Mawryngkhong while nil at Pyrkan and covered under the category of very less nitrogen. The Potassium level ranged from 83.3 to 97.6 lbs / acres and covered under the category of very less. Phosphorus was found to be in the range of 16.7 to 18.9 lbs / acres and covered under the category of less. The levels of organic matter in the soil was observed to be in the range of 0.44-0.64% and covered under the category of on an average sufficient medium average to average sufficiet. Sulphates, Carbonates and Boron were found below detection limit

At Mawdet

The soil at Mawdet (S13) was observed to be sandy clay loam in texture and slightly alkaline to neutral in nature. Nitrogen was absent in premonsoon season and ranged from 10.2 to 11.5 lbs / acres during rest of the two seasons. Potassium level ranged from 93.2 to 96.7 lbs / acres and covered under the category of very less. Phosphorus ranged from 19.6 to 21.2 lbs / acres and covered under the category of less. The levels of organic matter in the soil were

observed to be 0.69 to 0.72 %, covered under the category of sufficient. Sulphates, Carbonates and Boron were found below detection limit

Cultivation Areas

The soil at Karda and Nonglait (S9 & S5) were reported to be sandy & loamy in texture and slightly alkaline in nature. Nitrogen level was absent in soil from Nonglait and varied from Nil to 9.5 lbs / acres at Karda. Potassium level varied between 82.9 to 92.5 lbs / acres, falling under the category of less. Phosphorus varied from 17.6 to 19.9 lbs / acres, falling under the category of less. The levels of organic matter in the soil were reported in the range of 0.47 to 0.63 %, falling under the category of sufficient. Sulphates, Carbonates and Boron were found below detection limit

General Observations

Soil of the area was reported to be sandy to loamy in texture containing high humus and with nature varying pH from slightly acidic to alkaline. The nitrogen levels were reported to be under the category of low except in certain cases. Similarly, the Potassium levels were also under the category of low. Whereas the levels of Phosphorus were reported to be in the category of less to medium. The levels of organic matter in the soils were reported to be in the category of medium to on an average sufficient. Sulphates, Carbonates and Boron were found below detection limit

Land Capability

The flood plains are the significantly rich soil due to alluvial deposit. However in the plateau and hill slopes the soil depth is very low and large tracts of land are uncultivable. In and around the limestone block the soil is alkaline and does not support any healthy plant growth.

The hill slopes are extensively used for plantation of betel nuts, which requires running water and very little soil depth for growth. Also to prevent land sliding and soil erosion the hill slopes, the bamboo vegetation and the plantation plays an important role. The growth of the bamboo does not allow washing away of the little top soil above the rock structures and in the fissures and gullies of the hill slopes. The flood plains and the valley soil are primarily sandy alluvial deposit where paddy is grown.

4.8 ECOLOGY

In the present context, ecological study forms the most important aspect of the impact assessment studies. The impact on ecological parameters *viz.* flora and fauna is a direct consequence of the mining activity. The present study serves as an input to the EIA Report submitted for the proposed open-cast limestone mine at Phlangkaruh, Nongtrai and Shella confederacy (East Khasi Hill district of Meghalaya) of Lum Mawshun Minerals Private Limited (LMMPL). The primary objective of the study is as follows :

- To analyse the forest types both qualitatively and quantitatively;
- To prepare floristic checklist for core and buffer zone;

- To prepare list of rare and endangered plant species if any;
- To identify faunal checklist of core and buffer zone;
- To prepare rare and endangered animal species, if any;
- To evaluate wildlife habitat; and
- To evaluate impact of mining on flora and fauna, if any.

This report has been prepared based on extensive field investigations as well as review of data available with BSI and ZSI

Methodology

The ecological status survey was undertaken in December 2000 by Dr. A.K. Ghosh of Centre for Science and Development, Calcutta who along with his team intensively surveyed the area for the proposed project. The primary data relating to flora and fauna of the area was generated on site. Secondary data were obtained from Botanical Survey of India (Shillong Regional office), Zoological Survey of India (Shillong Regional office), Divisional forest offices (Territorial, Silviculture, Social Forestry and Wildlife), District Agriculture office of East Khasi Hill district, Meghalaya, through intensive interactive sessions with the above.

Both Terrestrial Ecosystem and Aquatic Ecosystem were investigated in depth during survey period. The analysis of terrestrial ecosystem covers the forest type analysis, floral analysis, faunal analysis and assessment of agriculture and livestock, etc. The analysis of aquatic ecosystem includes the study of planktons, benthos, macrophytes and aquatic fauna.

Terrestrial Ecosystem

Forest Types of Meghalaya

Since the works published by Hooker (1854), it became known that vegetation cover of North-East region, particularly Meghalaya region is rich and diverse. Rao (1968, 74), Bor (1942), Joseph (1968), Balakrishnan (1981), Baishya and Rao (1928), Haridasan and Rao (1985) and Haridasan (1999), surveyed the flora of Meghalaya and reported more than 3000 plant species from 22,549 Sq. km area. Broadly, the forest of Meghalaya can be grouped under Tropical and Temperate forest on the basis of their climatic association and species composition. Further, Tropical forests are classified as “Tropical moist” and “Dry deciduous”, “Tropical semi-evergreen”, “Tropical evergreen” and “Grassland” types.

Tropical moist and dry deciduous forest

This type of forests occurs at the lower elevation of the hills in Meghalaya. The dominant upper canopy forming species are *Tectona grandis, Terminalia myriocarpa, Sterculia villosa, Lagerstroemia parviflora* and *Gmelina arborea* both as natural and as plantation; while species like *Schima wallichii, Salmalia malabaricum, Albizia odontossima, Terminalia balerica* and *Amoora wallichi* are found in natural forest. The second story is composed of small trees and shrubs. The dominant species are C*areya arborea, Bridelia retusa, Grewia disperma,*

Holarrhena antidysenterica, Flemmingia macrophylla, Zizyphous mauritianus, Eupatorium odoratum and *Lantana camara*. Climbers and lianas are also very abundant; they are represented by *Combretum roxburghii, Holbolia latifolia, Ichinocarpus fruticens, Mikenea scandens* and *Derris elliptica*. There are abundance of bamboo species, viz. *Dendrocalamus hamiltonii, Bambusa tudla, Bambusa pallida* and *Arundinaria intermedia.*

Tropical semi-evergreen forest

This type of forest is found at an elevation of 900-1200 m. The dominant species of the upper canopy are as follows: *Elaeocarpus floribundus, Dillenia pentagyna, Dillenia indica, Symplocos racemosus, Garcinia indica* and *Careya arborea*. The second story of small trees and shrubs layer is not very dense. It is composed of *Ficus* spp., *Clerodendron infortunatum, Hypericum japonicum* and *Thysanolena maxima.*

Tropical evergreen forest

These forests are found in upper hill zone with high rainfall. The upper canopy is composed of dominant species like *Mesna ferra, Castanopsis indica, Terminalia belerica, laeocarpus floribundus, Pterospermum acerifolium* and *Lennaea coromandelia.* The second storied is composed of species like *Grasinia indica, Ficus racemosa, Saraca indica, Sterculia villosa* and *Mangifera indica.* The shrubs and small trees form the third storied. The dominant species are *Ficus reticulata, Justicia gendarusa* and *Dracaena elliptica.* Like semievergreen forest, this zone is also having wood climber viz. *Thunbergia grandilfora* and *Combretum roxenburghii* and the epiphytes like *Hoya parasitica,* species of *Dendrobium* and *Pothos scandens* are most frequent. The stream corridors have dominant trees like *Duabanga grandiflora.*

Grasslands

Grassland is found in hill slope after forest clearance by jhuming or in exposed river -beds. The dominant species are *Saccharunm spontaneum, Chrysopogon aciculatum, Imperata cylindrica, Eriocaulon chinensis* and *Paspalum dilatatum*.

Temperate Forests

These forests are located in high mountain zone (>above 1000 m) outside the present study area. The dominant species are *Quercus semiserrata, Alnus nepalensis, Castanopsis kuezii, Achima wallichi* and *Elaeocarpus acuminata*. The shrub layer is represented by *Mahonis pycnophylla, Daphne papyracea, Virubrum foetidum* and *Polygala arillata.* This region is also rich in epiphytic flora and climbers. In some places, the temperate flora is dominated by Pine forest, which is mostly planted.

A number of sacred groves are found in temperate zone. In a recent report, about 31 sacred grooves in east Khasi Hill district are recorded but almost all of them are located in upper hilly region outside the present study area.

Plantation and Orchards

In and around village settlements, there is frequent commercial plantation of Betelnut palm with *Piper nigrum*, pine apple, lemon grass, banana, turmeric and ginger and fruit trees like mango, guava, peach, pear and cherry. A few timber yielding species are also grown around the village orchards. Except road -side planting, plantation (in blocks) under social forestry schemes is not seen in the surveyed areas.

Riparian forest

The dominant species of riparian vegetation are *Homonya riparia, saccharum spontaneum, Calotropis procera, Eupatorium odoratum, Holarrhena antidysenterica, Hyptis suaveolens, Zyziphus mauritianus* and isolated trees like *Alstonia scholaris, Duabauga gradiflora* and *Sizygium cumini.*

Trends in the area

In general much of the original forests of the East Khasi Hill area and of the state itself have declined in past years due to jhuming or shifting agriculture and fuelwood / timber extraction. As most of the forest area is privately owned, there are few significant effort for forest conservation or afforestation.

Vegetation of Surveyed Area

The survey was carried out by using grids in both core zone i.e. project leasehold area and buffer zone i.e. within 10 km radius around the project leasehold area. No Reserve forest, Wildlife sanctuary, National Park or Biosphere Reserve exists within the core or buffer area. The results of primary survey are given below.

Vegetation cover of Core Zone

The project site covers an area of about 100 hectares with uneven terrain. Trees such as *Terminalia arjuna, Terminalia bellerica, Terminalia myriocarps, Alstonia scholaris, Ficus glomerata, Gmelina arborea, Bauhinia acuminata, Ailanthus grandis, Duabanga grandiflora* and *Sterculia villosa* are very frequent this area. The dominant shrubs of this area are *Eupatorium odonatum, Zizyphus muritinum* and *Clerodendron infortunatum, Saccharum spontaneum, Thysanolaena maxima* are abundant in exposed places. There are quite a good number of herbs in comparatively exposed areas. The dominant forms are *Sida cordifolia, Sida acuta, Urena lobata, Amaranthus viridis, Ageratum conyzoides* and *Bidens pillosa.* Climbers are fairly abundant. The most predominant forms are *Mikenia scandense* and *Combretum roxburghii.* Wild *Musa sapiantum* occurs in the lower elevation.

However no endemic or endangered plant species was found in the core zone area according to the primary survey and quadrants that were used for the same.

Vegetation cover of Buffer Zone

The study area extend from upper hills (>1000 m) to river bed and swampy paddy fields and is very diverse. There are a good number of village settlements with orchards and plantation areas. Thus the buffer zone shows different types of forests including tropical evergreen, tropical semi-evergreen, tropical moist and dry deciduous, grassland and plantations forest. The dominant species are as per described above.

Almost all households in the villages have homeland to grow crops like turmeric, ginger, banana, vegetables, betelnut or fruit trees.

The canopy cover of the upper hill forests ranges between 20-30% while that of village orchards ranges from 10-15%. The ground cover in grassland is fairly dense. Timber and fuelwood extraction from the forest is a continued process. The grazing in forest area is fairly low except in the areas around the village settlement.

The primary survey indicates that there are no endangered or endemic species in the buffer area, and that this is corroborated by a secondary data review.

4.8.2 Flora

Meghalaya and East Khasi hills are floristically fairly rich areas. The study area (core and buffer zone) extends from near sea level elevation to an elevation of about 800 m. The buffer zone extend from hilly subtropical regions in the north and in the eastern part, to plains and swamp land in the south. As such it has floristic components have tropical, subtropical, riparian and grassland zones.

The floral checklist was prepared on the basis of intensive study and field observations in the project core area and also extensive study in the buffer zone during December 2000.

In the floristic checklist (***Table 4.20***), both forest species (wild and planted) and cultivated orchard species are included. A good number of species are commercially cultivated in orchards, a few of which have medicinal values. Though in Meghalaya there are a number of endemic plant species reported earlier, none of the species was observed in the study area. A total of 71 trees, 34 shrubs, 21 climbers and epiphytes and about 48 common herb species is listed here from our field observation during the study period.

Table 4.20 Floral Checklist of Surveyed Area

S.N	Scientific Name	Local/ Common Name
Trees		
	Aegle marmelos	Heikhagok
	Ailanthes grandis	Ganmathai
	Albizia lucida	Siris
	Albizia odoratisima	Haya
	Albizia procera	Dumkol

S.N	Scientific Name	Local/ Common Name
	Alstonea scholaris	Chaton
	Amoora walichi	Agachi, Akshi
	Areca catechu	Betelnut Palm
	Artocarpus chaplasa	Dewa-sali
	Artocarpus integrifolia	Jackfruit
	Arundinaria intermedia	Perinypk
	Azadirachta indica	Baigaina
	Bambusa pallida	Shken
	Bambusa tulda	Shkong
	Bauhinia acuminata	Chingthrou
	Bauhinia purpurea	Chingthao-angauba
	Bixa orellana	Annatto
	Bridelia retusa	Geio
	Buddeja macrostachya	Tipoka-moli
	Careya arborea	Gemble
	Caryota urens	Tamak
	Cassia fistula	Haunaruaraung
	Castanopsis indica	Khashi badam
	Chikrasia tabularis	-
	Cinnamomum bejolghota	Ashokhyphum
	Cinnamomum tamala	Lapynriang
	Cocos nucifera	Coconut
	Dalbergia sissoo	Sisoo
	Dendrocalamus giganteus	Wa
	Dendrocalamus hamiltonii	Choya bans
	Dillenia indica	Heigri
	Dillenia pentagyna	Agachi, Akshi
	Duabanga grandiflora	Luaipap
	Elaeocarpus floribundus	Koying
	Erythrina arborecens	Hieto
	Ficus bengalensis	Bar
	Ficus glomerata	-
	Ficus hispida	Takpiang
	Ficus religiosa	Aliot
	Ficus reticulata	Fig
	Garuga pinata	Bonkung-esing
	Glochidion lanceolarium	-
	Gmelia arborea	-
	Grevillea robusta	Kabulia
	Grewia sapida	Brbe
	Kydia calycina	Anisep
	Lagerstomea parviflora	Jarul
	Lelnnea coromandelia	-
	Lichi chinensis	Dieng-soh-manir
	Macaranga peltata	-
	Mangifera indica	Am, Chillujak
	Mesua ferra	Karai
	Phoneix sylvestris	Datepalm
	Prunus persica	Chumberi
	Psidium guajava	Ambak
	Pterospermum acerifolium	-
	Quercus semiserrata	Kara
	Salmalia malabaricum	Semulu
	Sapindus mukorossi	Haitaguti
	Spondias pinnata	Ambithong
	Sterculia villosa	Chikaung-araung
	Symplocos ramossisima	Kharane
	Syzygium cumini	Golpai
	Tamarindus indica	Maunge

S.N	Scientific Name	Local/ Common Name
	Tectona grandis	Teak
	Terminalia arjuna	Arjuna
	Terminalia belerica	Bahera
	Toona ciliata	Poma
	Trema orientalis	Pampak
	Trewia nudiflora	Wangbhop
	Zizyphus mauritiana	Soh-broi
Shrubs		
	Acacia intsia	Ragre
	Cajanus cajan	Rahban
	Calamus erectus	Rue
	Calotropis gigantea	Akon
	Capparis spinosa	Koura
	Carica papaya	Awthabi
	Coix lacrymajobi	Chening
	Costos speciosus	Akotenarmg
	Desmodium pulchellum	Pangaug
	Eupatorium odoratum	Samalmari
	Flemingia macrophylla	Charaiaw
	Holarrhena antidysenterica	Bolmatra
	Homonya riparia	-
	Hyptdis suaveolense	Bantulsi
	Hypericum japonicum	Aaeemilang
	Jatropa cureas	Wa-kege
	Justicia gendarusa	-
	Lantana camara	Soh-pang-khlieh
	Clerodendrum infortunatum	Akalbiti
	Manihot esculenta	Tapioca
	Melastoma malabathricum	Akayoanyi
	Morinda citrifolia	Ach
	Morus alba	Sanukimbu
	Musa paradisica	Athiakol
	Nyctanthes arbor-tristis	Sephalika
	Pandanus fasciculatum	Keheki
	Phyllanthes uranaria	-
	Ricinus communis	Dalda grass
	Saccharum spontaneum	Kahibon
	Solanum torvum	Bako
	Streblus asper	Bulat
	Thysanoaena maxima	Holjaru
	Urena lobata	Bhatekuru
	Woodfordia fruticosa	-
Climbers and Epiphytes		
	Abrus plecatorius	Lalgadi
	Aristolochia cathartii	Baro-nirkhut
	Asclepias racemosus	-
	Bauhinia vahlii	Bhorla
	Combretum roxburghii	Arkeng-rikang
	Dendrobium dinsiflorum	Balgto
	Derris elliptica	Hiru rikang
	Dioscorea alata	Eugin
	Dioscorea belophylla	Ban-tarul
	Dioscorea hamiltonii	Ban-tarul
	Holboellia latifolia	Mezutsuk-moli
	Hoya parasitica	-
	Ichnocarpus frutescens	Jorakuchare
	Lablab purpureus	Tohi
	Mikenia scandanse	German-pula
	Piper nigrum	Jaluk

S.N	Scientific Name	Local/ Common Name
	Pothos scandens	-
	Smilax zeylanica	-
	Thunbergia gradiflora	Nungnung
	Tinospora cordifolia	Amaslota
	Vanda teosellata	Akhasi-gos
Herbs		
	Achyranthes aspera	Minamkachi
	Ageratum conyzoidas	Imchenriza
	Alternanthera sessilis	-
	Amaranthus viridis	-
	Ananus squamosus	Alipiong
	Andrographis paniculata	-
	Bidens pillosa	Bana
	Blumea lacera	Janya
	Boerhavia repens	-
	Calamintha umbrosa	-
	Carex filicina	Dimba lapia
	Centella asiatica	Atina
	Chenopodium ambrosoides	Chisik-bot
	Curcuma zedoaria	Amada
	Cymbopogon nurdas	Citronella
	Cynodon dactylon	Dubari
	Cyperus griffithi	Bajran
	Desmodium laxiflorum	Bhutu-ham
	Drymeria cordata	Achhamena
	Echinochloa crus-galli	-
	Eleusive indica	Bobosaben
	Eragrostis tenella	-
	Eriocanton luzulaefolium	-
	Euphorbia lutra	-
	Fimbristylis falcata	Arza
	Hedychium aurantiacum	-
	Imperata cylindrica	Altong
	Isachne albens	-
	Mimosa pudica	-
	Ocimum basilium	-
	Oxalis corniculata	Chota tengeri
	Paedaria foetida	Bhedailota
	Pennisetum americanum	Yangpah
	Polygonum molle	Borbung
	Polygonum orientale	Agasom
	Pouzozia hirta	Akhle
	Scoparia dulcis	Butburi
	Sida acuta	Barphum
	Sida cordifolia	Barial
	Solanum nigrum	-
	Sonchus asper	Akatsu
	Strobilanthus orientalis	Barcha
	Themeda villosa	Kahinwon
	Tridax procumbens	-
	Triumfelta rhomboidea	Sli-sko
	Vinca rosea	-
	Xanthium strumarium	Agra
	Zingiber officinale	Ada

Endangered Plant Species

According to the report of Haridasan and Rao (1985) and Haridasn (1999), 89 plant species are recorded as "Endangered" from the entire state of Meghalaya; among the endangered species *Nepenthes khasiana* is most widely known but was never recorded in the study area. For *in-situ* conservation of endangered flora and fauna, natural habitats at Nokrek, Balphakhram and other protected areas (Wildlife Sanctuary, etc.) have already been established specially in Garo Hills.

However from the earlier field survey records and observations made during the present survey it appears that none of the endangered plant species exist in the study area.

Medicinal Values of Plants

A total of 25 plants of known medicinal values have been recorded in the Buffer Zone of the study area (***Table: 4.21***). These have wide distribution in the state.

Table 4.21: Checklist of Medical Plants

S. N	Species	Parts useful for various medicinal purpose
	Abrus precatorius	Whole plant
	Achyranthus aspera	Root and stem
	Alstonea scholaris	Bark
	Andrographis paniculata	Whole plant
	Aristolochia cathertii	Whole plant
	Boerhaavia repens	Stem and leaf
	Calotropis gigantea	Stem and root
	Cinnamomum tamala	Leaf
	Curcuma longa	Rhizome
	Eupatorium odoratum	Leaf
	Holarrhena antidysenterica	Bark
	Justicia gendarussa	Stem and leaf
	Nyctanthes arbortristis	Leaf
	Ocimum basilicum	Stem and leaf
	Paederia foetida	Stem and leaf
	Piper longum	Fruit
	Rauvolfia serpentina	Root
	Saraca indica	Bark, leaf and flower
	Sida acuta	Root, stem and leaf
	Terminalia arjuna	Bark
	Terminalia balerica	Bark and fruit
	Terminalia chebula	Bark and fruit
	Tinospora cordifolia	Whole plant
	Vitis quadrangularis	Whole plant
	Zinziber officinalis	Rhizome

It is interesting to note the fact that most of the medicinal plants as listed were not commercially cultivated. However very recently, the Silviculture division of Meghalaya Forest Department, took up initiative for cultivation and commercial utilisation of these plant species.

Cryptogamic Flora

The study area specially Buffer zone show different species of ferns including tree fern, lihens and wood decaying fungi. The most common ferns belong to the gerera viz. *Diplazium, Pteris, Adiantum, Lygodium, Nephrolepis, Cyanthera, Argiopteris* and *Asplenium*. The dominant wood fungi are species of *Polyporus, Ganoderma, Lentinus* and *Schizophyllum*. The lichens are also fairly abundant in this area. The most common forms are Crantose and Foliose. In upper elevation of buffer zone, species of *Lycopodium* and *Selaginella* along with moss and liverwarts were observed particularly in moist places.

Phytosociology

For quantitative analysis of floristic components in different zones of core and buffer region, quadrates (20 m x 20 m) were laid in a linear grade. A total of ten quadrate sampling was performed for quantitative assessment of plant types in the core and buffer zone. The details are given in the ***Table 4.22***.

Table 4.22: Phytosociological Analysis of forest zones

Type of Forest with Location	S. N	Species	Frequency	Density	Abundance
A. Core zone					
i) Upper	1	Sterculia villosa	60	6.0	10.0
elevation, semi-	2	*Chikrasia tabularis*	20	1.0	20.0
evergreen forest	3	*Saraca indica*	10	1.0	10.0
patch	4	*Ficus glomerata*	20	8.0	2.5
	5	*Terminalia belerica*	20	4.0	5.0
	6	*Terminalia myriocarpa*	20	3.0	6.6
	7	*Alstonea scholaris*	40	8.0	5.0
	8	*Eupatorium odaratum*	100	10.0	10.0
	9	*Lantana camara*	50	6.0	8.3
	10	*Musa sapientum*	80	8.0	10.0
	11	*Toona ciliata*	20	2.0	10.0
	12	*Clerodendron infortunatum*	30	3.0	10.0
ii) Lower	1	*Duabanga grandiflora*	40	4.0	10.0
elevation, mix	2	*Alstonea scholaris*	30	5.0	6.0
semi-evergreen &	3	*Zyzyphus mautianus*	40	8.0	5.0
deciduous forest	4	*Terminalia belerica*	30	5.0	6.0
patch	5	*Terminalia arjuna*	20	5.0	4.0
	6	*Ficus glomerata*	30	6.0	5.0
	7	*Gmelina arborea*	30	5.0	6.0
	8	*Bauhinia acuminata*	40	8.0	5.0
	9	*Ailanthes grandis*	10	2.0	5.0
	10	*Eupatorium odoratum*	80	8.0	10.0
	11	*Musa sapientum*	80	8.0	10.0
	12	*Lantana camara*	40	8.0	8.0
	13	*Saccharum spontaneum*	50	5.0	10.0
	14	*Clerodendron infortunatum*	40	5.0	8.0
	15	*Thysanolaena maxima*	30	6.0	5.0
B. Buffer zone					
i) Evergreen	1	*Terminalia belerica*	30	6.0	5.0
forest patch	2	*Terminalia myriocarpa*	20	5.0	4.0
	3	*Castanopis indica*	20	4.0	5.0
	4	*Pterospermum acerifolium*	20	5.0	4.0
	5	*Sterculia villosa*	40	6.0	6.6
	6	*Ficus recemosa*	20	4.0	5.0
	7	*Gracinia indica*	10	5.0	2.0
	8	*Daubanga grandiflora*	20	6.0	3.3
	9	*Mangifera indica*	10	5.0	2.0
	10	*Mesua ferra*	20	4.0	5.0
ii) Semi-	1	*Dillenia pantagyna*	30	6.0	5.0
evergreen	2	*Symlocos recemosus*	20	5.0	4.0
deciduous forest	3	*Carya arborea*	10	2.0	5.0
patch	4	*Erythrina arborescense*	20	5.0	4.0
	5	*Clerodendron infortunatum*	40	8.0	5.0
	6	*Ficus glomerata*	20	5.0	4.0
	7	*Thysanolaena maxima*	20	4.0	5.0
	8	*Sterculia villosa*	30	6.0	5.0
	9	*Alstonia scholaris*	30	5.0	6.0
	10	*Hypericum japonicum*	20	5.0	4.0
iii) Grassland	1	*Saccharum spontaneum*	60	6.0	10.0
Patch	2	*Impamta cylindrica*	50	5.0	10.0
	3	*Paspalum dilatatum*	40	8.0	5.0
	4	*Calotropis gigantea*	30	6.0	5.0
	5	*Eupatorium odoratum*	60	10.0	6.0
	6	*Lantana camara*	40	8.0	5.0

Type of Forest with Location	S. N	Species	Frequency	Density	Abundance
	7	*Capparis spinosa*	10	2.0	5.0
	8	*Zyziphus nimularius*	20	5.0	4.0
	9	*Holarrhena antidysenterica*	60	6.0	10.0
iv) Village	1	*Areca catechu*	60	6.0	10.0
Orchard Patch	2	*Litchi chinensis*	20	5.0	4.0
(Shella)	3	*Mangifera indica*	30	6.0	5.0
	4	*Phyllanthes emblica*	10	2.0	5.0
	5	*Sizyzium cumini*	20	5.0	4.0
	6	*Cinnamomum tamala*	20	4.0	5.0
	7	*Dendrocalamus hamiltoni*	20	5.0	4.0
	8	*Tectona grandis*	20	6.0	3.3
	9	*Alstonea grandis*	20	5.0	4.0
	10	*Gmelina arborea*	30	6.0	5.0
	11	*Musa paradisiaca*	40	5.0	8.0
	12	*Artocarpus integrifolia*	30	6.0	5.0
v) Village	1	*Mangifera indica*	30	6.0	5.0
Orchard Patch II	2	*Musa paradisiaca*	40	8.0	5.0
(Durbar)	3	*Ficus glomerata*	30	6.0	5.0
	4	*Morus alba*	20	5.0	4.0
	5	*Cinnamomum tamala*	20	6.0	3.3
	6	*Artocarpus integrifolia*	20	4.0	5.0
	7	*Areca catechu*	60	6.0	10.0
	8	*Albizia odontosima*	40	8.0	5.0
	9	*Tonna ciliata*	20	2.0	10.0
	10	*Psidium guajava*	20	5.0	4.0

There is no endangered or rare species (as per Red Data Book published by BSI) observed during this study.

communities. Hunting being an age old tradition in the area, the pressure obviously increased with expanding population.

The present study as such reveals a rather poor profile of higher vertebrates, especially mammalian fauna. Frugivorous bats and small rodents and legomorphs remain the major representative both in the Core zone and in the Buffer zone (***Table 4.24***). None of the mammalian species could be identified as Rare and Endangered. The avian fauna observed totals 57 species. No separate record was available from Eastern Regional Centre of ZSI. Most of the bird species recorded in the study area are wide spread in distribution in Meghalaya and Eastern Himalayas. None of the bird species is considered "Endangered or Rare" as per schedule of IWPA, 1972 and its amendment version (***Table 4.25***).

The Herpetofaunal records from the study area indicate the possible occurrence of Rusells Viper and King Cobra in the past. A survey undertaken by ZSI in Meghalaya (published 1995) however, did not find these species. During the present study at most eight species of snakes and lizards (***Table4.23***) and two species of Amphibia, could be recorded (in the aquatic the ecosystem). None has been listed as “Endangered or Rare” in the IWPA. Of the vertebrates, Pisces (Fishes) have been dealt under Aquatic Ecosystem.

According to normal biodiversity studies, Butterflies are recorded as being of significant ecological value (besides Birds and Flowering Plants). Survey records in Eastern Regional Station of ZSI, Shillong indicate occurrence of 22 species belonging to Pieridae, Danaudae, Papillionidae. None of these species is considered “Rare and Endangered” (***Table4.27***).

Table 4.24: Checklist of Mammalian Species

Sl. No.	Scientific Name	Common Name	Local Status	IWPA
	Bandicota bengalensis	Indian Mole Rat	Common	V
	Bandicota indica	Bandicoot Rat	Common	V
	Cannomys badius	Bamboo Rat	Sporadic	V
	Cynoptarus sphinx	Shortnosed Fruit Bat	Common	V
	Dremomys lokriah	Himalayan Squirrels	Common	-
	Lepus nigricollis	Indian Hare	Rare	-
	Mus booduga	Indian Field Rat	Common	-
	Scotophilus heathi	Common yellow Bat	Common	-
	Vulpes bengalensis	Indian Fox	Sporadic	II

Table 4.25: Checklist of Bird Species

Sl. No.	Scientific Name	Common Name	Local Status	IWPA
	Columba livia	Blue Rock Pigeon	Common	IV
	Streptopelia chinensis	Spotted Dove	Common	IV
	Psittacula krameri	Roseringed Parakeet	Sporadic	IV
	Psittacula alexandria	Indian Redbreasted Parakeet	Rare	IV
	Loriculua verhalis	Lorikeet	Rare	IV
	Cuculus canorus	Cuckoo	Sporadic	IV
	Cuculus micropterus	Hawk Cuckoo	Sporadic	IV
	Clamator coromandus	Redwinged Crested Cuckoo	Rare	IV
	Eudynamys scolopacea	Koel	Common	-
	Centropus sinensis	Koel	Sporadic	-
	Strix leptogrammica	Brown Wood Owl	Rare	IV
	Hemiprone longipennis	House Swift	Common	-

Sl. No.	Scientific Name	Common Name	Local Status	IWPA
	Cypsiurus parvus	Palm swift	Common	-
	Caprimulgus asiaticua	Common Indian Nitghtar	Sporadic	IV
	Merops leschenaulti	Chestnutheaded Bee-eater	Common	-
	Merops orientalis	Small Green Bee-eater	Common	-
	Coracias garrulus	Roller	Rare	IV
	Upupa epops	Hoopoe	Rare	IV
	Megalaima haemacephala	Coppersmith	Common	IV
	Megalaima rubricapilla	Crimsonthroated Barbet	Common	IV
	Chyrysocolaptes festivus	Indian Goldenbacked Woodpecker	Sporadic	IV
	Dinopium bengalensis	Lesser Goldenbacked Woodpeacker	Sporadic	IV
	Megalaima asiatica	Blue throated Barbet	Common	IV
	Pitta nipalensis	Bluenaped Pitta	Common	IV
	Galerida cristata	Crested Lark	Rare	IV
	Lanius cristatus	Brown Shrike	Common	-
	Oriolus oriolus	Golden Oriole	Common	IV
	Oriolus xanthornus	Lackheaded Oriole	Common	IV
	Dicrurus adsimilis	Black Drongo	Sporadic	IV
	Dicrurus aeneus	Brown Drongo	Rare	IV
	Acridotheres tristis	Indian Myna	Sporadic	IV
	Acridotheres ginginianus	Bank Myna	Sporadic	IV
	Sturus contra	Pied Myna	Sporadic	IV
	Dendrocitta vagabunda	Tree Pie	Rare	IV
	Corvus splendens	House Crow	Rare	V
	Corvus macrorhynchos	Jungle Crow	Sporadic	V
	Hemipus picatus	Pied Flycatcher	Common	IV
	Pericrocotus erythropygius	Whitebellied Minivet	Common	IV
	Pericrocotus roseus	Rosy Minivet	Common	IV
	Chloropsis cochinchinensis	Goldmantled Chloropsis	Common	IV
	Pycnonotus atriceps	Blackheaded Bulbul	Common	IV
	Pycnonotus cafer	Redvented Bulbul	Common	IV
	Pellorneum ruficeps	Spotted Babbler	Sporadic	IV
	Alsippe poioicephala	Quaker Babbler	Sporadic	IV
	Gampsorhynchus rufulus	Whiteheaded Babbler	Sporadic	IV
	Turdoides striatus	Jungle Babbler	Rare	IV
	Garrulax maniligerus	Necklaced Laughing Thrus	Sporadic	IV
	Muscicapa mutti	Brown-breasted Flycatcher	Sporadic	IV
	Orthotomus mtorius	Tailor Bird	Common	-
	Copsychus saularis	Magpie Robin	Rare	-
	Dicacum erythrohynchos	Thickll's Flowerpecker	Common	IV
	Dicacum ignipeetus	Firebreasted Flowerpecker	Sporadic	IV
	Acthopyga siparaja	Yellowbacked Sunbird	Common	IV
	Nectarine asiatica	Purple Sunbird	Common	IV
	Passer domesticua	House Sparrow	Common	-
	Ploceus philippinus	Baya Weaver Bird	Rare	IV
	Lanchura mallaca	Blackheaded Munia	Sporadic	IV
	Milvus migrans	Pariah Kite	Common	IV

Table 4.26: Checklist of Reptiles

S. N.	Scientific Name	Common Name	Local Status	IWPA
	Ahaectulla nasutus	Common Green Whip Snake	Common	-
	Calotes jerdoni	Eastern Green Calotes	Rare	-
	Calotes versicolor	Common garden Lizard	Common	-
	Hemidactylus flaviviridis	House Gecko	Common	-
	Mabuya carinata	Common Skink	Sporadic	-
	Macropisthodon plumbicolor	Green Keelback	Common	-
	Varanus bengalensis	Common Indian Monitor	Sporadic	II

	Xenochrophis piscator	Checkered Keelback	Common	II

Table 4.27: Checklist of Lepidoptera

S.N	Scientific Name	Common Name
	Argynnis hyperbius	Indian Fritillary
	Catopsilia pomona	-
	Danaus chrysippus	Plain Tiger
	Danaus genutia	Common Tiger
	Danaus melissa	-
	Delius acalis	Red-Breasted jezebel
	Euploea mulciber	-
	Euploea mulciber	Striped Blue Crow
	Eurema blanda	Three Spot Grass Yellow
	Eurema hecabe	Common Grass Yellow
	Eurema laeta laeta	Spotless Grass Yellow
	Hypolimnas bolina	-
	Lamproptera eurius	-
	Pantoporia perius	Common Sergeant
	Papilio polytes	Common Mormon
	Precis almera	Peacock Pansy
	Precis atlites	Grey Pansy
	Precis iphita	Chocolate Pansy
	Precis lemonius	Lemon Pansy
	Symbrenthia hippoelus	Himalayan Jester
	Vanessa cardui	-
	Zemeros flegyas	Punchinello

Aquatic Ecosystem

The surveyed area is located in the water shed between the Umium river on the east and the Khasimarg river on the west. Several seasonal rivulates, nallahs and gullies dissect the surface, which result in the formation of spurs. The Umium river flows southwards; and has tributaries like Phlangkaruh river. In addition there are bill, swamp area in the south east part of Shella region.

The biological resources of aquatic systems were either collected or observed and analysed both qualitatively and quantitatively during the field survey. The major components are as follows :

Producers : Plankton (Phyto); Macrophytes; Benthos
Consumers: Plankton (Zoo); Fish; Amphibia; Water birds;Aquatic mammals

Planktons

These are microscopic life forms belonging to either Phytoplankton (algae) or Zooplanktons (Protozoa or rotifers, etc.) categories. They form the lowest trophic level of the aquatic ecosystem. Water samples were collected from three surface flowing sources, filtered through plankton net for collection of planktons. Then samples were processed and preserved for microscopic analysis. The species density is tabulated below (***Table 4.28***)

Table 4.28: Plankton Load (No./100 litre)

S. N	Species	Phalangkaruh	Shella	Tollyp
A. Phytoplankton				
	Volvox sp.	-	100	300
	Cosmarium sp.	50	100	100
	Formedia sp.	100	100	200
	Chlamydomonas sp.	100	50	100
	Navicula sp.	400	200	50
6	*Euglena* sp.	-	200	600
7.	*Pediastrum* sp.	200	600	-
8.	*Eudorina* sp.	100	50	-
B.Zooplankton				
1.	Rotifers	40	30	50
2.	Cladocera	30	40	-
	TOTAL :	1020	970	1400

Macrophytes

The swamps and freshwater beels area reveal a number of macrophytes. They constitute a major component of aquatic ecosystems. A checklist is given in ***Table 4.29***.

Table 4.29: Checklist of Macrophytes

Sl. No.	Species (Scientific Name)	Growth Form	Occurrence
	Cardenthera diformis	Amphibious	F
	Eichhornea crassipes	Floating	C
	Euryle ferox	Rooted at bottom but leave on surface	R
	Hydrilla verticillata	Submerged	C
	Hydrolea zyylanica	Amphibious	F
	Ipomea aquatica	Amphibious	F
	Lemna minor	Floating	F
	Ludwigia perviflora	Amphibious	F
	Naja naja	Submerged	F
	Nymphea naucheli	Rooted at bottom but leave on surface	C
	Plantago ovata	Submerged	F
	Potamogeton minor	Floating	F
	Utricularia racemosa	Submerged	C
	Vallisnaria spiralis	Submerged	C

Note: C= Common; R = Rare; F = Frequent

On the whole, it appears that except *Euryle ferox* (Katapadum), none of the aquatic forms appears to be rare. It is also important to note the fact, these water bodies were located in the peripheral part of the buffer zone and some may extend to Bangladesh region. None of the aquatic forms could be considered as endangered. No macrophyte was recorded in the Phalagkarauh river.

Benthic Forms

A few benthic filamentous algal forms were observed and collected from river bed and stagnant water pool. These are species of *Spirogyra, Zygnema, Oedogonium, Pithophora, Oscillatoria* and *Lyngbia.*

The above mentioned plants viz. planktons (phyto), benthos and macrophytes form the producer trophic order of the aquatic ecosystem.

Fishes

A total of 42 species of hill stream fishes have been recorded in the Shella and around by Zoological Survey of India, Shillong. In addition, records of fresh water pond fish could be noted in the literature and from the information obtained from local people. These are listed in ***Table 4.30***.

Amphibia

In spite of the fact that N.E. Indian region has more than 50 species of amphibia, only two species are recorded by Zoological Survey of India from the study area. No frogs and toad were seen during the present survey due to the cold climate. (***Table 4.31***)

Birds

A total of 12 species of aquatic birds have been spotted (***Table 4.32***) in the buffer zone.

Table 4.30: Checklist of Fishes

Sl. No.	Scientific Name	Local Name (Khasi)
	Acanthocobitis botia	-
	Acanthopthalmus pangia	-
	Ailia coila	Kha tungkra
	Amblypharyngodon mola	Kha muka
	Anabas testudineus	Kha Koi
	Anabas testudineus	-
	Badis badis	Kha snoing
	Barilius barna	Kha ilong
	Barilius bendelisis	Kha ilong
	Batasio batasio	-
	Batasio teggana	-
	Catla catla	-
	Chana orientalis	-
	Chana stewartii	-
	Chanda nama	Kha snad
	Clarias batracus	Kha Magur
	Colisa fasciatus	Kha snoing
	Danio devario	Shylynnai
	Glossogobius giuris	-
	Gudusia chapra	Kha Chapila
	Heteropneustes fossilis	Kha Singi
	Labeo gonius	Kha ski
	Labeo pangusia	Kha bah
	Labeo rohita	Kha bah
	Laguvia ribeiroi	-
	Lepidocephalus guntea	Sher Syngkai
	Monopterus cuchia	-
	Mystus bleekeri	Kha tynkara
	Mystus montanus	-
	Nandus nandus	Kha aniang
	Olyra horai	-

Sl. No.	Scientific Name	Local Name (Khasi)
	Osteobrama cotio cotio	-
	Parambassis rauga	-
	Pseudeutropius atherinoides	Kha tyngkara
	Puntius chola	Shalynnai
	Puntius sophore	Shalynnai
	Puntius ticto	Kha shalynnai
	Sarmostoma baccila	-
	Schistura savona	-
	Securicula gora	Kha ilong
	Somileptes gongota	Doh Sher
	Tetraodon cucutia	-

Table 4.31: Checklist of Amphibian

S. N	Scientific Name	Ommon Name
1.	Rana cyanophlyetis	Skipping Frog
2.	Rana limnocharis	Cricket Frog

Table 4.32: Checklist of Aquatic Birds

Sl. No.	Scientific Name	Common Name	Occurrence	Status in IWPA
	Alcedo atthis	Small Blue Kingfisher	Sporadic	IV
	Amaurornis phoenicurus	Whitebreasted Water Hen	Rare	IV
	Ardeola grayii	Pond Heron	Sporadic	IV
	Charadrius alexandrius	Little Ringed Plover	Sporadic	IV
	Egretta grazetta	Little Egret	Rare	IV
	Fulica atra	Coot	Sporadic	IV
	Gallinago stenura	Common Snipe	Sporadic	IV
	Halcyon smyrnensis	Whitebreasted Kingfisher	Sporadic	IV
	Motacilla alba	White Wagtail	Common	IV
	Phalacrocorax carbo	Little Cormorant	Rare	IV
	Tachybaptus ruficollis	Little Grebe	Rare	IV
	Tringa hypoleucos	Common Sandpiper	Sporadic	IV

None of these species is endangered.

4.8.5 Conclusion

The survey has thus found that there are no endangered or locally endemic flora or fauna within the core and buffer area, as reveal both by extensive literature review as well as field studies (10 quadrates). While other dominant fauna did exist in the past, hunting pressure and habitat destruction by local people appears to have eliminated most species, especially large and medium mammals. The impact of mining on flora and vegetation of the area will be mitigated through a detailed forest restoration programme, plan for which also been prepared.

4.9 VISUAL

4.9.1 Regional Landscape Setting

The regional landscape surrounding Nongtrai Limestone block has several distinct landscape types. These include rugged, vegetal cover on chain of hills, incised by numerous waterfronts and streams and channels. There are pockets of human settlements on foothills isolated in the vast landscape and distinct

pattern of betel nuts plantations and orchards in the foothills and some fields under cultivation in the flood plains.

South of the site the Phlangkaruh river meanders to the plains of Bangladesh in the process creates distinctive flood plains. To the east is the up coming commercial township of Shella on the bank of river Umium, while the foothills are covered with dense growth of vegetation. To the North-West include the village of Nongtrai, and the betel nut plantation area of the village. Scattered in the western horizon are patches of bamboo growth mostly wild in the foothills.

Other notable visual elements provide evidence of industrial activities. These includes make shift stacks of the lime kilns in the north and east of the site. The open cut limestone mining near Ishamati and Jatap are partially visible. Along the bank of river Umium quarried limestone are stockpiled in small heaps, waiting to be carried away to Bangladesh by boats. Further south the chimney of Chattak Cement factory in Bangladesh is also visible.

4.9.2 Visual Catchment

The views of the site are shown in ***Annex D.*** In some portions the potential views are restricted by elevated landscape. Present close range to the site is not available due to the plantation in the foothills and the vegetal cover. Important vantage points are the human settlements of the surrounding villages, the deep gorges and chain of hills in the north and the bank of Umium along the foothills.

5 SOCIO ECONOMIC PROFILE OF THE STUDY AREA

5.1 INTRODUCTION

The socio-economic profile of the study area is based on the site visit, group discussions with the villagers and the secondary data available from various concerned agencies and offices. Demographic profile, land use pattern and infrastructural facilities, etc, have been sourced from District Census Book, East Khasi Hills District, 1991; Basic Statistics of Meghalaya, 1991 and interviews and discussions with the local authorities and the villagers during the site visit by ERM team. A survey was conducted in the affected village Nongtrai and the total respondents were 137 households. Agricultural economics have also been worked based on the information collected from Agricultural Department and discussions held with the villagers at site. The study area villages have been categorised based on the radial distance from the exploration site. The categories taken for studying the socio-economic profile are 0-3 km (hereinafter referred to as *Grid I*), 3-7 km (hereinafter referred to as *Grid II*) and 7-10 km (hereinafter referred to as *Grid III*). The details of population, amenities available within the study area are given in *Annex E.*

The project is integrated with the run-of-mine transfer system to Bangladesh through conveyor belt, therefore, the areas of project can be divided into the following two areas:

- The proposed mine area of 100 ha and space required for office workshop, crusher and colony which is approximately 12.55 ha; and
- The corridor of 25 to 40 m wide all along the proposed conveyor belt of 17.3 km, which include 7.2 km (covers 26.6 ha of land) in the Indian territory.

No home or dwelling unit falls in the affected area. The mine area and area for crusher, colony & workshop belongs to the community of village Nongtrai for which LMMPL has undertaken an land lease agreement with the Nongtrai village council for 35 years. The 26.6 ha of area required for belt conveyor corridor is scrub land and part of this land, presently, is being used by habitants of the Shella village for agricultural purposes.

Limestone is an important and easily available mineral in Meghalaya and is usually exported by water channels to Bangladesh and also to the main towns like Cherrapunji and Shillong for the input of the small cement factories. There are also several lime kilns in the region. Surrounding the proposed site area essentially in the east and northeast There are some limestone quarries in the east and northeast direction from the proposed mines, which are actively engaged in limestone extraction.

5.2 STUDY AREA

5.2.1 Administrative Jurisdiction

The study area encompasses 56 villages within two CD blocks: Mawsynram and Shella Bholaganj as per ***Table 5.1 & 5.2***. The proposed mine site falls within the jurisdiction of the CD block of Mawsynram, comprising of 20 villages. Each village has a village Durbar, which is the lowest administrative unit at the village level. In the study area, Nongtrai and its hamlet village Phalangkaruh are covered under the same Durbar. Other villages, which from the part of the study area have separate Durbars comprising of one or two villages each.

Table 5.1: Villages in the study area

CD Block	Grid I	Grid II	Grid III
Mawsynram	2	12	9
Shela Bhlolaganj	3	14	16
Total	**5**	**26**	**25**

The site (longitude N 71°49'16.392", latitude E 25°10'5.022") is located in the War Khasi area of the East Khasi Hills in Nongtrai village, in Mawsynram CD blocks of East Khasi Hills district. The mine site falls in Shella Confederacy which comprises of nine villages. Nongtrai is one of the villages falling within the Shella Confederacy.

Table 5.2 Administrative Structure

	Mawsynnram Block		Shella Bholaganj Block	
	CD Block	Study Area	CD Block	Study Area
Area in sq km (approx)	523	NA	578	NA
Durbar	151	-	180	-
Villages	159	23	187	33
Inhabited Villages	151	23	180	33
Population	38194	7005	38022	10047
Sex Ratio (per 1000 males)	954		964	

5.2.2 *Social Setting*

The study area essentially comprises of agriculture and unreserved private/community forest dominated land in the region. The social setting is however, very different and typical of the region. Most of the villages are along the slope of the hills and are built on community land of the village. The agricultural fields are outside the village along other hill slopes. The agricultural lands either belong to the community or are private lands. The private lands are locally known *Ri-Kynti* whereas the community lands are known as *Ri-Raid.* The mainstay of the people of the region is agriculture. Based on discussion with the local population during the survey, it was observed that timber trade was an important and lucrative source of income of

the villages, however, with the ban on timber trading in year 1996 had hurt the economy of certain families. Principal crop in the study area is pepper (*kali mirch*). Major crops cultivated in the region include betel leaves and nuts, bay leaves (*Tejpatta),* bajra, maize, vegetables (for self-consumption) and fruits. Second to agriculture, Limestone mining is the other occupations of the people in the area. Animal husbandry is practiced for self-consumption. Major livestock of the study area consists of pigs, goat, hens and cows.

5.2.3 *Demography*

The population density per sq km is very thin due to the unutilised vast tracts of land in the study area. Comparatively study area under the CD Block Shella Bholaganj is more populated than Mawsynram CD block. Over 80% of the population belong to the Khasi tribe and its subtribes. The majority of the population within the study area is inhabited by War Khasis with agriculture as the main occupation. A segment of the Garo ethnic group and the Bengali migrants from Bangladesh form about rest 20% of the population. There is a small segment of population from the other states in India also mainly engaged in the limestone quarries and commercial activities. The War Khasis are primarily involved in agriculture and plantation activities while the Boro and the Garo population is generally hunters or daily wage working class. As per the law of the land no non-khasi community can own land in the area.

The sex ratio of the rural population in the CD blocks reveal that the number of female per thousand males is 954 in Shella while 964 in Mawsynram. The neighboring block of Pynursla has a strong female dominance of 1009 females per thousand males. Village Nongtrai is mainly inhabited by tribal *Khasi C*hristians community.

The total population in the study area stands at 17556 with 10.3%, 41% and 48.7% of the total inhabiting villages within the Grid I, Grid II and Grid III areas respectively. The number of females for every 1,000 males in the study area is around 938.

Scheduled Castes and Scheduled Tribes

There are segmented schedule caste population residing within the study area, however this population is mainly migrated from the other Indian states and neighboring Bangladesh.

In Meghalaya, over 17 tribes have been recognized as scheduled tribes as per the *Scheduled Caste and Scheduled Tribe Orders (Amendment) Act 1976* and the *Constitution (Scheduled Tribes) Order Amendment Act 1987*.

In the study area, the predominant scheduled tribe population is the Khasi followed by the Boro Kacharis and Garos. Each of these tribes has several sub-tribes that are also considered as scheduled tribe population as per the Indian regulation.

Khasi tribe comprises of a matriarchal family system, where lands belong to the female members of the family and the land is used to transfer in the name of the female members of next generation.

5.2.4 Occupational Pattern

Worker and Non-Worker Population

The main working class segment comprises of persons engaged in plantation and orchards. The cultivators and the agricultural activity is very minimal, usually the cultivation class is from the Khasi community. Some of the village of Mawrynkhong, Nongtrai and Shella are engaged in limestone quarries and lime kilns.

Boro villages mainly comprise of marginal workers, who either work in the plantations of the Khasi community or collect non-timber forest products (NTFP). Some of these people also work as daily wagers in the limestone quarries and with the State government for building roads and bridges.

5.2.5 Landuse Pattern

Total geographical area of Mawsynram block is 523 square km, while that of Shella Bholaganj block is 578 square km. 47.53% of the land (including both the districts) is under cultivation or plantation. Most of the lands are natural rain fed while in some areas some irrigation through canals and bamboo connectionare provided. The details of landuse of the study area as per satellite imagery IRS-1B, data is given in the ***Figure 5.1*** and ***Table 5.3.***

Table 5.3: Landuse based on IRS – 1B Data

Sl. No.	*Landuse*	*Area (Sq km)*	*% Area*
1	Settlement	5.42	1.72
2	Agriculture	82.63	26.3
3	Grass /Shrubs	14.61	4.65
4	Dense Vegetation	188.33	59.95
5	Sandy River Bed	1.82	0.58
6	Limestone	21.35	6.80

**Source: North- Eastern Hills University (NEHU)*

Reportedly there is no study, being undertaken on the land use pattern at the village level for the district and there are no records available on the land use pattern at the block level as well. In the district of east Khasi Hills most of the land belongs to the people and not to the state, the land tenure system are of different category. Re kyanti or the private land is the land which belongs exclusively to a person or persons (irrespective of how he/she and they got exclusively under his or their possession) and has its boundaries as permanent stones, or boundary stones or stones marking the division of land or of trees bamboos or rivers or of streams or of plant of definite marks.

Raid land is the land belonging to the community ot the people of the Riad. Raid in the Khasi district is the administration of the village durbar by the person known as Bakhraw or Basan or the elders or headman appointed within the state a section of the state, which is under the administration of the Bakhraw or Basans. This raid is called in Maharam state as Phra Kynbat in Shella and in Mawdan district as U Sande.

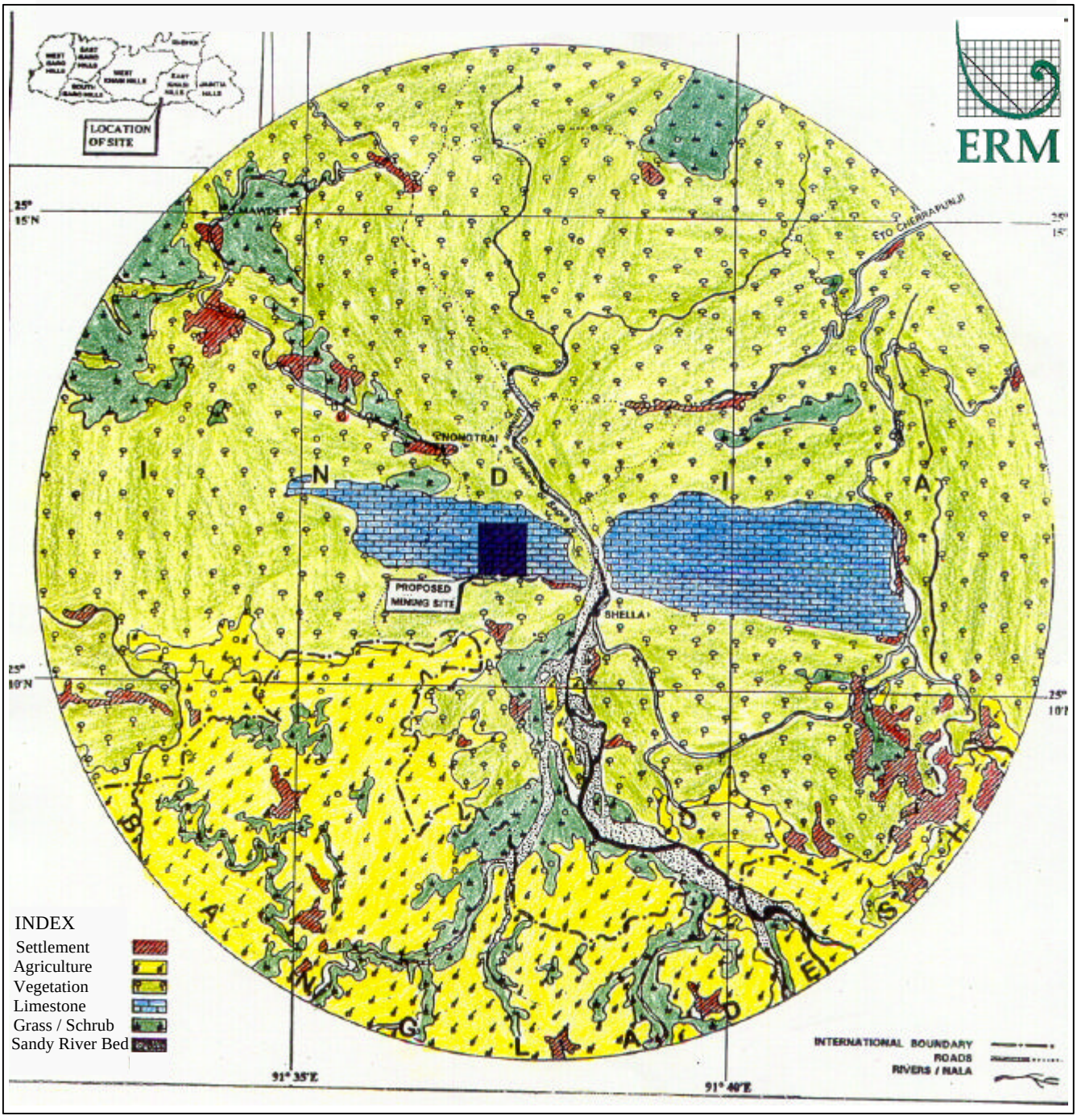


Figure 5.1: Landuse Pattern of the Study Area (Based on IRS - 1B Data)

Ancestral land (Ri Nongtymmen) means the land inherited from the mothers or grandmothers or uncle or elder brothers or father or grand father which is owned by those families who have descended from first owner.

In some Khasi states land is called Land of relatives (Ri Kur), while in some villages this is named as the same borne (Ri Shyeing) or land of family (Ri RaiIng) and in other places this is called Ri Phirang

Lyngdoh land *ie* Ri Lyngdoh is the private land of the Lyngdoh Clan or of certain group of relatives where there is forest dedicated to religious purpose called Law Lyngdoh (Priest Forest). The Syiem Land (Ri Syiem) has three kinds as:

- the private land of the Syiem family;
- the private lands which the syiem family and some Basan and myntri (Ministers) use for their maintenance as in maharam state and this is almost the same as the raid land or the *Ri Raid;*and
- consecrated forests (Law Kyntang) are the forest consecrated or set apart purposely for religious performances of the village.

Reserve Forests (Law Adong) are forests purposely reserved for the need of the village or town. Priest forests (Law Lyngdoh) are the consecrated forests for the purpose of religious performances therein.

Land of families or clan (Ri riad Kur) is the private land of the families within the clan which is owned collectively by them. These types of land are mostly found in Myelliem and Khyrim state.

The above mentioned land system was laid down by the forefathers to ensure both private and collective rights over the land and to provide land for every citizen according to the need. In course of time Riad land by means of Ri Dakhol and other similar means become the ri kyanti land. This has lead an innovation of raid land. Ri dhakol is land over which a person has obtained Ri kyanti rights of purchase or winning a court case

5.2.6 Agricultural Pattern

In Shella Bholaganj and Mawsynram, generally *kharif* (summer) crop is grown. Common *kharif* crops are maize, tejpatta, Betel nuts and paddy. At times, *Rabi* (winter) crop is also taken in the plane and the plateau areas of the blocks. The main *rabi* crops is paddy, with occasional cultivation of fruits in some areas. In Mawyanram the cultivation is more towards the Jalor district, *Kharif* crops are grown in sandy soils and are mostly rainfed. The black and white pepper that grows wild in the forests along with bay leaves. The usual harvesting season of these crops is early winter. In the foothills of the khasi hills, there are numerous tree species including palm trees. Several varieties of bamboo grows in this area often wild or at times under nourishment of the villagers. These are sold in local markets as NTFP and also there is a good export market for bamboos in Bangladesh. Forest permits are obtained for trading bamboo and its produce with the adjoining boarder markets in Bangladesh. The area has rich orchards and fruits like banana, oranges, peach and pomegranate grow well in this

region. Banana grows wild in the foothills. The fruit orchards are usually located in the upper plateau region of the study area, likewise in the foothills some amount of paddy cultivation and plantation activities are practiced.

Most of the land in the upper regions of the Cherrapunjee plateau, which forms a significant portion of the study area and receives a significant amount of rainfall is naturally irrigated. This provides adequate water supply for the crops cultivated in the region. During the monsoon several natural water sources trickle down the valley which is used for watering the fields. Thus it was observed that most of the plantations are in the foothills. In the Grid I of the study area the plantations includes mostly betel nut, bamboo and bay leaf. Paddy is cultivated along the Bangladesh bordering villages comprising mainly the floodplains of river Umium of Shella Blolaganj district which is also famous for orchards including the oranges peaches guava etc. However the orchards are rapidly depleting due to the anthropogenic activities. The Mawsynram block also has a significant area under bamboo cultivation, bamboo also grow in wild and is collected as an important NTFP.

5.2.7 Agricultural Productivity and Economics

According to information provided by the forest officer, Shillong, the study area is renowned for the betel nut cultivation and the variety grown in the foothills has distinction of producing good varieties of betel nuts. The floodplains are cultivated for turmeric and among the productive areas of the district.

5.2.8 Animal Husbandry

There are no census records on the livestock population of the district. During our study it was observed that almost all the local residents in the Mawsynram and Shella Bholaganj have livestock. No Government owned animal husbandry program is available within the East Khasi hills district. As can be gauged from the survey below, the poultry farming is the main husbandry operation and comprise of 50 % of the livestock, excluding dogs and goats. The next highest category of animal is the pigs, which forms nearly 30% of the total livestock population. It is found during the study that Khasi villages generally does not rear goats and cows, *Boro* villages rear goats and almost every house of Phlangkaruh and Desong villages has cows. Mawsynram has a veterinary hospital. Most of these units are lacking with infrastructure support and basic facilities.

5.2.9 Infrastructural Facilities

Infrastructure facilities are very poor in the district. However, in comparison to Mawsynram block, Shella Bholaganj is better equipped with these facilities. Specific details for these facilities are listed below in ***Table 5.4***.

Table 5.4 Infrastructural Facilities in the Study Area (Based on 1991 Census Data)

Study Area Distance from the Site		**0 - 3**	**3 - 7 km**	**7 – 10 km**	**0-10 km**	
Total No. of Villages in the Study Area		**5**	**26**	**25**	**56**	
Infrastructural Facility	**At the Distance**					
Education	**In the village**	4	15	20		*70% villages in the total study area have educational facilities in their villages, while remaining villages have to access these outside their villages. Most of these villages have Primary level education. Only one village in 3 km area have primary educational facility, while 37.5% and 45% villages in Grid II and Grid III area have primary level educational facility, respectively.*
	-[5]	1	5	5		
	-[5-10]	0	1	0		
Medical	**In the village**	0	3	4		*13% villages in the study area have medical facility in their villages. Though most of them (25%) have access to these at the distance of 5-10 km from their villages. In the 3 km radial distance, no villages have medical facility (PHS & Dispensary). 20% and 20% villages have medical facilities (PHS and Dispensary) available in their villages Grid II and Grid III, respectively.*
	-[5]	4	9	11		
	-[5-10]	0	4	3		
	-[10+]	1	6	7		
Drinking Water Availability (Types of Sources)	**#1 (T)**	5	12	18		*All the villages have only tap water as drinking water in the study area. Maximum number of villages are dependent on tap water, followed bysurface water sources. 55% of villages in 5 km distance have only one source of drinking water. 85% and 62% villages have 2 or more sources of drinking water sources (tubewell/tap/tank/river) in Grid II and Grid III, respectively. Drinking water facilities increase as we move farther to site.*

Study Area Distance from the Site		0 - 3	3 - 7 km	7 – 10 km	0-10 km	
	#2 (W)	0	3	2		
	#3 (S)	2	12	12		
	#4 (0)	0	2	0		
	#5 (R)	3	2	4		
Post & Telegraph	**In the village**	1	3	6		*18% of the villages in the study area have post and telegraph (P/T) facilities. 20% of the villages have P/T facilities (Post office & Phone) in Grid I. Near l2% and 30% villages have P/T facilities (Post Office) in their villages in the Grid II and Grid III. 46% and 60 % villages in the Grid II and Grid III have P/T facility at distance of 5 km from villages; and remaining at more than 5 km distance.*
	-[5]	4	12	15		
	-[5-10]	0	3	2		
	-[10+]	0	3	2		
Communications	**In village**	1 BS	5 BS	8		*37% of the villages are communicated by buses in their villages in the study area. Within Grid I, one village is having communication services (bus) till 5 km distance. Nearly 39% villages have bus facility in their villages in 5-10 km radius.*
	-[5]	3	9	10		
	-[5-10]	0	5	3		
	-[10+]	1	2	4		
Approach to village	**N A**	0	0	0		*24% of the villages do not have road connection in their villages in the study area. Only 33% villages have access to Kuchha road in Grid I. 27% and 19% villages do not have road facility in their villages in Grid II and Grid III. Most of the villages are connected by kuchha road. Only 6% and 13% are connected with pucca road in Grid II and Grid III.*
	Kuchha Road (KR)	1	1	6		

Study Area Distance from the Site		0 - 3	3 - 7 km	7 – 10 km	0-10 km	
	Pucca Road (PR)	1	7	7		
	Footpath (FP)	4	19	22		
Power Supply (Types of sources)	**#1 ED**	5	9	17		*20% villages in the study are have power supply in their villages. 35% villages do not have any type of power supply (ED, EAG) in the study area. All the villages have power supply in their villages in Grid I.*
	#2	0	0	0		
	Not Available	0	12	8		

Note: The distance for the infrastructure facilities is as per the approach road, from the subject village.

Education

The literacy rate in Shella is 49.61% (51.56% male literacy and 47.54% female literacy) compared to 45.91% (48.92% male literacy and 42.77% female literacy) in Mawsynram.

Female education is comparatively high than other Indian states, due to the influence of Christian missionary society.

Educational facilities available within the study area are primary school, middle school, high school and adult literacy centre. Most of the villages (about 70%) have primary level educational facility. Some of the large villages have secondary education facillities as well. Rest of the villages have education facility within 5 to 10 km. Within Grid I, 6 villages out of 9 villages (66%) have primary schools, with 2 middle schools and 1 adult literacy centre. Nongtrai has a middle school and a secondary school. The nearest higher secondary school is at Lawbah, while on the other side the higher secondary school is at Cherrapunji. The Boro and the Garo population within the study area is less educated, it is primarily due to the economic pressure and lack of amenities. However the primary education among this population is gradually increasing. The villages Lawbah, Maphlong and those near to the major cities of Mawsynram and Cherrapunji are being provided with better education facilities

Medical & Public Health

There are a total of 26 government medical institutions including Family Welfare Sub-centres (FWSC) in both districts. Out of these, 15 are in Shella Bholaganj, which includes 12 FWSC. Medical facilities are better in Shella Bholaganj as compared to Mawsynram.

The medical facilities available within the study area are dispensaries, hospital, maternity / home child welfare centers, family planning centers, primary health sub center, community health center and other similar facilities. It has been reported that 144 villages of the total 159 villages in the Mawsynram district and 168 villages of the total 180 villages in CD block of Shella Bholaganj does not have adequate medical facilities.

Medical facilities in the study area are very poor, nearly 31% villages have the facility within 5-10 km ; 25% villages have the facility at more than 10 km distance . In Grid I only 2 (22%) villages have medical facility in their village. Nongterai has one primary health sub-centre (PHS) and *Shella Bazar* has one dispensary. Village *Phalankaruah* has a facility available at a distance of 25 km. The medical facilities available in these units are also very poor. Once in a week the Ramkrishna Mission Charitable Society, located at Cherrapunji in mobile vans provide medical facilities in the remote villages.

Drinking water

Most of the villages obtain drinking water from the adjoining springs and rivers. Dug wells have been developed along the riverbanks in Disong village and in some of ther villages in the plain to obtain fresh drinking water.

Reportedly there is no scarcity of water however the quality is often non-potable due to bacteriological source contamination.

Census shows that only 20% villages have only one type of drinking water source in the study area. Water supply lineare provided to some of the villages in upper plateaus. The water is treated and PWD supplied lines to the villages.

Post and Telegraph

Only 3 villages are connected with telegraph within the study area. Some effort of solar telephone booths were tried in some of the villages reportedly most of these are at present non-functional. The nearest telephone facility available at site is at Shella Bazar. Within the Grid I, only 3% of the villages in the study area have post and telegraph (P/T) facilities. Recently telegraph post have been installed in the Mawsynram village.

Nearly 27% and 20% villages have P/T facilities (Post Office) in their villages in the Grid II and Grid III respectively. 47% and 32% villages within the 3-5 km and 5-15 km radial distance have P/T facility within 5 km and remaining at more than 5 km distance, respectively.

Communications

Apart from P/T services, transport is the main communication linkage in the study area. For long distances people mainly depend on the bus service, which is in general available within a distance of 10 km or more. There are two main hill tracts within the site area. One from Shillong to Hat Mowdon and other from Shillong to Cherrapunjee. Villagers mainly use their cycles as a transportation means. 31% of the villages are communicated by buses in the study area.

Road Network

Most of the villages, are located along the main roads. However the internal roads leading to the village or from the village to the main roads are not well defined often they are hilly tracts and are non-motorable roads. Villages in Grid II and Grid III are provided with road facilities which are asphalt topped. Only 6% and 13% are connected with pucca road in Grid II and Grid III respectively.

No national highways fall within the study area . The two main routes within this hilly terrain are: (1) Shillong – Mawphlang- Mawsynram- Balat- Maheshkola- Baghmara route which connects Shillong with the boarder areas and (2) The other important routes are Shilong- Pynursala- Dawki route, Shillong-Mawphlang- Weiloi route extended to Mawsynram and Balat in one direction and Mawkyrwat in another. For the local transport villagers walk along the hilly tracts, the village across the hills provide shortcuts and are very commonly used and provides very unique mode of communication. In the Ishamati and Shella bazar area the river of Umium and Ishamati canal are also used for plying.

Power and Electricity

The CD blocks has 57% of the villages with power supply while the availability of power in Shella Bholaganj CD block is 41.1%. With the introduction of Rural Electrification Scheme in East Khasi Hills district, more villages are anticipated to be electrified. Some of the villages have been provided with solar heaters and lighting systems.

Industries and Labour

Due to lack of adequate infrastructure, very few large industries are found in the districts. The only dominant industrial activity observed within the study area is the excavation of limestone and other minerals and stone from the hills. At some places very thin coal seams were found under excavation by the local people. By enlarge limestone is the most important and easily available mineral, which is exported by water channels to Bangladesh and also to the main towns like Cherrapunji and Shillong . There are also several lime kilns in the region. There are some limestone quarries in the east and northeast direction which are actively engaged in limestone extraction.

Cottage industries like carpentry, pottery, bamboo works, weaving, manufacturing, rope-making, indigenous confectionery, brick manufacturing etc. are also reported in both the districts. Fishing and hunting with collection of NTFPs from the adjoining forests are one of the major activities.

Labour in the study area is cheaply available. Labour is mainly employed in the agricultural fields, during monsoon season (4 months). Mostly landless people (in particular, people belonging to Boro & Garo community) are employed as agricultural labourers. During the discussion with the villagers, daily wages for the laborers is Rs 70.00 per day for male and Rs 60.00 per day for female in addition to food.

5.3 SOCIAL SETUP OF NONGTRAI VILLAGE

Nongtrai is one of the 168 villages in the Mawsynran CD block. According to the census of 1991, the total population of Nongtrai is 754. The average population distribution comes to about 5-6 persons per household. The ratio of male to female ration is 1:1 as per the survey conducted.

People of Nongtrai belong to Khasi tribe and are residing in this village for more than 20 years. It is one of the oldest settlements in the area. Mostly people are followers of Christianity. The population has considerable mix of Presbyterian, Church of God and Catholics. There are few persons who are the followers of indigenous Khasi faith.

The literacy rate in the village is 66.44% (as per the survey conducted). There are two lower primary schools and a Middle English school in the village. Majority of the school going students discontinues their studies after completion of lower primary and middle level education due to lack of motivation and financial constraint. There are about 10 graduates in the village and the total number of college going students at present is 40. The area shows considerably high level

of female literacy up to 47 % compared to the male literacy rate of 53.2%. ***Table 5.5*** below provides an information on the total educated population in the village of Nongtrai.

Table.5.5 Education rate in the village of Nongtrai

Education level	Village Nongtrai (in %)	CD block of Mawsynram (in %)
Primary	67.66%	49.63%
Secondary	24.35%	30.3%
College	7.98%	12.34%

The primary occupation of the villagers of Nongtrai is Agriculture and plantation. The working population includes primarily agricultural labourers and landowners and the worker in the other commercial activities.

Reportedly there are few government service holders and local traders.

The plantation of betel nut and leaf in the slopes of the hills are an important income generating source. Some paddy and maize cultivation in the plains are also carried out. Other produces include Bay leaf, wild pepper, brooms, oranges and other NTFPs. Until recently timber trade was one of the major income generation source of the village, however with the ban of timber trade this is no longer practised. Most of the respondents are engaged in Agriculture / Plantation. ***Table 5.6*** below provides the estimate of the various crops and vegetation that grows by the agricultural population in Nongtrai:

Table 5.6 Percentage of Agricultural Cultivation

Sl No	Crops	% of total agricultural
1	Paddy	12.19
2	Black Pepper	59.75
3	White Pepper	34.14
4	Betel Leaf	65.85
5	Betel Nut	87.80
6	Bamboo	1.21
7	Tejpatta	52.43

5.3.1 Income Sources

The survey among the respondents reveals that the annual income of the people of Nongtrai is on an average of less than Rs 30,000. The primary source being the agriculture. There are two limekilns in the vicinity of the village. Some illegally operated quarries are also located within the village premises. Usually the Khasi households have pigs and hens as main husbandry while none of the houses were reported to have any goat or cattle population. As per the survey conducted, there are over 300 hens and about 60 pigs population in Nongtrai village.

5.3.2 Administrative Set Up

Each confederacy has an elected candidate as Chief (Wardhar). Under the wardhar, there are village chiefs or headman. The Nongtrai headman is elected by the village council and the village council has two committee's as:

- Special affairs committee relating to boundary dispute; and
- Local affairs committee relating to Governmental Schemes and methods of implementation.

The village council selects two prominent members for the Wadhar Durbar. Maintenance of law and order and settlement of land disputes are the two main functions of the village council. Each village also has a village defence party, which plays vital role in maintaining social tranquillity.

5.3.3 Social organisations

Nongtrai has the following socio-political organisation within the village:

- Nongtrai Sports Club; A registered village organisation with an objective of promoting sports and culture in the village;

- United Lawbah Border Area Welfare Association. This organisation is a self styled outfit for integrated developed of the people residing in border areas;

- Federation of Khasi, Jaintia and Garo people (FKJGP) It is a state based socio political organisation with an objective to protect the interest of indigenous people. This organisation has an unit in the village; and

- Khasi Students Union(KSU): A state based student organisation with an aim to promote the welfare for the students community in particular and the society in general . KSU has a unit in the village.

5.3.4 Culture and festivals

Khasi society is a society in which all groups are considered equal. It is the women who inherit the property and is the legal owner of the property. In some of the War area of the south khasi hills males also own property. Although female is the owner of the property, they are not part of the village administration, the administrative decision making is the exclusive right of their male counterparts. In the villages the market day that rotates in the region over week is an important occasion and also is the day when the village Durbar meets. Khasis commemorate this day with archery practised by the village youth.

Another popular celebration is Shad Suk Mynseim (the dance of Contentment or happiness) – an expression of thanksgiving for the blessings of prosperity that the people have enjoyed during the year. Another important festival is the Shad Nongkrem (Nongkrem dance).

Due to large dominance of Christian population Easter and Christmas are also celebrated with great pomp and show.

6 PREDICTION OF IMPACTS

In this section, the potential impacts of the proposed mining and allied activities, which could cause significant environmental concerns, are identified and discussed. This discussion will form the basis for environmental management planning and will lead to designing of an EMP for LMMPL limestone mining project.

Based on the field study, the villages and hamlets located within 2 km distance from the mine site are considered to be the villages located within potential impacts zone. These villages are Nongtrai, Phlangkaruh, Pyrkan, Mawrynkhang and Shella Bazar.

6.1 ENVIRONMENTAL IMPACTS FROM MINING & ASSOCIATED INFRASTRUCTURE

The project activities that are likely to cause potential impacts on environment are as follows:

- Mining operations;
- Limestone Crushing; and
- Associated Infrastructure.

A brief description of these activities and associated environmental impacts are discussed below.

6.1.1 Mining Operations

Mining operations involve development of benches, approach roads, haul roads, drilling, blasting, excavation and handling & transportation of limestone and waste materials. The likely effects of these activities are:

- Land degradation;
- Deforestation;
- Visual intrusion of land;
- Fugitive dust generation;
- Higher run-off during rains;
- Higher noise and vibration levels; and
- Human health risks.

The haulage of Limestone within the mining area, etc will lead to emissions of fugitive dust and higher noise levels in the mining area.

The proposed project also includes installation and operation of crushing unit for sizing of Limestone and conveyor system for transportation of sized limestone through belt conveyor to Bangladesh. These operations generally result in generation of dust and higher noise levels and thereby poses health hazards. However, it is proposed that adequate control measures will be provided which include installation of bag filters, water sprinkling in area around crusher and covered belt conveyor to reduce the fugitive dust emissions.

Proposed open cast mine will result in disturbance of the land use pattern of the area and cutting of benches will result in higher chance of erosions effects due to surface run-offs during heavy rainfall. The proposed limestone mining area is devoid of persistent soil cover, which is due to high rainfall, karstic topography and absence of impurities due to which one can anticipate that the overburden (OB) resulting from the proposed mining operation will be insignificant.

It is proposed to maintain the mining floor level at a gradient of 1 in 200 to divert the mine surface run-off water during rainy season into the garland drains, which are proposed to be made in the periphery of the mining benches and haul roads. The water collected in the garland drains will be discharged to natural drains after passing through check dams.

6.1.2 Limestone Crushing

It is proposed to set up a crushing unit just outside the lease area on the southern side. The run-of-mine (ROM) limestone of approximately 1000 mm size will be fed to a two stage roller crusher, which will crush the limestone to ~80mm. It is proposed to operate the crusher in two shifts six days a week. Major sources of pollution from the crusher area include washing water, rejects, dust and noise.

6.1.3 Associated Infrastructure

The associated infrastructural facilities for the LMMPL mining project include:

- Storage & Handling facilities (for fuel oil, lubricating oils and explosives) and workshops;
- Mine offices and housing colony;
- Water supply;
- Telecommunications;
- Power supply; and
- Belt conveyor .

The environmental impacts associated with these infrastructural facilities are described in the following sub sections.

Storage & Handling

Storage and handling of fuel oils, lubricating oil & grease, and explosives, are areas of concern from environmental, health and safety point of view. Vehicle maintenance and repairing workshops (for mining equipment and machines) would generate waste oils; oil & grease and suspended particles which may also find their way into the wastewater streams. Oil & grease spillage may also contaminate the soil in and around the workshop area. The wastewater from the workshop area therefore needs to be treated before being discharged into the main wastewater stream.

Magazine area is another important area where safety precautions are to be adhered strictly in terms of procedures for handling and storage of explosives as they pose serious safety risks.

Mine Offices and Colony

Mine offices, colony and other community facilities will mainly contribute towards solid waste and sanitary wastewater. A proper collection, transportation and disposal system will have to be developed for solid waste management. Also, sanitary wastewater will need treatment to avoid any health hazards due to water borne diseases.

Water Supply

Water requirement for the mine and its infrastructure will be met through Phlangkaruh River. LMMPL proposes to install a pump for meeting the water requirement, both for industrial and domestic usage. Overhead water storage tank with adequate capacity will be provided both at the mine site as well as in the colony area. Outlet points for water in the proposed mining lease area will be provided at various places inside the mine office complex. One water sprinkler is also proposed for dust suppression as well as for supply of water to any off-site work. The raw water will also be treated to comply with the drinking water quality requirements before being supplied to the mine office and the housing colony.

Telecommunications

Telephone facilities will be provided in the offices, workshop, crushing plant, colony, etc. For this purpose, it is proposed to install an Electronic Personnel Automatic Branch Exchange (EPABX) system of 50 lines capacity, expandable to 100 lines. Besides, for effective supervision, it is proposed to provide walkie-talkies sets for mine operations.

The telecommunication infrastructure that will be developed as a part of the project will also improve the telecommunication facilities available in the study area.

Power supply

The main power (at 33KV) sources from Meghalaya State Electricity board will definitely have a positive impact on the project site that is at present supplied through an intermittent power sources.

A standby DG set of 2.5 MW capacity is also proposed to take care of situation of power failure from MSEB. The diesel generator will have insignificant impact, as its operation will be only in case of state electricity power failure. It is proposed to provide adequate stack height to the DG sets and noise insulation for the DG set installed room.

Belt Conveyor

To lay down the overhead fully covered belt conveyor from the crusher to the Chhatak in Bangladesh cement plant at a distance of approximately 17.3 km including 7.2 km within India and rest in Bangladesh, will require clearing of the scrubs along the narrow corridor ranging 25 to 40 m. The total land requirement for corridor will be about 26.6 hectare within the Indian territory. This land is being acquired by LMMPL and the effort will ensure minimal impact on the environment.

Dust suppression measures such as water sprinkling at source areas as well as proper lubrication and related noise control measures will be essential from the point of view of health & safety of people.

6.2 CLIMATE

Micro-climatic conditions such as temperature, rainfall, wind-speed and relative humidity, etc are regional phenomenon and are affected only if there are significant variations in the environmental set up.

6.3 AMBIENT AIR QUALITY

The open cast mining operations will generate high levels of suspended particulate matter (SPM) and to a very limited extent SO_2, NO_x, and CO due to blasting (using explosives), fuel oil combustion, etc. The potential sources of dust emissions are crusher fitted with bag filters and fugitive emissions from blasting and transportation. The provision of DG set will be meant for standby power back up system, which will not be a continuous source of emission.

The above systems necessitate mine workers and others directly involved in the mining / field activity to wear dust mask as a safety precaution. RSPM is the main cause of lung diseases and other respiratory disorders amongst the workers. Transportation of limestone from mine to cement factory by conveyor belt will also contribute to dust emissions to some extent.

The ambient air quality monitoring results show that in the villages around the mine area, SPM concentrations are within the prescribed limits (CPCB standards) during the monitoring period. At present the only source of pollution is the domestic activities and some small scale quarrying activities. Once the mining operation takes place, it is anticipated that marginal increase will occur in the SPM level of the core and the buffer zones. Dust suppression measures are, therefore, of utmost importance.

Vehicular movements within the mine site will add marginally to the contribute NO_x and CO concentration. Monitored values of SO_2, NO_x, CO, & HC in the ambient air are reported to be very low. It is proposed that industry ensures regular maintenance and engine tuning of vehicles used within the mine area so that the emission levels remain within the stipulated norms.

The prevailing wind direction during the monitoring period was predominant mainly from Northeast direction. If adequate dust suppression measures are not provided, the dust particles and RSPM will be transported to villages in the

impact area in the southwest and southern side comprising Phlangkaruh village approximately 700 m outside the southern boundary of the mine lease area.

SPM levels will be higher within the active operational areas (mine area) due to blasting, transportation and crushing, however, in the buffer zone it is not likely to be affected with dust problems, if proper dust suppression measures are taken.

Probable impacts of air pollutants on plants and animals are listed in the following ***Table 6.1***.

Table 6.1 Effects of Air Pollutants on Plants and Animals

Pollutants	***Principal Anthropogenic Sources***	***Effects***
Carbon Dioxide	Fuel combustion for heating, transport, energy production	No direct effect on people, however, may lead to increase in global warming
Carbon Monoxide	Incomplete fuel combustion (as in motor vehicles)	Deprives tissues of oxygen. People with respiratory diseases.
Sulphur Dioxide	Burning of sulphur containing fuels like fuel oil	Combined with smoke, increases risk and effects of respiratory diseases. Causes suffocation, irritation of throat and eyes. Combines with atmospheric water vapour to produce acid rain. Reduces crop yield. Leads to acidification of soils. Corrodes buildings.
Suspended particulate matter	Smoke from domestic, industrial and vehicular sources	Possible toxic effects depend on specific composition. Aggravates effects of SO_2 Reduces sunlight.

6.3.1 Occupational Health Hazards Due to Dust Pollution

Progressive disintegration of suspended solid particles or dust results in major health problems. Smaller the particle size (less than 10 μ) higher is the chemical and biological reactivity, resulting in increased toxicity than the parent lump. These micron sized particles, once air-borne, are extremely difficult to be collected or trapped. Due to the `minute size of the particles, the ambient environment remains clear giving a deceptive sense of security to the workers and the management.

This restorable dust has serious impact on the health of the workers. Lung functions are impaired due to both respirable and non-respirable dust particles. Chronic exposure leads to respiratory illnesses like asthma, emphysema, severe dyspnea (shortness of breath), bronchitis and in extreme cases pneumoconiosis or the black-lung disease of miners. There may be several components of limestone dust. The effect of dust may be harmful to the human health.

The summary of likely impacts on the ambient air quality of the study area is given in ***Table 6.2***

Table 6.2 Summary of Impact Assessment: Air Quality

Impact Area	Nature of Impact [1]	Targets/Interests [2]	Magnitude and extent [3]	Overall significance [4]
Derogation of air quality	For the duration of the project. However, impacts would largely be reversible. Emissions of SPM (dust) and to a smaller extent SO_2, NO_x, would occur during all stages of the project	Nearby villages. Approximately 50 workers. No sensitive Interests.	Generally Local/Regional impact. Dust emissions should be quickly suppressed to insignificant levels. Impact on site accommodation some distance from operational areas.	•• Major significance
Deposition of pollutants, SPM (dust) in human beings and in local area	Potentially long-term impact due to accumulation of SPM, SO_2 deposition	Potential effect on human health due to SPM deposition in the lungs; Potential effect on land and soil quality of nearby agricultural fields; Marginal effect on flora and fauna, because of degraded vegetation.	Localised adverse effect. Magnitude dependent on emissions and management of dust control.	• Moderate (In case of human health, as immediate consequences of dust will be on human beings) ❍ Minor/ moderate significance, in case of land, flora and fauna. However, should the control measures fail, the potential impact could be of major significance)

[1] Description; short or long term; reversible or permanent; associated with construction, operation, decommissioning; cumulative, accidental, etc
[2] Targets and interests potentially affected.
[3] Adverse or beneficial; small, large, etc; very localised (mine site only), local, regional national.
[4] Overall significance against criteria (❍ minor; • moderate, some significance; •• major)

6.4 NOISE ENVIRONMENT

Once the mine becomes operational, there would be various sources of noise in the area. These sources would be:

- Drilling;
- Blasting;
- Operation of HEMM;
- Crusher and Workshop ;
- Vehicular Movement; and
- Belt Conveyor.

Mining operations and the limestone crusher would be the main sources of noise pollution. Noise due to vehicular movement will be intermittent, but will also add to the background noise level.

It has been observed that mechanisation of mining technology generally leads to higher noise levels if not properly controlled. Operation of drills, shovels, dumpers, pay loaders and dozers involve noise generation above 90 dB(A), which is the prescribed Threshold Limit Value (TLV). Result of noise surveys carried out in opencast mines in India using similar Heavy Earth Moving Machinery (HEMM) equipment is indicated in ***Table 6.3***.

Table 6.3 Noise Level Due to HEMM in Opencast Mines in India

	Equipment	Measurement Location	Noise Level dB (A)
Equipment Noise			
1	Shovel, Operating	Operator's Position	80-82
	- do -	03 m away	94-100
	Electric Shovel Operating	10 m away	87-92
2	Dozer, Operating	Operator's position	92-98
	- do -	10 m away	87-96
3	Drill, Operating	Operator's position	94-98
4	Dumper, operating (50 t)	12 m away	88-102
	Dumper, operating (80 t)	12 m away	70
	Dumper, operating	03 m away	98-100
5	Dozer & Dumper both, operating	06 m away	95-110
Ambient Noise			
1	Mine area		84-92

It is being observed that at the mine site where heavy earth moving machinery is in operation, noise level is more than the stipulated 90 dB (A) per DGMS Circular, No 18 (Tech) of 1975. The noise level is within the tolerance limit at a distance of 15 to 20 m or so.

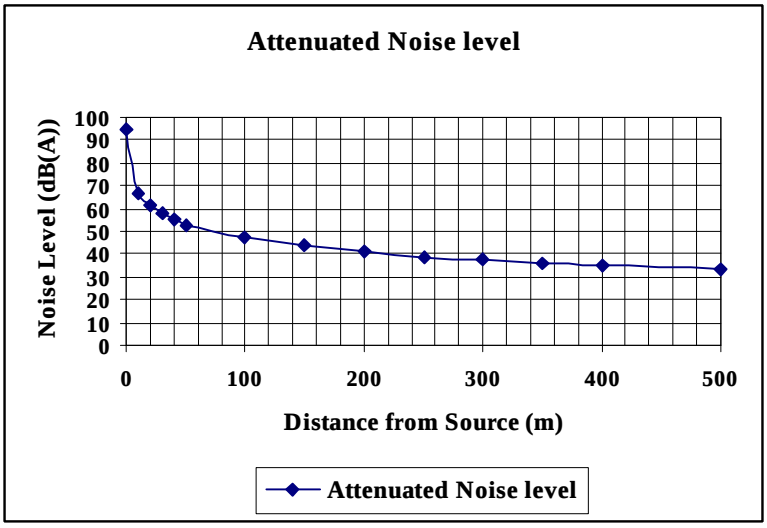
The sound pressure level generated by a noise source decreases with increasing distance from the source due to wave divergence. Noise attenuation with respect to distance in all directions over horizontal distance can be given by the following equation:

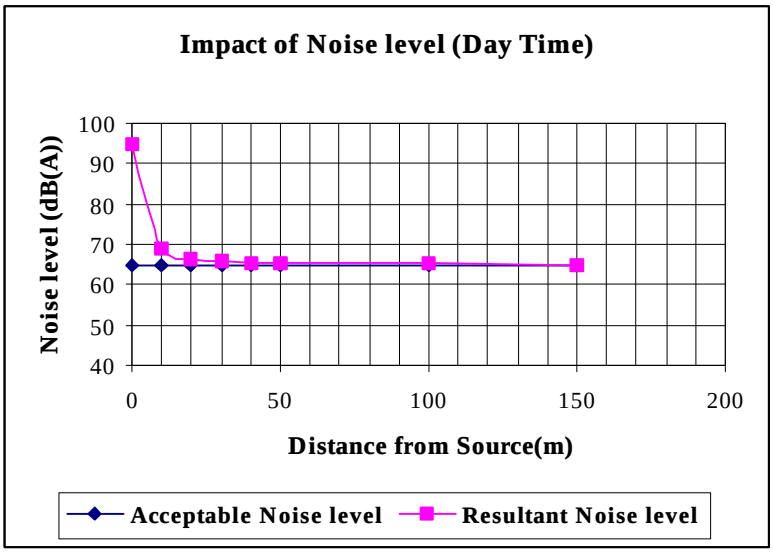
Sound level $dB(A) = L_w - 20 \log_{10} R-8$

Where L_w = Sound level of source, dB(A)&

R = Source distance, m

For an approximate estimation of dispersion of noise in the ambient air from the source point, a standard mathematical model for sound wave propagation is used by considering 95dB(A) as the resultant noise level generated from mining operation and output of the same is shown in ***Figure 6.1.***





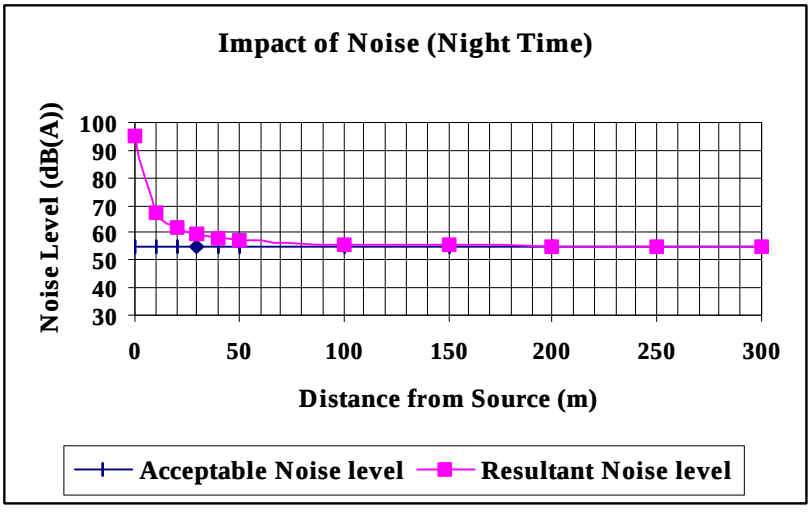


Figure 6.1: Impact on Ambient Noise Level of the Study Area

On perusal of graph as shown in ***Figure 6.1***, it is clear that noise generated by the proposed mining activities will be merged with the noise level of 65 dB (A) (during day time) at a distance of 150 m from the source and with the noise level of 55 dB(A)(during night time) at a distance of 300 m from the source. There will not be any noise impact from the proposed mines during night time as the mine operation will be restricted to two shifts operation only and no machinery operation will take place during night time. 65 dB(A) and 55 dB(A) are the limits during day time and night time respectively for mixed areas prescribed by CPCB. Therefore, no negative impacts are anticipated at the nearest village Phlangkaruh and villages farther than it.

The noise produced by blasting would be for extremely short duration of around 0.5 seconds, though with a high intensity. The impacts over the surrounding habitat can be minimised by adopting adequate precautions during blasting and also by properly scheduling it as indicated in the management plan. While considering proper noise prevention and control measures have been included, the effect of increased noise levels due to mining over villages such as Phlangkaruh in the immediate vicinity also needs to be considered. Creation of noise bunds near the periphery is expected to act as an effective barrier against its propagation of sound waves towards the human settlements.

6.4.1 Occupational Health Hazards of Noise Pollution

The noise levels in many situations would be above TLV. Exposure to noise levels, above TLV, has been found to have detrimental effect on the workers' health. Mine workers working for more than 4 to 4.5 hours per shift will be greatly affected, unless suitable mitigatory measures are taken. The adverse effects of high noise levels on exposed workers may result in:

- Annoyance;
- Fatigue;
- Temporary shift of threshold limit of hearing;
- Permanent loss of hearing; and
- Hypertension and high blood cholesterol, etc.

Noise pollution poses a major health risk to the mine workers. When noise in the form of waves impinges the eardrum, it begins to vibrate, stimulating other delicate tissues and organs in the ear. If the magnitude of noise exceeds the tolerance limits, it is manifested in the form of discomfort leading to annoyance and in extreme cases to loss of hearing. Detrimental effects of noise pollution are not only related to sound pressure level and frequency, but also on the total duration of exposure and the age of the person. ***Table 6.4*** below gives frequency levels and associated mental and physical response of humans.

Table 6.4 Noise Exposure Levels & Its Effects

Noise Levels (dB(A))	Exposure Time	Effects
85	Continuous	Safe
85-90	Continuous	Annoyance and irritation
90-100	Short term	Temporary shift in hearing threshold, generally with complete recovery
Above 100	Continuous	Permanent loss of hearing
	Short term	Permanent hearing loss can be avoided
100-110	Several years	Permanent deafness
110-120	Few months	Permanent deafness
120	Short term	Extreme discomfort
140	Short term	Discomfort with actual pain
150 and above	Single exposure	Mechanical damage to the ear

6.5 GROUND VIBRATIONS

Due to blasting, the vibrations can cause damage to the nearby structures if appropriate control measures are not adopted. Therefore, the control measures suggested in management plan should be adhered to.

Blasting will also result in flyrocks. The factors, which influence flyrock production, are long explosive column with little stemming column, improper burden, loose material or pebbles near the holes and long water column in the hole. The actual blasts at the mines are to be closely monitored for any fly rocks and precautions against fly rock are to be taken are as per given in management plan.

When an explosive charge is fired in a hole, stress waves propagate radically in all directions and cause the rock particles to oscillate. This oscillation is felt as ground vibration. The existing mining operations using deep hole drilling and blasting using delay detonators are bound to produce ground vibrations. The total explosive consumption is proposed to be 7500 kg / week (six days a week).

Blasting, in addition to easing the hard strata, generates ground vibrations and instantaneous noise. Ground vibrations from mine blasting may be expressed by amplitude, frequency and duration of blast. The variables, which influence ground vibrations are controllable and non-controllable. The non-controllable variables include:

- general surface terrain;
- type and depth of overburden; and
- wind.

Similarly, the controllable variations include:

- type of explosives;
- charge per delay';
- delay interval;
- direction of blast progression;
- burden;
- spacing; and
- specific charge and coupling ratio.

The vibrations are measured as per the assessment criteria given under Bureau of Indian Standard *Criteria for Safety and Design Structures Subject to Underground Blasts – IS : 6922 – 1973 (Reaffirmed 1995).*

Per the assessment criteria, the value of ground particle velocity may be computed from the following expression:

$$V = K_1[Q^{2/3}/R]^{1.25}$$

Where

V = Ground particle velocity in mm / sec

K1 = Constant which may be normally taken as 880 for soft rocks and soil and 1400 for hard rocks

Q = Charge per delay (kg), and

R = Distance (m) from blast point

Based on the above equation, the ground particle velocities at different distances (20 m, 50 m, 100 m, 190 m, 400 m, 500 m and 550 m are calculated considering K_1 are being considered 880 for soft rocks and 1400 for hard rocks. Per the Standard, for safety of structures from threshold damage, the ground particle velocity should not exceed the following:

Soil, Weathered or Soft rock	50 mm / sec
Hard Rock	70 mm / sec

The results are presented in the ***Table*** 6***.5*** below for the maximum charge.

Table 6.5 Ground Particle Velocities (V)

Sl.No	Constant K1	Charge per Delay	Ground Particle Velocity (V) mm / second							
			Distance from the Blasting (meters)							
			50	100	150	190	250	400	500	510
1	880	Q = 72 kg	233.6	98.2	59.2	44.0	31.2	17.4	13.1	12.8
2	1400	Q = 72 kg	371.7	156.3	94.1	70.0	49.7	27.6	20.9	20.4

It is clear that with Q = 72 kg charge per delay the ground particle velocity up to 190 m is above the permissible level for hard rock, however, at subsequent distances the ground particle velocities are expected to be within the safe limits for any structures.

Thus, it can be concluded that the ground vibrations generated by blasting during the mining operations will not likely to effect the structures proposed in the vicinity of > 190 m from the point of blast. Concrete structures like workshop, office, store etc should not be proposed within the core mine area. These structures otherwise will be affected by the ground vibrations.

6.6 WATER ENVIRONMENT

Umium is the main river in the study area, which is flanked by Mawsynram plateau to the west and Cherrapunji plateau to the east. The Umium river flows into the Sylhet basin of Bangladesh.

The proposed project lies in sub-tropical region surrounded by natural watercourses, springs and waterfalls. The drainage from the proposed mine area falls into a drainage net of Phalangkaruh river which culminates into Umium river. Thus the main drainage in the study area is governed by the Phlangkaruh river and the Umium river along with its tributaries.

The proposed mine site comprises of karst topography which can be characterised by presence of fissures, joints, fractures, cavities and sink holes. The southern portion of the mine site comprises of twin sinkholes, which is reportedly of dimensions (250 m $_x$ 50 m $_x$ 30 m). There is also a set of three springs appearing at approximately 300 m south at an elevation of 22 m RL. These springs appear even during non-rainy season showing their link with some surface water drainage. It has been reported by folklore of Nongtrai village that water from Fotsgnet Stream near their village links with water springs, which forms a rivulet called Phlangkaruh stream.

Due to heavy rainfall, the area is prone to surface runoff and soil erosion that ultimately will lead to the river systems flowing along the gorges and the foothills.

There is no perennial water stream within the mine lease area. The Phlangkaruh river originating in the foothills of the mine lease area is anticipated to be loaded with additional sediment due to surface runoff during rainy season. During the rains the storm water may carry solids and debris from the opencast mine area and the limestone dumps in the absence of any control measures. The rehabilitation of excavated land and final land restoration will, however, stabilise the drainage pattern also.

6.6.1 Impacts On Surface Water

The potential impact on the surface water quality is likely to be due to higher load of suspended solids. Sources of suspended solids would be:

- Discharge of mine runoff during rains to the surface water channels;
- Wash off from waste dumps and limestone stock piles during rainy season;
- Oil spillage from maintenance workshops;and
- Oil effluent from residential colonies.

Wash-off from limestone Dumps

During the heavy rainfall , the wash-off from the limestone dumps will lead to the adjoining surface water body. This is likely to increase the alkalinity of the water and also increase the suspended solids within the water samples. Therefore, landscape of the limestone dumping area should be shaped, capped and graded, so as to prevent soil erosion along with the run-off.

Oil Spillage from Maintenance Workshops

Oil spillage from the workshop in the wastewater will add to the pollution load resulting in oil and grease contamination of surface water from mine infrastructural facilities. Treatment of the wastewater will lead to pass through a bar screen followed by oil trap where oil content of wastewater will be recovered. This will be followed by subsequent treatment before final discharge. Once the oil is removed and the wastewater generating from the workshop is treated, it will have negligible impact on the environment.

Effluent from Residential Colony

Sanitary waste water generated from various facilities such as amenity centres and residential units will be about 40 kL / day from a township of 20 families and is proposed to be treated before discharge. This sanitary wastewater, if discharged without proper treatment, will have adverse impact on the surface and ground water quality and could lead to water borne diseases, etc.

Regular monitoring of mine water quality is essential to prevent and control the pollution of the nearby surface water. Monitoring results will also form the basis for adoption of appropriate treatment process and up-gradation of treatment facilities developed in due course of time.

Impact of Polluted Water

The polluted water generally contains objectionable odour and colour. It may also be acidic, toxic and highly turbid. Such water is unfit for drinking or any other use. In some cases these may also contain pathogenic microorganisms, which pose potential health hazard. The impact of polluted water would be as follows:

This water may cause various water-borne diseases;

- The polluted water may not be useful for animal husbandry, re-vegetation and human or animal consumption; and
- High turbidity, oils and grease film on water may not allow proper oxygenation of the surface water. Further, high turbidity may prevent sunlight to enter into the water body to promote photosynthesis of aquatic plants. So polluted water may affect the aquatic life.

As the proposed daily quantities of water used is small and there will be treatment of effluent generated which is proposed to be used for watering the green belt plantation, hence, open cast mining operation will not disturb the natural drainage pattern of the core and buffer area both upstream and

downstream. As such the inhabitants of the area depending on river water are expected to be unaffected due to mining operations at Shella block.

6.6.2 Impacts Of Mining On Ground Water

The potential impact of mining would have negligible impact on the ground water, as the site and its adjoining areas are, located at an elevated topography coupled with mine run-off management planning and regional geology. The likely chances of the contaminants reaching the groundwater are very rare. In general, the entire study area is devoid of borewells . The summary of impact assessment on water resources is given in the ***Table 6.6.***

Table 6.6 Summary of Impact Assessment: Water Resources

Impact Area	Nature of Impact[1]	Targets/Interests affected [2]	Magnitude and extent [3]	Overall significance[4]
Surface Water				
Physical impact	Long term modification to the distribution of rain water catchment	Local inhabitants depending on the river water	Local	O Minor
	Increase in siltation load of the adjoining water bodies	River Umium and Phlangkaruh and the sink hole within the near the mine site	Regional	•• Moderate / Major
Chemical Impact	Short term contamination of surface water flows due to mine effluent, run-off, etc	Water bodies, springs and sink holes	Local, small scale	O Minor
	Failure of tailings impoundment	Increase in siltation load in the rivers	Local / Regional but risk of occurrence very low	O Minor, but would have major impact if occurred
Ground Water				
Groundwater quantity	Long term, medium reduction	Aquifers along the river beds in the plain land	Local / Regional	❍ Minor
Resource Management				
Resource Management	Long term, medium reduction	Judicious abstraction of water for usage	Regional	•• Moderate / Major

[1] Description; short or long term; reversible or permanent; associated with construction, operation, decommissioning; cumulative, accidental, etc

[2] Targets and interests potentially affected.

[3] Adverse or beneficial; small, large, etc; very localised (sites only), local, regional national.

[4] Overall significance against criteria (❍ minor; • moderate, some significance; •• major)

6.7 IMPACT ON DRAINAGE PATTERN AND SILTATION

The conclusive findings of hydro geological study of the area are as follows:

6.7.1 Inventory of Springs and Water Courses

No springs or perennial water sources exist within the mine lease area. The following discussion relates therefore to the surrounding water catchment for the Phlangkaruh, as well as some areas to the West of and outside the catchment.

- The most important spring in the area is the spring of *the Phlangkaruh river,* a few hundred meters South West of the mining lease area. Phalangkaruh is one of the small, independent water basins forming a separate drainage system along the southern margin of the hills.

- All the observations and review of geologic/ physiographic information indicate that the Phlangkaruh spring is an overflow spring, flowing at a deep level beyond the west and north of the mine lease area.

- A number of *spring- fed streams on the Nongtrai escarpment* (several km north of the site) were noted to dissolve completely and flow underground upon entering the lower limestone level. Seven tracer tests have confirmed that water from surface courses as far as 4.7 km West-North-West of the Phlangkaruh is flowing underground and into the springs. The area of the Prang limestone is therefore being recharged by springs from the Langpar formation in the Nongtrai area.

- A survey of springs and surface water courses in the larger catchment area indicates *that there are some 11 perennial (but low flow) streams or trickles in the area.* Flow of these were measured along the road from Nongtrai to the site, and it should be noted that not all of these discharge into the Phlangkaruh catchment area. Discharge rates during the dry season were very low (between 0.00075 and 0.032 m3/ second).

- *A water balance has also been carried out for the area.* The calculations indicate that a water surplus for the area exists from the months of March until October. The largest surplus is found in June. During this period, first the saturated storage volume is recharged and then the subsurface water flow increases.

6.7.2 Hydrogeological Findings

No perennial water flows through the mine block area (e.g., the area to be mined out or 1 sq km by up to 90 metres vertical depth), were found.

There are no surface water flows or springs on the site. The nearest underground water flow found is south and west of the mining area, and at an elevation of approximately 20 m RL, some 70 m below maximum mining depth.

The mining area has solution channels and cavities which carry the monsoon season runoff from the mine lease area through the subsurface, to emerge eventually in the Phlangkaruh river through various springs. It has not been possible to map these channels (some at a vertical depth of 170 m), nor

determine which ones carry the bulk of the surface run-off, due to their sheer number, differing depths, crossing paths, and sizes / routes.

These channels do, however, only carry seasonal runoff from the mine area itself, and not from a wider catchment, and alteration of these channels will therefore not significantly affect the quantum of water to emerge from the springs;

The vadose water in the upper part of the limestone area has been shown to contribute only to 6% of the flow in Phlangkaruh river during the monsoon season. The total reduction of the monsoon season flow in Phlangkaruh river would thus amount to a maximum of approximately 1.2%.

Underground channels in caves attached to the twin sinkholes South of the mining lease area), and channels arriving from the North Western Nongtrai area, are perennial water flow channels, which also carry a large quantum of seasonal runoff.

The hydraulic connection from the "twin sinkholes" to the Phlangkaruh spring has been proven through tracer tests, though the time required for the tracer dye to emerge at the spring (9 hours) indicates a highly tortuous route.

The tracer studies also revealed that (part of) the water flowing out of the springs originates at a distance as far as 4.7 km North West of the springs, near Nongtrai.

It consequently appears that subsurface channels are flowing well to the South and West of the mining lease area (nearest distance 300 m).

The study of the geology and geomorphology confirms these findings – namely that the source water is flowing at a distance to the South West, and not through or immediately under the mining area.

The above conclusions indicate that proposed mining operation will not significantly affect the perennial water flow to the springs at the head of the Phlangkaruh river.

6.7.3 Siltation

As per the directive of MoEF, a study was carried out by Center for Study of Man and Environment, Calcutta. Based on the this study, possible impacts of mining on the Phalangkaruh river system are summarised as follows:

- The mining lease area of 1 sq km falls mainly (seventy percent) in the upper part of the drainage basin of southerly flowing Phlangkaruh river. About thirty percent of the leased block crosses the drainage divide basin and transgresses into the catchment area of the easterly flowing Umium river. However, as per the mine plan design, this area of 0.3 sq km will be integrated with drainage basin of Phlangkaruh as a result of topological change to be brought about mining. Hence, the size of the affected drainage basin works out to be 3 sq km (2.7 sq km of the Phlangkaruh basin and 0.3 sq km of adjacent basin). Opencast mining of limestone will cumulatively affect an area of 1 sq. km in the uppermost part of the basin (190 m to 90 m).

Mining will be restricted to 1 sq km of 3 sq km of integrated drainage basin. Hence the ratio of the area to be directly affected is around 33% of the basin. Like all rivers, the Phlangkaruh is also in the state of dynamic equilibrium. The change to be brought about by mining is likely to trigger certain responses in the hydraulic geometry of the river.

- The limestone covers the upper part of the drainage basin. It has a moderate slope towards the south along the flow direction of the Phlangkaruh. Opencast mining will decisively change the slope. The entire mass between 190 m and 90 m RL in the mining block will be eventually removed. This will alter the surface flow regime over the limestone terrain. Assuming average rainfall to be 4450 mm and the mine block to be 1 sq. km, flow pattern of 4.4×10^6 m^3 of water will be affected. Mining will alter the north – eastern perimeter of the drainage, divide and integrate about 0.3 sq. km of the adjacent basin with that of Phlangkaruh River.

- The limestone terrain is cavernous and riddled with solution cavities, sinkholes and underground channels. Surface run-off gets into the cavities and resurge as springs which supply a large quantity of water to the Phlangkaruh river. Limestone is chemically very pure. Percentage of insoluble minerals is negligible. Hence the contribution of limestone to particulate suspended load is insignificant. But it contributes almost the entire quantum of dissolved load in the Phlangkaruh River. Hence, quantum of dissolved load may change but there will be very little impact on siltation process.

- Most of the particulate sediment load (bed load and suspended load) of the Phlangkaruh river is contributed by the Kopili shale, which covers nearly 47.8% area of the drainage basin. Limestone mining will not destablise the integrity of the system of creeks and gullies which transfer sediments from the shale terrain to the trunk channel. Hence, siltation process of the river will not be much affected unless spring water discharge gets modified due to mining.

- The conceptual mining plan envisages utilisation of water resource of the Phlangkaruh river for meeting the entire industrial and domestic water demand of the establishment. The quality of water matches the required standard. Since the hydrological system is delicate it is strongly recommended that care must be taken to ensure that the river is not turned into a sink for waste disposal. That will be counter-productive.

On the basis of the various studies, the following are the main conclusions:

- The quantum of water flow into the Phalangkaruh will not be reduced based on current information as there are no perennial springs or streams on site, and the perennial underground water channel flows to the west and well below maximum mining depth. Likewise, monsoon rains will simply be re-channelled into the Phalangkaruh via a man made route, as noted in the catchment area treatment plan.

- The potential impact on water quality will be mitigated through good mining practice and development of various infrastructure, such as sumps,

garland drains, etc. Based on the numerous planned measures, impact on water quality is expected to be controlled sufficiently to ensure no major impact on downstream water quality. Monitoring will confirm this and further improvements made if required.

6.8 LANDUSE

The proposed mining operation and conveyor belt corridor will change the topography and the landscape of limestone bearing area and its immediate vicinity in the core zone only.

The core area of 157 ha consists of 100 ha for mining , 2.5 ha for crusher, 4 ha. for infrastructure (workshop & office area,17.9 ha for green belt all around the mine site , 26.6 ha for belt conveyor corridor and 6 ha for township. The opening of the mine is proposed to be from the north- eastern side and appropriate location of dumps will give definite advantage in terms of keeping the land disturbance at the minimum.

Due to the crusher, no major topographical change is likely to take place except some levelling and construction of structures.

No adverse impacts are anticipated on land use of buffer zone due to the proposed mining operations, as all the mining activities will be confined to core zone only, except mine site and resettlement colony and an additional corridor of land which will be required for installation of the belt conveyor. The proposed belt conveyor will cause minor change in topography due to steel columns to be laid under the belt structure. Out of total land, loss of agricultural land for paddy & vegetables and bamboo plantation will be 33% and 11% respectively while, rest of the land belongs to river sand area and bushes, required for the development of corridor of belt conveyor of 25 to 40 m width running 7.2 km within Indian Territory will also be minimum with respect to the study area.

6.8.1 Soil

Impact on soil will be localised ie around the mine site. Generally soil in the area is found only in the cervices and fissures while the rest of the area is barren rocky area. So likelihood of any adverse impact from soil erosion and disturbance in quality is remote. However, the impacts that will occur are reversible as the impacts will be felt in the initial stages of mine operation, *ie* till the vegetative cover is developed. The summary of impact assessment on soil and land use is given in the ***Table 6.7.***

Table 6.7 Summary of Impact Assessment: Soil and Land-use

Impact Area	*Nature of Impact [1]*	*Targets/Interests[2]*	*Magnitude and extent[3]*	*Overall significance [4]*
Land use	Change in original land use, land degradation, reversible (partially)	Reduction of degraded vegetation, loss of top soil, visual intrusion	Mine lease area only, small scale; beneficial effect in terms of compensatory afforestation with	• Moderate

Impact Area	*Nature of Impact* [1]	*Targets/Interests*[2]	*Magnitude and extent*[3]	*Overall significance* [4]
			higher success percentage expected	
Derogation of soil quality	Cumulative contamination with dust, surface run-off; reversible	Soil quality, flora and fauna, including grazing livestock	Localised near sources; small contribution to existing background levels, provided dust control and overburden is managed	❍ Minor
	Physical effects on soils due to topsoil removal, nutrient loss; irreversible	Soil quality, flora	Site areas only	• Moderate

[1] Description; short or long term; reversible or permanent; associated with construction, operation, decommissioning; cumulative, accidental, etc
[2] Targets and interests potentially affected.
[3] Adverse or beneficial; small, large, etc; very localised (sites only), local, regional national.
[4] Overall significance against criteria (❍ minor; • moderate, some significance; • • major)

6.9 SOLID WASTE DISPOSAL

The mine being devoid of any OB, and very thin layer of clay restricted only in few crevices, it is anticipated that there will be no overburden and almost negligible quantity of clay.

The other solid waste expected to be generated is ETP sludge approximately 0.1 to 0.15 tpd. The ETP waste being rich in nutrient will be used as manure in plantation.

The domestic solid waste from colony and mine is expected to be generated to the tune of 0.4 tpd, which will be disposed of as municipal waste.

6.10 ECOLOGICAL IMPACTS

A study was conducted during the winter 2000-2001 to survey living natural resources, both flora and fauna, from the proposed Limestone Mining Area (1 km, the "core area") as well as a 10 km radius around the site (the "buffer area"), located in the East Khasi Hills, Meghalaya.

The study was carried out at both Terrestrial Ecosystem and Aquatic Ecosystems. Under the Terrestrial Ecosystem, seven different types of forest / grassland have been noted (but no rainforest area). Vegetation cover of the Core Zone and Buffer Zone showed variable canopy cover. Floristic composition show 73 species of trees, 34 shrub, 21 climbers and epiphytes and 48 common herb. No endangered or localised endemic species were recorded.

The Phytosociological analysis of forest zone done for 27 species in Core Zone and 51 species in Buffer Zone revealed a variable frequency, density and

abundance rate. Fauna of the area show a very poor representation of Mammals by only nine species (mostly small mammals), 58 species of birds, 8 species of Reptiles. None of these are considered as "Endangered or Rare". Unpublished data for Butterflies show 22 species in the region, which are otherwise common elsewhere in Meghalaya and NorthEast India.

The Aquatic Ecosystem study was aimed at Planktons and Macrophytes besides benthics, fishes, amphibia and birds. A total of seven species of Phytoplankton, two species of zooplankton, 14 species of Macrophytes, six genera of algae, 42 species of fishes (ZSI data), 2 species of amphibia (ZSI data) and 12 species of birds are represented in the aquatic system. None of these are known to be Endangered or Rare.

Based on the above discussion, it is clear that study area is not having any endangered or rare species. The impact of mining on flora and vegetation will be further mitigated through a detailed afforestation plan as given in ***Section 8*** of the report.

6.11 SOCIO-ECONOMIC IMPACTS

In terms of the major socio-economic impacts, the project will provide more direct and indirect job opportunities and better economic standards to the project affected people and others, through improved infrastructural, community facilities, etc.

Development of residential colony, creation of civic and welfare amenities like primary health care, communications, educational institutes, recreational facilities, etc, that will develop along with the project will ensure better quality of life for the local population.

7 IMPACT EVALUATION

7.1 APPROACH

To account for the qualitative nature of the environmental impacts it is necessary that quantitative analysis is to be done so as to remove the factor of subjectivity in the decision making. In this section, environmental impacts due to the proposed Limestone mining activities have been quantified under two scenarios:

- without environmnetal management plan; and
- with the environment plan.

Various methodologies are in use for identification and evaluation of the environmental impacts *eg* Adhoc, Overlays, Checklists, Matrix method, and Networks approach. Each method has its own merits and demerits.

Leopold Impact Matrix is the most widely used technique, however, it has an associated disadvantage of subjective valuation of certain impacts. Therefore, the improved "Modified Matrix" method has been used in this report which involves establishment of cause-effect relationship.

This method involves assignment of "Parameter Importance Value" (PIV) against each environmental impact parameter. These values are determined by subjective judgement considering the relative importance or significance of individual parameter. After deciding on PIV, these values have to be distributed among all the cause-effect relationships established between the affected environmental parameters and the related project activities by means of indices which are called "Relative Parameter Importance Indices" (RPII). The sum of all the indices should be equal to unity. The value of RPII is decided based on the relative importance of cause-effect relationship and the most important one is given highest RPII value and the subsequent impact parameters are assigned RPII values in the descending order.

Another index which is to be determined for each cause effect relationship is called "Environmental Impact Index" (EII). The scale for EII varies from zero to one. The value "1" is assigned to an impact of highest order and "0" is assigned to an impact of negligible magnitude. For adverse impacts, EII carries a negative sign, and for beneficial impacts it carries positive sign. For determining the value of EII, the environmental impact parameters are divided into two categories, A & B.

Category "A" includes those impact parameters whose quality varies linearly with the magnitude of impact related to the project activities and includes:

- Surface and ground water resources;
- Socio-economic aspects;
- Land use; and
- Human settlements.

Category "B" includes those impact parameters whose quality varies logarithmically with the magnitude of the impacts and includes:

- water quality;
- Hydrogeology and drainage pattern;
- Air quality;
- Noise level;
- Health;
- Flora; and
- Fauna.

In the latter case, a slight change in impact magnitude will have insignificant change in environmental quality, but as the magnitude increases, the deterioration in quality increases logarithmically. The basis for determining EII for *category A* and *category B* are given in ***Table 7.1*** and ***Table 7.2*** respectively.

Table 7.1 Determination of EII for Category "A" Parameters

S No	Impact Magnitude (in %)	EII
1	No Change	0
2	0-4.9% Change	0.05
3	5-14.9% Change	0.1
4	15-24.9% Change	0.2
5	25-34.9% Change	0.3
6	35-44.9% Change	0.4
7	45-54.9% Change	0.5
8	55-64.9% Change	0.6
9	65-74.9% Change	0.7
10	74-84.9% Change	0.8
11	85-94.9% Change	0.9
12	>95% Change	1

Table 7.2 Determination of EII for Category "B" Parameters

S No	Impact Magnitude (in %)	EII
1	No Change	0
2	0-4.9% Change	0.02
3	5-14.9% Change	0.05
4	15-24.9% Change	0.10
5	25-34.9% Change	0.15
6	35-44.9% Change	0.25
7	45-54.9% Change	0.5
8	55-64.9% Change	0.75
9	>65% Change	1

After determining EII for each cause-effect relationship, the same will be multiplied with RPII to get "Weighted Environmental Impact Index" (WEII). These values are once again multiplied with PIV and addition of all these values gives the impact score for that particular environmental parameter. The impact score so obtained for all impact parameters is added together to get total impact score. This total impact score is used for interpretation and decision making.

Details regarding the PIV, RPII, EII, WEII specific to the Limestone mining project are described in the following sections, which is followed by the analysis and evaluation of potential environmental impacts.

7.2 PROJECT SPECIFIC EVALUATION

7.2.1 PIV For Environmental Components

The environmental components listed in the earlier section are assigned with PIVs so as to convert the environmental impacts into commensurate units, which could be aggregated easily to get the total score of environmental impacts. PIVs are assigned by marking and pair-wise comparison procedure. This procedure involves preparation of a table containing number of columns corresponding to the range of values, which can be assigned a "score of importance" against each impact area. The score of importance is any integer ranging from one to six. The most affected parameter carries a score of six and the least affected parameter carries a score of one.

Assigning Importance Ranking:

- Air quality in mines with respect to SPM / RSPM levels is of more concern, followed by NO_x and SO_2 levels, which are of lesser importance. The SPM / RSPM levels are expected to be high within the mining area. Hence it is given a ranking of 4.

- Although high noise levels are largely confined to the working environment, this impact increases due to the presence of vehicular traffic. Hence the ranking is given as 4.

- Ground Vibrations will not have any impact to the surroundings beyond the safety zone as recommended by DGMS. However, the ground vibrations within the safety zone plays an important role, therefore, is given a ranking of 2.

- The proposed mine will source surface water for requirement of approximately 100 m^3 / day for dust suppression, domestic supply, and green belt development and 50 m^3 / day for colony. There will not be any effluent generated as mine run off except during rainy season. It is proposed to treat and reuse the effluent generated from the domestic and washing activities at the limestone mine in green belt development. Impact on quality and quantity of nearby surface water body will be insignificant hence it is given a ranking of 1.

- Hydrogeological and drainage pattern of the study area is represented by surface water bodies, aquifers, hilly topography, geology of the area and high rainfall, therefore, is given a ranking of 5.

- The impact of land use is more pronounced because of degradation of land due to mining activities, disposal of overburden soil, construction of structures confined to limited area in the region. The landuse degradation will be one time *ie* during the mine development phase only, however, in the long run landuse will result in positive impacts due to improvements in the socio-economic infrastructure and family earnings. The land use is given a ranking as 3.

The impact on fauna will be less pronounced, hence the ranking given is 2.

- The impact on flora is given a ranking of 4, which would be significantly affected due to clearing of vegetation in mining and allied activities during mine development period only, however, in the long run, there will be positive impact on flora due intensive afforestation by the project proponent.

- The impacts on human health in the surrounding area will be insignificant with appropriate mitigative measures. Hence the ranking for impact on human health is 2..

- The socio-economic aspects of the region will improve with the development of the project. Hence a ranking of 4 is given.

- The impact on culture in the study area would be minor due to influx of specialised staff required for mining operations. Hence a ranking of 1 is given.

Determination of PIV

The impact areas considered along with their rankings and the weightage for each impact area are as given in ***Table 7.3***. The total PIV is assumed to be 1,000 per the standard practice. The value of total PIV is distributed among each impact area according to its weightage.

Table 7.3 Determination of PIV

Impact Area	Ranking (on 1 to 6 scale)	Weightage	PIV
Air quality	4	4/32	125.0
Noise levels	4	4/32	125.0
Ground Vibration	2	2/32	62.5
Water resources	1	1/32	31.25
Hydrogeology and Drainage Pattern	5	5/32	156.25
Land use, soil characteristics	3	3/32	93.75
Fauna	2	2/32	62.5
Flora	4	4/32	125.0
Health	2	2/32	62.5
Socio-economic aspects	4	4/32	125.0
Culture	1	1/32	31.25
Total	32	-	-

7.2.2 Relative Parameter Importance Index (RPII)

The RPII indicates the importance of interaction between the action and environmental components. It is assigned any value between 0 and 1 so that the sum of all the values of RPII under each environmental component is equal to 1. The importance of an interaction is related to the significance or assessment of the consequences of the anticipated interaction. Assignment of RPII to an interaction is based on the subjective judgement. While deciding on RPII, first the RPII values are distributed among adverse and beneficial impacts depending upon their significance. The RPII values so distributed are once again distributed among the respective interactions depending upon their individual significance. The most important interaction under a particular impact area is given the maximum RPII, whereas the least important one is given minimum RPII. As the significance increases, the RPII also increases. The RPII values for all the interactions, along with the criteria for deciding the same is presented in ***Table 7.4*** and ***Table 7.5***.

7.2.3 Environmental Impact Index (EII)

The EII represents the magnitude of an impact due to the interaction established between an environmental component and a project activity. This impact magnitude is represented by a numerical value that is determined from ***Tables 7.4*** & ***7.5***. The environmental components are grouped into two categories viz A and B (***Table 7.1*** *and* ***Table 7.2***). EIIs are determined for each impact area project activity interaction and are given in ***Table 7.4*** and ***Table 7.5*** along with the remarks.

Table 7.4 Potential Impact Identification Matrix (Without Environmental Management Plan ie Without Mitigative Measures)

Environmental Components	Project Activities	Interaction No	Impacts	Adverse / Beneficial	RPII Values	Remarks for RPII	EII
Air quality	Blasting	1	Dust & gases (NO_x) are produced during blasting. High SPM is observed during these operations.	Adverse	0.15	Instantaneous blasting once in a day (during afternoon) confined to very small area.	-0.1
Air quality	Loading / Unloading and Transportation within the mine area	2	Causes dust nuisance as well as NO_x pollution due to vehicular emissions	Adverse	0.30	Continuous operation during the two shifts in a day	-0.15
Air quality	Limestone Crushing	3	Dust raised during crushing operations	Adverse	0.2	Batch operation two shifts a day	-0.10
Air quality	Transportation through Belt Conveyor	4	Increase in SPM level	Adverse	0.10	Continuous covered operation with possible spills	-0.05
Air quality	Stock Piling of crushed limestone and disposal of solid waste	5	Increase in SPM level	Adverse	0.20	Windy conditions may add up dust levels	-0.10
Air quality	DG Set	6	Increase in SO_2 and NO_x levels	Adverse	0.05	Standby operation	-0.02
Water resources	Water required for mine (dust suppression, workshop, domestic supply and green belt) and colony	1	Impact due to continuous drawing of water	Adverse	0.2	Insignificant resource utilisation	-0.1
Water resources	Wastewater generated from workshop, domestic usage from the mine	2	Deterioration in soil and ground water quality when discharged untreated for greenbelt development	Adverse	0.5	Workshop wastewater will contain high oil and grease contaminants	-0.5

Environmental Components	Project Activities	Interaction No	Impacts	Adverse / Beneficial	RPII Values	Remarks for RPII	EII
Water resources	Domestic wastewater generated from the Colony	3	Deterioration in surface / ground water and soil quality when discharged untreated for greenbelt development	Adverse	0.3	Solely domestic wastewater	-0.15
Noise levels	Blasting	1	High Impulsive Noise levels	Adverse	0.30	Instantaneous blasting once in a day (during afternoon), confined to very small area	-0.15
Noise levels	Machine operation (including crusher operation)	2	Increase in noise levels	Adverse	0.40	Continuous operation during two shifts	-0.25
Noise levels	Transportation including belt conveyor movement	3	Increase in noise levels	Adverse	0.30	Continuous operation during two shifts	-0.15
Ground Vibrations	Blasting Operations	1	Impulsive ground vibrations	Adverse	1.0	Instantaneous blasting once in a day (during afternoon) confined within the safety zone.	-1.00
Hydrogeology and Drainage pattern	Excavation of limestone	1	May change regional hydrology and drainage pattern of the area	Adverse	1.0	Change in hydrology and drainage pattern	-1.00
Landuse and soil characteristics	Excavation of limestone	1	Impact due to opencast excavation	Adverse	0.4	Degradation of land but confined to only M.L area.	-0.40
Landuse and soil characteristics	Disposal of solid waste	2	Land degradation due to disposal of solid wastes	Adverse	0.1	Solid waste in the form of waste generated in initial stage of mining	-0.10
Landuse and soil	Transportation & crushing	3	Impact due to settling of air	Adverse	0.2	Operation shall be batch operation for	-0.20

Environmental Components	Project Activities	Interaction No	Impacts	Adverse / Beneficial	RPII Values	Remarks for RPII	EII
characteristics	operation		borne dust			two shifts in a day	
Landuse and soil characteristics	Plantation & agricultural yield	4	Impact due to clearing of existing plantation in the mining area	Adverse	0.3	No vegetative cover in premitigative stage	-0.3
Fauna	Mining & crushing operations	1	Affects wild life through air & noise pollution	Adverse	0.8	All operations are opencast hence significant impact is observed but confined to only M.L area	-1.0
Fauna	Transportation	2	Adverse effect due to air and noise pollution by movement of conveyor belt & vehicular traffic	Adverse	0.2	Vehicular traffic is mainly confined to domestic purpose	-0.10
Flora	Mining & crushing operations	1	Impact due to air noise pollution and loss of existing flora	Adverse	0.8	All operations are opencast hence significant impact is observed but confined to only M.L area	-1.0
Flora	Transportation	2	Adverse impact of dust emissions due to movement of conveyor belt and vehicular traffic	Adverse	0.2	Vehicular traffic is mainly confined to domestic purpose	-0.10
Health	Mining & crushing operations	1	Deteriorates workers health due to air & noise pollution, accidents & injuries	Adverse	0.5	The maximum importance is given to interaction 1 as the workers are exposed to high levels of noise & air pollutants	-0.5
Health	Transportation	2	Deteriorates health due to air & noise pollution	Adverse	0.3	Mainly confined to the domestic purposes	-0.15

Environmental Components	Project Activities	Interaction No	Impacts	Adverse / Beneficial	RPII Values	Remarks for RPII	EII
Health	Provision of civic amenities	3	Affects health through disposal of sewage on open land which causes mosquito nuisance water borne diseases	Adverse	0.1	Small quantity of sewage is being generated.	-0.05
Health	Plantation	4	During mining development stage the plantation exist in the area shall be removedas it improves the health of inhabitants by acting as a barrier to air & noise pollution, uptake of liquid waste disposed on land and imparts pleasant atmosphere	Adverse	0.1	No plantation in the premitigative stage	0.05
Socio-economic aspects	Mining & crushing operations	1	Increased employment opportunities both direct and indirect thereby increasing economic status of people	Beneficial	0.5	Has a large potential	0.50
Socio-economic aspects	Colony & civic amenities	2	Increased employment opportunities both direct and indirect	Beneficial	0.2	Has a moderate potential	0.20
Socio-economic aspects	Transportation	3	Increased employment opportunities (mostly indirect employment) and there by increase in the economic status	Beneficial	0.1	Has less significant potential	0.10
Socio-economic aspects	Land acquisition for mine site and belt conveyor	4	Loss of land	Adverse	0.2	Activities confined to small Area	-0.20
Culture	Establishment of the project	1	Long term impact	Adverse	1.0	Influx of people of various cultures will have substantial effect on local culture	-1.0

Table 7.5 Potential Impact Identification Matrix (With Environment management Plan ie with Mitigative Measures)

Environmental Components	Project Activities	Interaction No	Impacts	Adverse / Beneficial	RPII Values	Remark for RPII	EII
Air quality	Blasting	1	Dust & gases (NO_x) are produced after blasting. High SPM is observed during these operations.	Adverse Dilution of impacts	0.10 0.05	By optimisation Of blasting Operation and development of green belt Shall reduce Impacts	-0.05
Air quality	Loading /Unloading and transportation within the M.L area	2	Causes dust nuisance as well as NO_x pollution due to vehicular emissions	Adverse Dilution of impacts	0.2 0.1	By using dust preventive and suppression measures shall reduce impacts	-0.10
Air quality	Limestone Crushing	3	Dust raised during crushing operations	Adverse Dilution of impacts	0.1 0.1	Impacts shall be reduced by providing Bag filter	-0.05
Air quality	Transpotation through belt conveyor	4	Increase in SPM level	Adverse Dilution of impacts	0.05 0.05	Provision of closed system shall make the impacts insignificant	-0.05
Air quality	Stockpiling of crushed limestone and disposal of solid waste	5	Increase in SPM level	Adverse Dilution of impacts	0.15 0.05	Provision of green belt around the site shall reduce the impacts	-0.10
Air quality	DG set	6	No impact	No impact Dilution	0.0 0.05	By providing adequate stack height	0.0
Water resources	Water required for mine(dust suppression,	1	Impact due to continuous drawing of water	Adverse	0.2	Insignificant resource utilisation	-0.1

Environmental Components	Project Activities	Interaction No	Impacts	Adverse / Beneficial	RPII Values	Remark for RPII	EII
	workshop,domestic supply and green belt)and colony						
Water resources	Wastewater generated from workshop,domestic usages from the mine	2	Deterioration in soil and ground water quality when discharged untreated for green belt development	No impact Dilution of impacts	0.0 0.5	Treated effluent shall meet the statutory requirement for usages in green belt development	0.0
Water resources	Domestic waste water generated from colony	3	Deterioration in soil and ground water quality when discharged untreated for green belt development	No impact Dilution of impacts	0.0 0.3	Treated effluent shall meet the statutory requirement for usages in green belt development	0.0
Noise levels	Blasting	1	High impulsive noise levels	Adverse Dilution of impacts	0.2 0.1	By optimising blasting operation and adopting noise preventive measures shall reduce impacts	-0.10
Noise levels	Machine operation(including crusher operation)	2	Increase the noise levels	Adverse Dilution of impacts	0.05 0.35	By adopting noise preventive measures impacts shall be reduced	-0.05
Noise levels	Transportation including belt conveyor movement	3	Increase in noise levels	Adverse Dilution of impacts	0.1 0.2	By adopting noise preventive measures impacts shall be reduced	-0.05
Ground Vibrations	Blasting operation	1	Impulsive ground vibrations	Adverse Dilution of impacts	0.2 0.8	By optimising blasting technique and provision of green belt	-0.1
Hydrology and drainage	Excavation of limestone	1	May change regional hydrology and drainage pattern of the area	Adverse Dilution	0.7 0.3	Avoiding mining in sensitive areas and optimising blasting	-1.0

Environmental Components	Project Activities	Interaction No	Impacts	Adverse / Beneficial	RPII Values	Remark for RPII	EII
Landuse and soil characteristics	Excavation of limestone	1	Impact due to open cast excavation	Adverse Dilution	0.1 0.3	Short term reversible impacts only	-0.1
Landuse and soil characteristics	Disposal of solid waste	2	Landuse degradation due to disposal of solid waste	Adverse Dilution	0.0 0.1	Solid waste generated in the initial stage of mining only	0.0
Landuse and soil characteristics	Transpotation & crushing operation	3	Impacts due to settling of air borne dust	Adverse Dilution of impacts	0.1 0.1	By adopting dust suppression measures	-0.1
Landuse and soil characteristics	Plantation and agriculture yield	4	Beneficial effect on land as it improves aesthetics & provides for wildlife.Also increase in agriculture yield	Beneficial Dilution	0.0 0.3	By adoption of dense afforestation programme and use of latest methods for agriculture by local habitants as increase in their daily earning	0.0
Wildlife	Mining & crushing operations	1	Short term reversible impacts only	Adverse Dilution of impacts	0.3 0.5	By adopting pollution control measures	-0.15
Wildlife	Transportation	2	Short term reversible impacts only	Adverse Dilution of impacts	0.1 0.1	By adopting pollution control measures	-0.05
Flora	Mining & Crushing operations	1	Short term reversible impacts only	Adverse Dilution of impacts	0.4 0.4	By adopting pollution control measures	-0.25
Flora	Transportation	2	Adverse impact of dust emissions due to vehicular traffic and movement of conveyor belt	Adverse Dilution of impacts	0.1 0.1	By adopting pollution control measures	-0.05
Health	Mining & crushing operations	1	Deteriorates workers health due to air & noise pollution, accidents & injuries	Adverse Dilution of impacts	0.3 0.2	Adoption of effective pollution control measures	-0.15
Health	Transportation	2	Deteriorates health due to	Adverse	0.2	By adopting effective	-0.1

Environmental Components	Project Activities	Interaction No	Impacts	Adverse / Beneficial	RPII Values	Remark for RPII	EII
			air & noise pollution	Dilution of impacts	0.1	pollution control measures	
Health	Provision of civic amenities	3	Affects health through disposal of sewage on open land which causes mosquito nuisance water borne diseases	Adverse Dilution of impacts	0.0 0.1	By adopting pollution control measures	0.0
Health	Plantation	4	Greenbelt development shall have positive impact	Adverse Dilution of impacts	0.0 0.1	By adopting pollution control measures	0.0
Socio-economic aspects	Mining & crushing operations	1	Long term impacts	Beneficial	0.5	Increased employment opportunities both direct and indirect thereby increasing economic status of people	0.5
Socio-economic aspects	Colony & civic amenities	2	Long term moderate impacts	Beneficial	0.20	Increased employment opportunities (mostly indirect employment) and thereby increase in the economic status	0.20
Socio-economic aspects	Transport	3	Increased employment both by direct & indirect ways. Employment in commercial services, improved economic status of people	Beneficial	0.1	Employment is restricted to limited persons	0.10
Socio-economic aspects	Land acquisition for mine site and belt conveyor	4	Loss of land	No Impact Dilution	0.0 0.2	Adequate compensation will be paid	0.00
Culture	Establishment of the project	1	Long term impacts	Adverse	1.0	Influx of people of various cultures will have substantial effect on local culture	-1.0

7.2.4 Weighted Environmental Impact Index (WEII)

It is necessary to establish RPII and EII in order to arrive at WEII. The WEII is determined by multiplying RPII and EII of the corresponding interactions ***(Table 7.3)***.

$[WEII]_{A=Interaction} = [RPII]_{A=Interaction} \times [EII]_{A=Interaction}$

7.3 POTENTIAL IMPACT IDENTIFICATION WITHOUT MITIGATIVE MEASURES

After arriving at WEII and PIV values as described above, the environmental impact matrix incorporating all the environmental components and project activities (without mitigative measures) are presented in ***Table 7.6.***

Table 7.6 Impact Matrix Without Mitigative Measures

Impact Area	WEII (RPII x EII)	PIV	Total (WEII x PIV)
Air quality	-0.106	125.0	-13.25
Water resources	-0.315	31.25	-9.85
Noise level	-0.19	125.0	-23.75
Ground vibrations	-1.0	62.5	-62.5
Hydrogeology and drainage	-1.0	156.25	-156.25
Landuse and soil characteristics	-0.3	93.75	-28.13
Fauna	-0.82	62.5	-51.25
Flora	-0.82	125.0	-102.5
Health	-0.305	62.5	-19.06
Socio-economic	0.46	125.0	57.5
Culture	-1.0	31.25	-31.25
Total			-469.29

The impact is calculated by multiplying the sum of all WEIIs against each environmental component by its corresponding PIV. Total impact score is calculated by adding all individual impact scores. The total impact score is assessed by using the following relative scale:

Upto -200	:	No significant impact on environment.
-200 to –400	:	Significant but reversible impact; Appropriate control measures are important.
-400 to -600	:	Significant and mostly reversible in short term; mitigation measures crucial.
-600 to -800	:	Major impact mostly irreversible.
-800 to –1000	:	Permanent irreversible impact.

7.3 SUMMARY OF IMPACTS

The total impact score is –469.29. This indicates that in the overall consideration, adverse impacts are not very significant vis-à-vis the beneficial impacts of the project. However, it is certain that if mitigative measures are not employed in time, the negative impacts may accumulate to such an extent that the assimilative capacity of the region may not be able to sustain the ecological balance. Therefore mitigative measures are important and crucial in the context of future development / expansion of the existing mining leases in the region. The predominantly affected environmental attributes are air quality, hydrogeology, land use and soil characteristics and health. On the other hand economic aspects and public utilities in the region will be benefited with the advent of new industries.

7.4 POTENTIAL IMPACT IDENTIFICATION WITH MITIGATIVE MEASURES

Components such as PIV, RPII, EII, WEII and sum of the above are arrived at and the same are shown in ***Tables 7.3***, *7.**5*** and 7.***7***.

Table 7.7 Impact Matrix With Mitigative Measures

Impact Area	WEII (RPII x EII)	PIV	Total (WEII x PIV)
Air quality	-0.0475	125.0	-5.94
Water resources	-0.02	31.25	-0.63
Noise levels	-0.0275	125.0	-3.44
Ground vibrations	-0.02	62.5	-1.25
Hydrogeology and drainage	-0.70	156.25	-109.37
Landuse and soil characteristics	-0.02	93.75	-1.88
Fauna	-0.05	62.5	-3.13
Flora	-0.105	125.0	-13.13
Health	-0.065	62.5	-4.06
Socio – economic	0.30	125.0	37.5
Culture	-1.0	31.25	-31.25
Total			-136.58

It is observed that the total score which was originally –469.29 (without mitigative measures) has improved to –136.58 (with mitigative measures).

7.5 RESIDUAL IMPACT IDENTIFICATION

As discussed earlier, the negative score of 469.29 at pre-mitigative stage indicates significant adverse and reversible impacts that can be managed by adopting appropriate pollution control measures (-136.58). Thus, mitigative measures and strict adherence to EMP assumes greater importance. Adequate care has been taken at the planning and engineering stage to incorporate environmental protection measures in the proposed mining activities. Various

control measures such as afforestation programme, land reclamation, effluent treatment plants, dust suppression measures etc. have been proposed for mitigating the adverse impacts. With regular monitoring of implementation of the suggested environmental management measures, it is expected that environmental quality of various affected parameters would be controlled to a great extent and it will be possible to maintain the ecological setting of the region.

8 ENVIRONMENTAL MANAGEMENT PLAN

This section discusses the management plan for mitigation / abatement of adverse environmental impacts and enhancement of beneficial impacts due to mining. The EMP has been designed within the framework of various Indian legislative and regulatory requirements on environmental and socio-economic aspects.

8.1 AMBIENT AIR QUALITY MANAGEMENT

Mitigative measures suggested for air pollution controls are based on the baseline ambient air quality of the area. From the point of view of maintenance of an acceptable ambient air quality in the region, it is desirable that air quality is monitored on a regular basis to check compliance of standards as prescribed by CPCB. In case of non-compliance, appropriate mitigative measures need to be checked.

As per the results of ambient air quality monitoring data, the background concentrations of SPM, RSPM, SO_2, CO and NO_x are within the stipulated CPCB standards for most of the samples. The proposed mining operations and related activities are expected to add to the levels of air borne particulate mainly during daytime. The addition of gaseous pollutants due to the proposed mining activities is expected to be relatively low.

8.2 CONTROLLING DUST LEVEL

Dust would be generated during blasting, mining, crushing operations, and also during handling and transportation of the material. The suggested control measures are:

Mines

Dust suppression systems (water spraying) to be adopted at:

- faces / sites before and after blasting,
- faces / sites while loading; and
- use of sharp teeth for shovels.
- Dust extraction systems to be used in drill machines; and
- use of sharp drill bits for drilling holes and drills with water flushing systems (wet drilling) to reduce dust generation.

Stock-piles

- Mist sprays to be provided at appropriate places for preventing dust pollution during handling and stockpiling of limestone; and
- OB waste dumps, if any, shall be sprayed with water, as they are the major source of air borne particulate matter / dust.

Haulage

- regular water spraying on haulage roads during transportation of limestone and waste by water sprinklers;
- transfer points for transporting limestone to be provided with appropriate hoods / chutes to prevent dust emissions; and
- dumping of limestone and waste should from an optimum height (preferably not too high) so as to reduce the dust blow.

Crusher

- Crusher is to be provided with Bag Filters to arrest any dust emission. The dust emission level to be kept within the prescribed standard of 150 mg/Nm^3; and
- Water sprinkling system to be provided to check any fugitive emissions from the crushing operation.

Belt Conveyor

- close conduit type belt conveyor to be used for transportation of crushed material to Cement plant at Chattak, Bangladesh. The belt and idlers to be maintained in proper condition so as to avoid spillage of material and prevent any fugitive emissions.

8.3 CONTROLLING CO LEVELS

The concentration of CO in the ambient air is found to be below permissible levels at all the air quality monitoring locations. Expected increase in the CO concentration is very low as CO emissions from mining operations are less as compared to other pollutants. Heavy and light vehicles are the major sources of CO in the mine. All vehicles and their exhausts would be well maintained and regularly tested for pollutants concentration.

8.4 CONTROLLING NO_x LEVELS

NO_x emissions in the mine mainly occur during blasting operations. The main reasons for NO_x emissions are:

- poor quality of explosives having large oxygen imbalance. This may be due to:
  - manufacturing defect; and
  - use of expired explosives in which ingredients have disintegrated.
- incomplete detonation, which may be due to low Primer to Column ratio.

To ensure low NO_x levels following control measures would be adopted:

- use of good quality explosives having proper oxygen balance with regular monitoring;

- regular updating of the date of manufacture / expiry to avoid confusions. A normal procedure should be formulated to check / visually inspect all explosives, and if disintegrated ingredients are spotted, the explosives won't be used, even if the date has not expired; and
- the Primer to Column ratio would be rationalised so as to produce minimum NO_x.

8.5 GREENBELT

Even with the various dust suppression measures in place, dust generated from mine faces, fine dust produced during blasting operations are difficult to control. Therefore, in addition to the above mitigative measures, it is proposed to have dense green belt in and around the mine site, crushing, loading and unloading facilities, corridor of belt conveyor route and mine colony and in abandoned mine area during reclamation process. Width of the greenbelt will be on the eastern and southern sites of lease area 50 m (7.5 m within ML area and 42.5 m outside ML area) and 100 m (7.5 m within ML area and 92.5 m outside ML area) respectively.

It is expected that plants with 10, 20 and 30 m height can reduce dust pollution by 50, 70 and 80% respectively. A combination of these would be planted depending on the requirements and the extent of the problem.

8.6 OCCUPATIONAL HEALTH & SAFETY MEASURES TO CONTROL DUST INHALATION

All the above precautions would be adopted to prevent dust generation at site and to be dispersed in the outside environment. However, for the safety of workers at site, engaged at the strategic locations / dust generation points like drills, loading & unloading points, crushing *etc.*, dust masks would be provided. Dust masks would prevent inhalation of RSPM thereby reducing the risk of lung diseases and other respiratory disorders. Regular health monitoring of workers and nearby villagers in the impacted area (~1 km from the core zone) should be carried out by LMMPL.

8.7 NOISE POLLUTION CONTROL

The ambient noise level monitoring carried out in and around the proposed mine shows that the ambient noise levels are well within the stipulated limits of CPCB.

Within an operational mine, major noise sources are operation of mine machineries and equipment, blasting, crushing units and belt conveyor. Noise generation may be for an instant, intermittent or continuous periods, with low to high decibels.

To keep noise generation in control, latest sophisticated technology and equipment have been considered. Drills, loaders, dumpers etc with larger capacities should be acquired to reduce the number of operational units at a time, thereby reducing the noise generating sources.

The equipment systems will include cabins to ensure that the operators and other work persons, in and around the operating equipment, have comfortable

work stations. To keep the ambient noise levels within the permissible limits of 65 dB(A), the following measures should be adopted:

- innovative approaches of using improvised plant and machinery designs, with in-built mechanism to reduce sound emissions like improved silencers, mufflers and closed noise generating parts;
- procurement of drill, loaders and dumpers and other equipment with noise proof system in operator's cabin;
- confining the equipment with heavy noise emissions in soundproof cabins, so that noise is not transmitted to other areas;
- regular and proper maintenance of noise generating machinery including the transport vehicles and belt conveyors, to maintain the noise levels;
- blasting operations to be carried out only during daytime so as to avoid high noise intensity in night time;
- siting of mine colony, buildings and other infrastructure away from the noise sources with the probability of sound waves being directed towards them being least;
- provision should be made for noise absorbing pads at foundations of vibrating equipment to reduce noise emissions; and
- thick green belt should be provided at the mine periphery, within the mine lease area along the roads and all around the working areas, to screen the noise.

Phlangkaruh village is the nearest habitat located at about 0.7km away from the ML area. The noise generation from the mine will therefore be matter of concern to the inhabitants. It is recommended that green belt should be developed along the corridor of conveyor route.

8.8 OCCUPATIONAL HEALTH AND SAFETY MEASURES TO CONTROL EXPOSURE TO NOISE

To protect the workers from exposure to high levels of noise, following measures would be adopted:

- provision of protective devices like ear muffs / ear plugs to workers who cannot be isolated from the source of high intensity noise, e.g. blasting;
- confining the noise by isolating the source of noise as discussed above; and
- reducing the exposure time of workers to the higher noise levels by shift management.

8.9 CONTROL OF GROUND VIBRATIONS & FLY ROCKS BOULDER

Ground vibrations due to blasting and its impact on various mine structures, should be studied in details when the mine becomes operational, especially the charge per delay factor. Drilling and charging pattern should accordingly modified based on this study. Thereafter, a proper management plan should be designed and administered. General measures to reduce ground vibration & flyrocks resulting from blasting are given below:

- Peak particle velocity or ground vibrations for safety of nearby structures and residential buildings should be well within 12.5 mm / sec;

- to contain fly rocks, stemming column should not be less than the burden of the hole, and the blasting area should be muffled;
- short delay detonators should preferably be used in blasting rounds rather than detonating fuse as trunk line;
- detonating fuse, if used, should be covered at least with 150 mm thick cover of sand or drill cuttings.;
- blasting should be carried out in the daytime, as during the night time the sound intensity becomes higher;
- blasting should not be carried out when strong winds are blowing towards the inhabited areas;
- each blast should be carefully planned, checked, and executed under the supervision of a responsible officer. Blasting data / observations should be recorded; and
- *Bruggs mesh* shall be provided as and when required for arresting any fly rocks and boulders from mining operation as shown in *Figure 8.1A & 8.1B.*

As per the mining plan, in order to ensure slope stabilisation, controlled production blasting shall be adopted to avoid tension cracks and back breaks. Such cracks may get filled with water, which reduces the stability of excavated slopes and the angle of slopes.

8.10 WATER QUALITY MANAGEMENT

8.10.1 Water Resources

The daily water requirement for the mine operations would be approximately 150 m^3 / day (100 m^3 / day for mine area and 50 m^3 / day for the township proposed to be approximately 2 km southeast of the mine area). The water for mine area and township is to be sourced from the Phlangkaruh river and stored in an overhead tank provided at each of the locations.

The generation of wastewater from the mine operations is expected to be approximately 50 m^3 / day which will be treated in the Effluent Treatment Plant (ETP) provided at the mine location and will be reused for spraying on the haul roads and development of green belt.

The generation of domestic wastewater from the township will be approximately 40 m^3 / day, which will be treated in the Sewage Treatment Plant (STP) provided near the township. The treated domestic wastewater will be used in plantations.

The details of proposed treatment for wastewater from mines and colony are given in the following subsection.

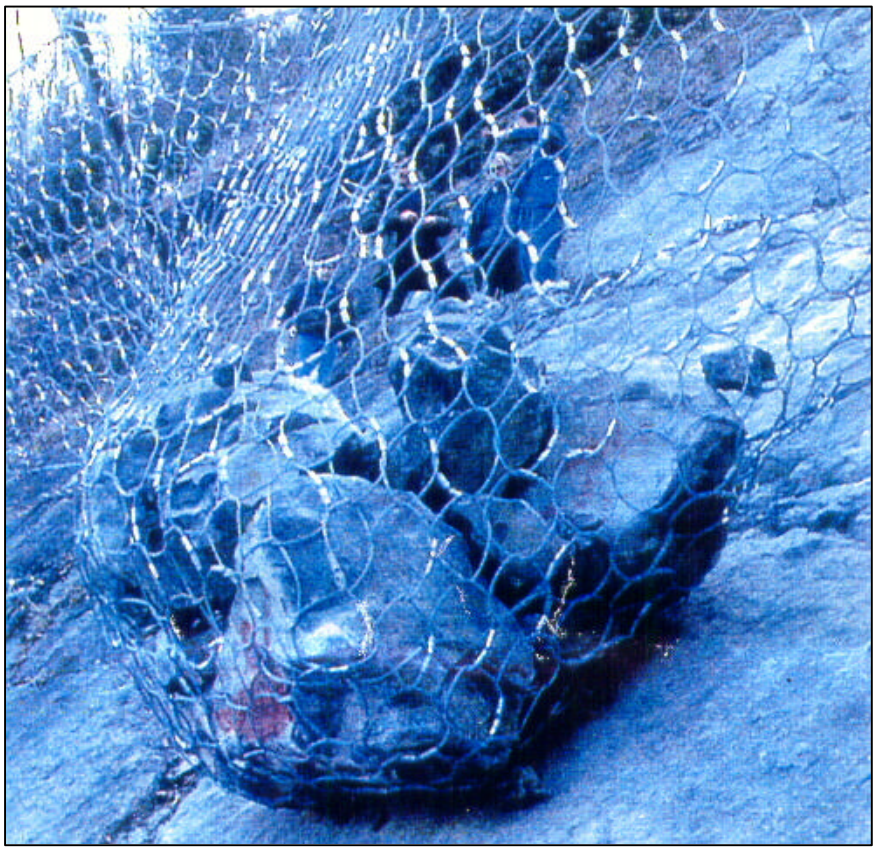


Figure 8.1B: Proposed Brugg mesh for protection from fly rocks and boulders

Figure 8.1A: Proposed Brugg mesh for protection from fly rocks and boulders

8.11 EFFLUENT TREATMENT/MANAGEMENT

8.11.1 Effluent Treatment/Management

Wastewater from mines

The wastewater generation is likely to be of the order of 50 m^3/day from the workshop, crushing plant, floor washing and domestic uses. The wastewater will be led to pass through a bar screen followed by oil trap where oil content of wastewater will be recovered. From oil trap wastewater will pass through sedimentation tank followed by Activated Sludge Process (ASP) comprising of aeration tank provided with low HP surface aerators and sludge re-circulation system. In the aeration tank, wastewater will be treated with the help of bacteria provided with sustained regular dosing of nutrients in the form of DI-ammonium phosphate. The wastewater from aeration tank will pass through clarifier for settling of the solids. The treated water will then be used in watering the green belt. The so treated wastewater be subjected to maximum reuse /recycling.

The treated wastewater will contain BOD less than 30 mg/L and total suspended solids less than 100 mg/L and will be reused for spraying on the haul roads and development of green belt. The left over treated wastewater if any will be discharged into nearby water body.

Wastewater from Colony

The wastewater generation is likely to be about 40 m^3/day from the township of about 20 families. Wastewater from individual houses will be led to septic tanks. Four to five septic tanks' overflow will be led to a soaking pit. The waste overflow water from the soaking pits will be led by underground drainage pipes to a sewerage treatment plant (STP). The sewage water is expected to consist of suspended (floating matter) and dissolved organic matter, which is biodegradable. The proposed STP's philosophy is a bar screen to trap large floating particles, an equalisation tank to take care of the flow fluctuations followed by a Activated Sludge Process (ASP) based treatment. The ASP will comprise of:

- an Aeration Tank where wastewater will be treated with the help of bacteria provided with sustained regular dosing of nutrients in the form of DI-ammonium phosphate;
- Low HP surface aerators to maintain required oxygen content in the Aeration Tank;
- Conical Clarifier for settling of impurities of wastewater from Aeration Tank; and
- Sludge Recirculation System to maintain proper Food: Micro-organism (F:M) ratio in the Aeration Tank.

The quality of outlet of the STP is expected to contain BOD content in less than 30 mg/L and total suspended solids less than 100 mg/L and will be reused in watering the green belt.

8.12 WATER MANAGEMENT

Following measures will be adopted to mitigate the impact on the water resources:

- the blasting activities will have to take care on the sinkholes, cracks and fissures in the site activities.
- during excavation and drilling activities effort must be taken to avoid face collapse at these cracks and fissures.
- to prevent surface water contamination by oil / grease, leak proof containers shall be used for storage and transportation of oil / grease. The floors of oil / grease handling area will be kept effectively impervious. Any wash off from the oil / grease handling area or workshop will be drained through impervious drains, collected in specially constructed pit and treated in the ETP appropriately before releasing for final discharge.

To prevent degradation and maintain the water quality during rainy season, adequate control measures should be adopted to check the mine run-off into the natural streams. Following control measures are proposed to be adopted:

Catchment Area Treatment Plan

A catchment area treatment plan has been developed keeping in mind the results of the hydrology / hydrogeology study as well as the climate data. As there are no perennial water sources running on or through the site, the mine water discharge is limited to the monsoon season only. To keep water from entering the mine during this period, a series of independent and un-linked garland drains will be developed along the mine's top bench (except south), which will bend to guide the water to the nearest natural surface drain. Bunds will also be provided. In order to prevent infiltration downwards, blasted materials will be distributed and compacted on the platforms as they progress and appropriate drains will be provided.

In terms of water quality, good mining practices planned, as well as the natural state of surrounding areas, should ensure that rain water run-off from the mine does not contain any toxic elements. As the site has no overburden or excess clay, potential discharge of sediments is quite limited and any residual clay or limestone particles which are washed down will be captured by a sump located at the lowest bench. Any karst features in the sump area will be plugged to prevent infiltration, and the clear water will be decanted into the nearest garland drain and hence the Phlangkaruh. The sump will be cleaned regularly and discharge water monitored consistently. If required, based on monitoring, an additional catch pit can be located at the main garland drain.

Garland Drains

The mine catchment area will gradually increase to 30 hectares at the end of five years and to 90 hectares at the end of 53 years. The sump proposed in the bottom bench will be designed based on the peak discharge and will be expanded over a period of time to accommodate the increasing quantum of water discharge. Presently, the capacity of the sump is designed to hold the

entire quantum of peak discharge water for more than 10 minutes. Depending on the silt load, the sump can be modified both in shape and size to arrest the silts more effectively. As the mining operations go deeper, concurrently, the size, gradient and the length of the garland drains will also undergo modifications. The main garland drain so designed will terminate at 50m RL. From here on the water will be allowed to join the Phalangkaruh through the existing natural drainage. Design parameters for main garland drain at the end of five years and at the end of the life of the mine are given in *Table 8.1:*

Table 8.1: Garland Drain details

Period	Depth of channel	Bed-width of channel	Bed slope of channel	Channel length of main garland drain
At end of five years	0.75 m	1.4 m	~ 1 in 30	~ 2,000 m
At end of life of mine	1.2 m	2.6 m	~ 1 in 50	1,600 m

Check dam and siltation pond need to be constructed of appropriate size to arrest silt and sediment flows from soil and mineral dumps. The water so collected should be utilised for watering the mine area, roads, green belt development etc. The drain should be regularly desilted and maintained. The garland drain (size, gradient and length) and sump capacity should be designed keeping 50% safety margin over and above the peak sudden rainfall and maximum discharge in the area adjoining the mine site. Sump capacity should also provide adequate retention period to provide proper settling of silt material.

The belt conveyor will be properly covered and maintained leak proof to prevent spillage of material during rains.

The sewage waste will be drained by underground impervious drains to an appropriately designed sewage treatment plant to prevent any pollution of surface or ground water.

The surface water around the mine, crushing/loading plant and infrastructure will be regularly tested and appropriate control measures adopted in case of any pollutant is detected above the prescribed limits.

8.13 LAND MANAGEMENT

Land degradation is one of the major adverse impacts of opencast mining in the form of excavated voids and also in the form of waste dumps. Land reclamation plan must, therefore, be implemented simultaneously with the mining activities.

8.13.1 Land Reclamation

One of the requirement of MMRD Act, 1957 is to ensure simultaneous reclamation of land along with other mining operations. To reduce the time gap between land excavation and reclamation, yearwise program of excavation including limestone, top soil and OB has to be charted out. The current landuse within the mine area and the final elevation after excavation of the limestone reserve is anticipated to be an elevation difference of 90 m RL.

Land degradation is one of the major adverse impacts of opencast mining. Any effort to control adverse impacts would be incomplete without an appropriate land reclamation strategy.

The first step in a successful reclamation programme is to decide the post reclamation land use. In this case it is considered appropriate to convert the land under a cover of dense vegetation, keeping in view the following:

- The area being rich in vegetation, further plantation would match with the existing environment; and
- Trees absorb CO_2, contribute oxygen, purify the air, conserve the soil and prevent its erosion. Trees promotes precipitation and add to stabilisation of slopes.

Keeping the above in view, the land reclamation shall be carried out with an emphasis on plantation. At any point of time the area under disturbance shall be kept at minimum. This shall be achieved by ensuring reclamation of excavated area concurrently with mining activities by reducing the gap between the first damage (mining) and the first repair (reclamation) to the bare minimum.

The disturbed land including area disturbed due to excavation, dumping, construction of haul roads, ramps, structures etc. would be fully reclaimed before finally abandoning the mine. The reclamation process shall take:

- One year for grading and top soil spreading; and
- Another four years for landscaping and stabilisation of plantation.

Thus the area shall be fully reclaimed within five years of completion of mining operations.

During post mining period, in the mine area all the disturbed areas will be reclaimed before decommissioning / abandoning the mine, excluding the buildings meant for garages, office, magazine etc; which will be left as such to be later used as social infrastructures (school, health centre, etc) by the population in the vicinity. The colony will remain as such to be used by the surrounding population. The belt conveyors, crushing plant and material handling system will be dismantled and reclaimed.

Soil Conservation Measures

Top soil, if any will be properly stacked at earmarked dump site with adequate measures and the same will be used for reclamation and rehabilitation of the

mined out areas.To prevent soil erosion and wash-off of dump-fines from freshly excavated benches and dumps following measures shall be adopted:

- garland drains will be provided around the mine wherever required to arrest any soil from the mine area being carried away by the rain water;
- Toe drains with suitable baffles will be provided all along the toe of the soil dumps to arrest any soil from the dump slopes being carried away by the rain water;
- special local stone paved chutes and channels will be provided, wherever required, to allow controlled descent of water, especially from the top of the slope along to the foothills;
- bench levels will be provided with water gradient against the general pit slope, to decrease the speed of storm water and prevent its uncontrolled descent.
- gully formations, if any, on sides of the benches shall be provided with check dams of local stone or sand filled bags. The inactive slopes will be planted with bushes, grass, shrubs and trees after applying top soil to prevent soil erosion;
- loose material slopes will be covered by plantation by making contour trenches at 2 m interval to check soil erosion both due to wind and rain;
- retaining walls (concrete or local stone) will be provided, around the stockpile or wherever required, to support the benches or any loose material as well as to arrest sliding of loose debris.

8.14 AFFORESTATION PLAN

The Afforestation (Restoration) plan has been prepared keeping in view the land use changes that will occur due to mining operation in the area. The objectives of the restoration plan are to:

- reclaim the mined out areas by planting trees which are indigenous in nature;
- provide a green belt around the periphery of the mining area to combat the dispersal of dust in the adjoining areas;
- protect the erosion of the soil;
- conserve moisture for increasing ground water recharging;
- restore the ecology of the area;
- restore aesthetic beauty of the locality; and
- meet the requirement of fodder, fuel and timber of the local community.

8.14.1 Selection of Appropriate Species

Species have been selected and restoration programme developed in order to ensure a diverse and robust polyculture forest, which will be developed after mining. Species that are native to the area have been given preference. At the same time the species which have dust tolerance have also been focused on; growth rates of the species have also been considered, as the area needs to be covered very quickly. The area is also full of lime stone and will be uneven after completion of mining, and the base is likely to have residual lime stone and be devoid of any top- soil and nutrition. As such the species which can survive in such adverse conditions have been selected.

After considering all the aspects stated above, the following species are recommended to be planted in the area in phased manner, according to availability of land, on completion of mining of lime stone at various stages as given in ***Table 8.2*** (All the species recommended are selected from indigenous flora.).

Table 8.2 Selected Species

Scientific Name	Local Name
Trees	
Alstonia scholaris	Chhatian, Lazarong pantong
Albizzia procera	Haya
Albizzia odoratissima	Haya, Maklong
Artocarpus chaplasha	Dewasali
Artocarpus heterophyllous	Belang; Deing-soh-pham
Bauhinia purpurea	Megong; Rabert
Chukrasia tabularis	Chikrashi
Duabange grandiflora	Luaipap
Gmelina arborea	Pang-band; Phang-araung
Erythrina arboresceus	Bogamodar; Deing sang
Michelia champaca	Champ; Leihao-peisang
Sterculia villosa	Jinge-kaung; Kanthlyen-kung
Tetrameles nudiflora	Orang-phop
Tonna ciliata	Poma
Areca catechu	Betel nut
Bamboos	
Dendrocalamus hamiltonii	Hiku
Bambusa khasiana	-
Shrubs	
Holarrhena antidysenterica	Bol-matra, Dudhkhuri
Grass	
Thysonolena maxima	Amliso

8.14.2 Availability of Area for Restoration

Total area available for the limestone mine is 100 hactares with the following break up details:

Table 8.3 Break up of the Mining Area

Break up details		Area in Hectares
Dump Storage	:	1.5*
Roads	:	4.5
Safety Zone Area on 7.5 m along the Northern & Western Lengths	:	1.5
Initial Green Belt in side the mine site along Eastern & Southern Lengths	:	1.5
Sink Hole Protected area falling within the Mine site (excluding 0.5 ha of area overalapped by southern green belt)	:	1.5
Mined Out Area	:	89.5

Note: The ultimate mining area will be 91 Hectares including 1.5 area used for Dump Storage

Once the site is mined out, the total area available for the afforestation would be as per the following details:

Table 8.4 Area Available for Afforestation

Break up details		Area in Hectares
Total Mined Out Area	:	91
Area under afforestation as part of Green Belt in the Easteran & Southern Lengths	:	1.5
Safety Zone Area to be put under afforestation once site is mined out (i..e. 5 m all along the northern & western lenghts)	:	1.0
Total Area Available under Afforestation	:	93.5

It is to be noted down that the area under twin-sink holes immediately south west of the mining area having rich flora is proposed to be protected by 100 m. With the result the total area under sink holes & its protection sums up to 7 hectares of which 2 hectares falls within the within and rest outside the ML area.

Thus for the post-mining scenario, the area distribution will be as under:

Table 8.5 Details of Post - Mining Area

Break up details		Area in Hectares
Total area to be put under afforestation	:	93.5
Roads	:	4.5
Sink holes (other than 0.5 ha overlapping by southern green belt inside the mine area)	:	1.5
Area kept unused on northern and western lengths (i.e. 2.5mx1000x2): and 0.5 ha	:	0.5
Total Area	**:**	**100.0**

The approved mining plan notes that, up to the end of 25th year, 11.73 ha of land is available for afforestation from the years 1st, 10th, 20th and 25th year while 74.77 ha is said to be available at the end of 53 rd year. It is presumed that some area will be available in between the period from 25th to 53rd years and as such small areas of 12.97 ha have been proposed to be afforested at 30th, 35th, 40th, 45th year. The balance area of 61.80 ha are proposed to be planted in the 53rd, 54th and 55th years as it will be difficult to raise plantation on such a vast area during one year.

The northern and western portion of the mine areas are currently have good vegetation with 20-30% crown density while the eastern and southern portion are having density of 10-20%. A green belt is proposed to be developed on the eastern side for mine lease to a width of 50 m (7.5 m within lease area and 42.5 m outside lease area) and on southern side to a width of 100 m (7.5 m with in lease area and 92.5 m out side lease area).

Further in the colony area, afforestation is to be done with ornamental and shade tree species viz. *Michelia champaca, Bauhinia purpurea, Alstonea scholaris,*

etc. and fruit species viz. *Areca catechu, Artocarpus heterophyllus.* Additional afforestation will also be done as per the following details:

Table 8.6 Details of Afforested area outside the ML area

Details		Area in Hectares
Green belt outside the mine area	:	13.50
Afforestation in the colony area along road sides, house premises, parks, etc.	:	2.0
Afforestation in the other nearby area	:	2.4
Total Area	**:**	**17.9**

According to the approved mining plan the area which will be available for afforestated at various stages of the mining operation are given below (***Table 8.7***).

Table 8.7 Area available for Afforestation

MINING AREA				Green belt	Colony	Total area
At the end of the year of mining	Area available for afforestation (ha)	To be taken up for afforestation at the year of mining	Area to be taken up for afforestation (ha)	Area (ha)	Area (ha)	At different year (ha)
01	3.50	3	3.50	6.50	1.00	11.00
-	-	4	-	7.00	1.00	8.00
-	-	4	-	2.40	-	2.40
10	3.63	12	3.63	-	-	3.63
20	2.20	22	2.20	-	-	2.20
25	2.40	27	2.40	-	-	2.40
30	2.42	32	2.42	-	-	2.42
35	2.45	37	2.45	-	-	2.45
40	2.65	42	2.65	-	-	2.65
45	2.65	47	2.65	-	-	2.65
50	2.80	52	2.80	-	-	2.80
51	20.00	53	20.00	-	-	20.00
52	20.00	54	20.00	-	-	20.00
53	21.80	55	21.80	-	-	21.00
Total	**86.50**		**86.50**	**15.90**	**2.00**	**104.40**

As given in the ***Table 8.3***, 91 ha of mined out area will be available after the mining is over of which 86.5 ha of area will be afforested in phased manner as given in the ***Table 8.6*** and rest of the area will be afforested at the time of mine closure, thus summing up total area to be put under afforestation as 93.5 ha. of 100 ha.

8.14.3 Nursery

As there is no Forest Department nursery in the area hence there is no possibility of obtaining the desired seedlings. As such, a nursery is proposed to be established by the LMMPL. Land for nursery is being already negotiated at three different areas around the proposed project area.

An area of 0.3 ha will be sufficient for the required nursery. The area should be as close as possible to the plantation site. On the other hand, a source of water

for watering the seedlings is an essential criteria. Attempts should be made to create an earthen dam near by or within the mining lease area to store the water, where the nursery is to be located. The stored water in the earthen dam will be utilised in watering the plantation seedlings during the dry period of the year. If it is not feasible to create the earthen dam the nursery may be located down on the bank of river Phalgkurgh . The following key points will be considered for proposed afforestation programme:

Seed

For successful afforestation, good nursery stock is essential. For this purpose good matured seeds from genetically superior trees are required. Seeds will be collected mostly from the Forest Department and if some seeds are not available with them, then those are to be collected from the reputed seed suppliers. A time schedule is to be followed according to the availability of seeds, as per their maturity and viability.

Seedlings

Two years old fall seedlings are to be planted for afforestation. For this purpose polythene tube of size 22.5cm x 15cm with thick gauge is to be procured and the seedlings are to be raised in the polythene tubes after filling the same with imported good earth and cowdung manure in 3:1 proportion.

Small sized Seeds

For small sized seeds (e.g. *Alstonia*, *chukrasia spp*), the seeds are to be sown in mother beds after pre-treatment and to be picked out in polythene tubes, while the bigger seeds are to be dibbled in the polythene tubes directly.

Weeding, Cleaning and Howing

Weeding, cleaning, howing of seedlings and application of oil cake are to be done occasionally to boost up the growth of the seedlings. Soaking, shifting and culling of seedlings to be done to avoid penetrating the root in the nursery soil and to get the seedlings of uniform height.

At least one permanent semi-skilled staff is to be recruited beside casual staff, and maintained for upkeepment of the nursery at the project cost.

8.14.4 Plantation Technique

Soil Work

The mine-area is almost devoid of any topsoil. Hence the soil will not be available after mining. Further, after mining, it is expected that the excavated area will be having some lime stone block.

The excavated area left out after mining is to be terraced and contour bunding is to be done with the rubbish (stone dust) and boulder particles at the site preferably at 10m interval. Planting pits of size 45 cm x 30 cm at the top, 30 cm x 30 cm at the bottom and 45 cm deep are to be dug at 2 m apart lines and 2.5 m

apart in line in staggered manner. No pits should be dug along contour bund which will be used for sowing seeds and planting broom stick shrubs and bamboos. As the area is expected to be full of lime stone in the bottom strata, the help of drill machine may be resorted to in some cases, where it is not possible to dig the planting pits manually. The planting pits are to be filled up with good imported earth mixed with cowdung in 3 : 1 proportion. If it is difficult to procure cowdung, then sane may be replaced by leaf compost, which may be prepared at the nursery site.

Planting Pattern

Contour bund made after terracing will be planted with Root stalk of *Thysonella maxima; Holarrhena antidysenterica* are to be planted along contour bund at 1 m apart. Rhizomes of *Bambusa* sp. */ Dendrocalamus hamiltonii* are to be planted along the contour bund at 10 m apart. Seeds of Chukrasia may also be sown along the contour bund.

The tall seedlings (2 years. old) raised in the nursery are to be planted in the planting pits at the ontset of monsoon. The species should be planted with suitable design as per nursery stock. Planting should be completed by the month of May. Replacing of casualities should be done as and when vacancy occurs.

Tending Operation

During first year, 100 grams of chemical fertilizer should be applied to each plant in two doses while 1st and 2nd weeding, cleaning and mulching is done after one month interval of planting. 3rd weeding, cleaning and mulching without chemical fertilizer is also to be done after two months of 2nd mulching in the first year. Protection of seedlings against grazing is to be done by providing watch & ward personnel. Fire protection measure is to be taken during dry season. Plantation is also to be irrigated by laying a water pipe line from the identified water source with the help of a pump once in a week during dry season from November to April.

During the 2nd year replacing casualities are to be done again. Weeding, cleaning and mulching is to be done two times during the year (during the months of June and September). Protection against grazing, fire and system of irrigation should be continued as has been recommended for the 1st year.

During 3rd year of plantation weeding and mulching of seedlings are again to be done twice (June & September). Fire protection measures are to be taken from November to April.

During 4th and 5th year fire protection measure is to be taken from November to April.

All the plantation and nursery works are to be done under the direct supervision of a senior and experienced forest ranger, who may be put on deputation from the State Forest Department.

8.14.5 Protection of Afforested Area

The afforested area needs to be protected from cattle menace, soil erosion, plant diseases etc. Check bunds, masonry chutes, protected drains etc will be formed to prevent soil erosion and washing away of nutrients alongwith the run-off. Plants will be sprayed with pesticides to protect them from diseases. Soil working, maturing etc will be done whenever necessary. Plants will be protected from cattle menace by proper watch and ward or fencing.

8.15 SOLID WASTE MANAGEMENT

The mine being devoid of overburden and some clay being restricted only in the crevices, the quantity of clay expected to be almost negligible. Approximately 0.1 to 0.15 tpd of sludge from the treatment of wastewater will be generated from the activated sludge process based wastewater. This sludge is anticipated to be rich in nitrogen and phosphorous and can be utilised as manure for the plantations.

Solid waste generated from sewage treatment plant treating residential and industrial areas will also be dumped in the waste dump area. Domestic solid wastes includes kitchen waste, plastic packets, sanitary napkins, vegetable residuals, fish scales / bones etc. from the proposed mine site colony. The colony will contain approximately 20 families. Considering 5 persons per family and each person will generate 0.4 kg of solid waste per day, i.e. 2 kg per family per day. This will result in generation of 40kg solid waste per day. This solid waste will be disposed off through local municipality.

Other industrial solid wastes include solid wastes from maintenance shop Solid wastes from maintenance shop include cotton waste, plastics, used gloves, filters, used non-metallic parts etc. which will be disposed off through local municipality.

8.16 MEASURES TO REDUCE VISUAL INTRUSION

As already mentioned, the system of mining, transport and equipment selection will be decided based on environmental considerations and also to ensure that visual intrusion will be minimum. However, following control measures are recommended to be adopted to reduce it further visual intrusion:

- thick tree belts will be planted along the roads on the periphery of the excavation;
- the virgin areas around the excavation will be afforested to improve the scenic value; and
- the equipment and structures (facilities) which may be visible from a distance will be coloured in such a way, that they merge with the background.

8.17 DISASTER MANAGEMENT PLAN

The mining operation shall be carried out under the management control and direction of a qualified mines manager holding a first class manager's certificate of competency to manage a metalluferous mine granted by Director General of mines safety (DGMS), Dhanbad. DGMS have been issuing a number of standing orders and circulars to be followed by the mine management in case of disaster, if any. Moreover mining staff would be sent to refresher courses from time to time to keep them abreast of the regulations. However following natural / industrial hazards may occur during normal operation:

- slope failure at the mine faces;
- accident due to explosives;
- accident due to heavy equipment / machinery;
- sabotage in case of magazine; and
- accidents due to fly rocks and boulders.

In order to take care of above hazards / disasters, the following control shall be adopted:

- all safety precautions and provisions of Metalliferous Mine regulation 1961 are strictly followed during all mining operations;
- checking and regular maintenance of garland drains and earthen bunds to avoid any inflow of surface water into mining area;
- entry of unauthorised persons shall be prohibited;
- fire fighting and first aid provisions in the mines office complex and mining Area;
- provision of all the safety appliances such as safety boots, helmets, goggles etc. would be made available to the employees and regular check to ensure the use;
- training and refresher courses for all the employees working in the hazardous premises;
- working of mine as per approved plan, related amendments and other regulatory provisions;
- cleaning of mine faces shall be done regularly;
- handling of explosives, charging and blasting shall be carried out by competent persons only;
- provision of magazine at safe place with fencing and necessary security arrangement;
- suppression of dust on the haulage roads;
- awareness of safety and disaster through competitions ,posters and other similar drives;
- *Bruggs mesh* shall be provided to arrest any fly rocks and boulders from mining operation as shown in *Figure 8.1A & 8.1B.*

8.18 HEALTH AND SAFETY

Health and safety aspects of the mine will be taken care off as per the World Bank (WB) guidelines on open pit mining. The guidelines provide the detailed information on the aspects that are required to be taken into account for maintaining proper health and safety issues.

The workers continuously exposed to dust will be provided with some protective devices like dust mask to prevent respiratory disorders. The workers continuously exposed to a high noise will be provided with ear muffs / ear plugs. Green belt in and around the mining area will be developed to attenuate noise and dust impact.

The blasting carried out in the mine area will be carefully planned and executed under the supervision of a responsible officer, to avoid any accidents. The protective devices will be provided to the employees handling hazardous substances. Proper handling of the hazardous chemicals and the maintenance of Material Safety Data Sheet (MSDS) will be followed to ensure safety within the mine.

Drinking water supply for the employees and to the proposed colony will be provided by the project authority. The standard of the drinking water will be per WHO guidelines.

Proper sanitary facilities will be taken care by the project authority so that employees do not suffer from any health ailments. The employees will be made aware of general sanitary practices.

Periodical training programme to inform the employees about their task, associated risk, and safe working practices will be undertaken. Training will also include information on accident prevention, proper control and maintenance of equipment and safe material handling practices.

A regular monitoring of the Occupational Health and Safety will reduce the chances of accidents in the mine. Records of job related accidents and illness should be maintained per the requirements stated in the WB guidelines. These informations will be reviewed and evaluated to improve the effectiveness of Environmental Health and Safety programme.

8.19 ENVIRONMENTAL MANAGEMENT SYSTEM

LMMPL will adopt environmental management system (EMS) which will assist mine management to meet both current and future environmental requirements and challenges. EMS will provide a structural view and control of the organisation's environmental performance that will be applied from planning and exploration to mine closure.

The following components are being taken to establish an EMS:

- Organisational Commitment;
- Environmental Policy;
- Resettlement & Rehabilitation (R&R) Policy;
- Environmental Impact Assessment;
- Community Consultation;
- Objectives and Targets;
- Environmental Management Plan (EMP);
- R&R Plan;
- Community Development Plan / Indigenous People's Development Plan;
- Documentation;
- Responsibilities and Reporting Structure;
- Training;
- Environmental Review Audits; and
- Emission and performance monitoring.

LMMPL will prepare a detailed reclamation and mine closure plan of mine operation prior to commencement of the mine operation.

LMMPL will follow a comprehensive and systematic health and safety function which involves all personnel seeking to identify hazards and assessing risk to prevent and eliminate all accidents / injuries. A basis will be evolved for identifying and correcting unsafe practices and conditions, monitoring safely performance and recognising results.

LMMPL will follow National Occupational Safety Association (NOSA) standard, which is pro-actively and successfully utilised by numerous companies throughout the world including mining operation. The key components on NOSA standard are :

- Premises and Housekeeping;
- Electrical, Mechanical and Personal Safeguarding;
- Fire Protection and Prevention;
- Accident Recording and Investigation; and
- Safety Organisation.

In future LMMPL may follow ISO-14000 standard ostensibly being designed for corporate environmental management system.

8.20 SOCIO- ECONOMIC DEVELOPMENT

The project is integrated with the run-of-mine transfer system to Bangladesh through conveyor belt. The impacts of the mining project on socio-economic conditions of the people of surrounding villages are assessed based on interactions with LMMPL or its representatives. It is anticipated that the project would bring following benefits to the people of the Nongtrai and surrounding villages:

- Generation of employment and improved standard of living;

- Establishment of small and medium scale engineering ancillaries, agro based industries with cascading employment opportunities;
- Increased revenue to the state by way of royalty, taxes and duties;
- Improved green cover;
- Superior communication and transport facilities etc.

In addition to above, due to increase in purchasing power of local habitants, there shall be significant change in the socio-economic scenario of the area. The details of the potential benefits due to the project are discussed in the following sub sections:

8.20.1 Compensatory Arrangements

Mine and Other Related Areas

The land for the mine site and related areas is being leased to LMMPL for 35 years by the Nongtrai village, which owns the mine site and surround land. The compensation arrangement for LMMPL is to give the Nongtrai village council (locally known as *Durbar*) Rupees 5/- per tonne of limestone exported from the mine site. Based upon of 2.0 million tonnes per annum of limestone exported (i.e. 7,000 tonnes per day), it is estimated that the village *Durbar* will receive Rupees 10 million per annum.

The *Durbar* with the assistance of the socio-economist decided to allocate 30% of the income stream generated from the mine to community based projects such as education, health and infrastructure projects. The remaining 70% will be distributed equally among the households of Nongtrai village. The compensation arrangements will significantly increase the household income of the villagers and the social infrastructure of the village.

There are 137 households in the Nongtrai village as per the survey done in September 1999. Therefore, each year for the lifetime of the mine, approximately Rs 3.0 million will go to the community projects and approximately Rs 7.0 million will go for distribution to the households. With the distribution among 137 households, the Nongtrai villagers will get additional income of Rs 51,000 per year from the project. This income is comparatively double of the present average income of the villagers of approximately Rs 20,000.

The royalties will therefore, have significant benefits to the household income of those residing in the village and the funds available for community based infrastructure and service projects. The community will need to manage entry to the village to control newcomers coming and setting in the village and benefiting from the future income stream.

LMMPL has already submitted a security deposit to the *Durbar*. This is already earning interest, which is financing the salary of teachers in the two existing primary schools in the village.

LMMPL will also pay royalty to the District Council at a rate of Rs 32 per tonne of limestone exported *i.e.* Rs 64 million per annum, which the District Council can invest regionally.

Besides, LMMPL will also pay tax to Meghalaya Government as applicable from time to time.

Corridor Area for Conveyor Belt

The land required for the corridor for the belt conveyor belongs to 55 families comprising of total 423 family members within the Indian Territory as per the details given in ***Table 8.8.***

Table 8.8: Affected Families en-route Corridor of Belt Conveyor

Sl. No.	Village	Number of affected families
1	Village Nongtrai	3
2	Village Shella	49
3	Village Nongwar	2
4	Village Tyngnger	1

Total land required for the corridor of belt conveyor is 26.6 ha with approximately 33% being used for cultivation of paddy & vegetables, 11% for bamboo cultivation and rest representing bush, scrub and river sand area.

The estimated cost of corridor for belt conveyor land is approximately Rs 4.4 million. The price proposed to be paid to the affected families by the project proponent will be Rs. 70,000 to 80,000 per acre for agricultural / bamboo cultivation land and for the rest it would be Rs 50,000 to 60000 per acre. The compensatory cost will also be in terms of social welfare assistance for the affected people. There will also be annual monitory benefit to the affected families for the corridor land by way of disbursement of Rs 1.0 million per annum.

8.21 SOCIO ECONOMIC WELFARE ASSISTANCE

The proposed project shall enhance the prospects of employment. Recruitment for the unskilled and semiskilled workers for the proposed project will be from the nearby villages. The development of the basic amenities viz. roads, transportation, electricity, drinking water, proper sanitation, educational institutions, medical facilities, entertainment, etc. will be developed as far as possible.

As described above, the village Nongtrai will spend 30% of its revenue generated from the project on community developmental projects like education, health and infrastructure. Besides, these, LMMPL will also extend following facilities to the villagers in the surrounding areas:

8.21.1 Employment Opportunities

LMMPL wishes to generate benefits to the people as it recognises that in general the local households have low incomes. LMMPL will therefore, attempt to use local labour, wherever possible, to work for the project. There will be certain unskilled positions such as night guards, cleaners, and labourers for road construction. In addition, semi skilled work force for drivers and machine operators will also be employed from the local areas. Labourers from Nongtrai and Shella villages will be given equal priority for application for employment. However, skilled work force to the extent not locally available will be brought from outside the local areas.

Influx of Workers

LMMPL estimates that it will need approximately 25 workers from outside the district (representing approximately 50% of the workforce). Most of the skilled workers will be hired from Shillong with management coming from Calcutta. Many workers, particularly from Shillong in Meghalaya State, will probably not bring their families preferring to return home on bi-monthly or monthly basis. This will reduce the need for housing near the mine area.

The workers and their families when applicable will be housed in a colony comprising of accommodation for 20 families. It has been agreed that the Nongtrai village will provide the land for the colony. The site for the colony is approximately 2 km south of the mine site, which is uninhabited area, covered with scrub and isolated land from the nearby settlements. The isolated location of the colony area will help in reducing any potential cultural conflicts, which may arise between the incoming workers and the residents of the area.

Nongtrai *Durbar* acknowledges the need for the project to bring in skilled workers and the council members do not foresee any problems with the skilled workforce coming from outside and integrating in the local area.

8.21.2 Medical Assistance

- provision of weekly clinics in Nongtrai and Shella villages which will be available to the villagers of Nongtrai, Phlangkaruh, Pyrkan and Shella;
- regular immunisation programmes;
- appointment of village health worker in each village; and
- extend of medical assistance including provision of ambulance in case emergency through health centre set up for project colony.

8.21.3 Education

- repair / rebuilding of village schools;
- institution of scholarships to intelligent students for higher studies; and
- providing support to existing primary education schools.

8.21.4 Vocational Training

Conducting tailoring / embroidery / hobby classes for village women.

8.21.5 Assistance in Utilising Government Programmes

Collecting and disseminating information pertaining to various government schemes and providing guidance and assistance to eligible persons for making good use of these schemes e.g. loans for setting up small business etc.

8.21.6 Social Afforestation

To maintain ecological balance, the project will promote afforestation programmes by providing saplings to schools, village communities and individuals. Initially, about 5-6 schools will be motivated annually plant trees within their compounds.

8.21.7 Communication

The development of the project will result in better condition of the state highway road and other communication facilities like post office, telephone, telegraph office etc.

8.22 ENVIRONMENTAL CONTROL & MONITORING PROGRAMME

For successful implementation of an EMP, it is important that an effective environmental monitoring cell should be set up whose role would be to check the efficiency of the organisational set up responsible for implementation of EMP. The organisational and institutional structure of the proposed Environmental Management Cell is described below.

8.22.1 Environmental Management Cell (EMC)

A Cell for Environmental Management within LLMPL at the project level, will take the overall responsibility for co-ordination of the actions required for environmental management and mitigation, and for monitoring the progress of the proposed management plans and actions to be taken for the project. The Cell will be under the overall supervision of the General Manager, LLMPL, and responsible for monitoring of the implementation of the various actions which are to be executed by the agencies specified in the EMP. The Cell will report on a regular basis to the General Manger. The Cell will be headed by a qualified environmental engineer and the other members of the cell that will include a Geologist, Environmental Engineer, a Sociologist, a Horticulturist and a Mining Engineer.

The EMC will prepare a formal report on environmental management and mitigation for the General Manager at six-monthly intervals. Reports on any urgent or significant issues may be prepared at shorter intervals. Apart from responsibilities listed above, the EMC will have the responsibility of the following:

- Collection of water and air samples within and outside the work zone;
- Analysing the water and air samples;
- Implementation of the control and protective measures;
- Land reclamation and vegetation;
- Co-ordination of the environment related activities within LLMPL;

- Collection of the statistics of health of workers;
- Green belt development including nursery management;
- Awareness and implementing safety programmes; and
- Monitor the progress of implementation of EMP.

8.22.2 Responsibilities of the Supervisors in the Environmental Management Team

Senior Engineer (Environment): A person of the rank of Manager will be responsible for planning and implementation of the control and protective measures. He will co-ordinate the environment related activities within the project area. He shall have to co-ordinate on a daily basis with the Mine Manager for proper allocation and functioning of the Pollution control and monitoring equipment including the land reclamation and water spraying trucks. He shall also have to co-ordinate with the outside agencies including contractors for monitoring and controlling the tasks related to green belt development, afforestation and other social and biological reclamation. He shall also interact with the medical officer of the LMMPL and collect & synthesise the workers' sickness record to analyse the possible occurrences of occupational diseases. He will be responsible for monitoring of the progress of implementation of environmental control measures and will be reporting directly to the Mines Manager.

Environmental Engineer: He will be responsible for collecting water and air samples and analysing water and air samples as well as collecting statistics of health of workers and population of surrounding villages. He will be responsible for maintaining the schedule, duration and parameters to be monitored. He will be helped in his job by Assistant Engineer, one Junior Officer and 2 workmen. The Assistant Engineer will also supervise the implementation of environmental protection measures viz. water sprinkling / spraying creation of storm water drains, garland drains, culverts and other protective measures / arrangements.

Geologist: He will be responsible for supervising and guiding environmental team on geological, aspects in the pollution management, such as groundwater, etc.

Mining Engineer: He will be responsible for providing technical inputs necessary from the mining operation's point of view, in managing the environment. He will work in close association with the geologist and environmental engineer.

Sociologist: He will be member of the R&R Steering Committee and will be responsible for collection of information on the PAPs, socio-economic conditions of the study area and co-ordinate the implementation of R&R activities. He will report to Senior Engineer (Environment) and also to General Manager (Limestone Mining Project).

Botanist/Agricultural Scientist/Horticulturist: He will be the overall in-charge of biological reclamation and plantation scheme to be carried out in and around the mine lease area and maintenance of green belt and the ecologically sensitive areas. He will be responsible for green belt development, avenue plantation, plantation in the colony, developments of gardens and lawns both around and

within the ML area, and the colony. He will be taking decisions regarding the selection of plant / tree species having high survival rate based on the climatic conditions and soil characteristics. He will be responsible for setting up a nursery and acquiring saplings from local nurseries, if necessary and supervise and control the contractors engaged for plantation.

Agencies to be consulted for the implementation of control measures are as follows:

- Meghalaya State Pollution Control Board;
- Nongtrai village Durbar;
- Centre for Eco Development, North Eastern Hill University;
- Nongtrai Sports Club ; and
- Department of Forests, Meghalaya.

8.22.3 Monitoring Schedule and Parameters

To evaluate the effectiveness of environmental management programme, regular monitoring of the important environmental parameters will be taken up. The schedule, duration and parameters to be monitored are shown in the ***Table 8.9*** below.

Table 8.9 Monitoring Schedule and Parameters

	Description of Parameters	Schedule and duration of monitoring
Air Quality (SPM,RPM,CO, SO_2, NO_x)		
A	In the vicinity of the mine	One sample over 24 hours continuous duration, once a week throughout the year.
B	In the vicinity of crushing plant and limestone handling areas	One sample over 24 hours continuous duration, twice in a week throughout the year.
C	In the surrounding areas covering five locations	One sample over 24 hours continuous duration, twice in a week throughout the year.
Water Quality		
a	Treated Wastewater quality generated from ETP and STP	Twice a week for selected parameters like, pH, TSS, TDS, COD, BOD and Oil and Grease. The detailed analysis should be carried out once in three months.
b	Surface and ground water quality in the vicinity of the mine area for water portability conforming to Drinking Water Standard IS: 10500 : 1991	Once in three months.
Ambient Noise level		Quarterly
Inventory of flora		Once in two years in project monitoring area
Soil quality		Once a year on all reclaimed areas and adjoining villages
Socio-economic condition of local population physical survey		Once in two years

In addition to above, as per the directives of the MoEF in its Environmental Clearance granted through letter no J-11015/10/2000-IA II(M) dated August 9, 2001, enclosed as ***Annex C***), the following monitoring will also be carried out:

- Scientific monitoring will be carried out within 1 km radius around the lease area on monthly basis for the outflow of all springs, hill slopes , collapse of caves and cavities and blockage of subsurface water channels;
- Regular monitoring of water quality of Phlangkaruh springs and river including ground water will be carried out for physico-chemical and biological parameters. Monitoring will be continuous during initial mining operation
- After the mine becomes operational, ground vibrations due to blasting and its impact on various mine structures will be studied in detail and report will also be submitted to MoEF;
- Digital processing of the entire lease area using remote sensing technique will be carried out regularly once in three years for monitoring land use pattern and physiography of the area and report will be submitted to MoEF at New Delhi and its regional office at Shillong; and

- A detailed decommissioning plan will be submitted to MoEF, 5 years advance for approval.

For effective implementation and mid-term corrective measures, if required, monitoring and control of programme implementation are essential.

For air, water and noise pollution control measures, it has been suggested that samples would be collected and tested all round the year with appropriate frequency at strategic places by suitable agencies. In case, it is found that any of the control parameters exceed the tolerance limit as fixed by the State / Central Pollution Control Board or any other statuary body, preventive measures will be taken and if required expert opinion will be sought for proper remedial measures.

EMC would be responsible for the three major functions such as impact analysis, environmental pollution control and monitoring.

8.22.4 Financial Parameters

Capital Cost Estimated for EMP: The ***Table 8.10 & 8.11*** below gives overall investment on the environmental safeguards and measuring for successful monitoring and implementation of control measures (including land reclamation).

Table 8.10 Capital Cost Estimate for EMP

S No	Particulars	Total Cost (Rs in million)
A	Pollution Control Provisions in Mines / Miscellaneous Services	
1	Water Management and Quality including Water Lorries / Sprinklers and Effluent Treatment Plant	5.00
2	Water Retention garland drains	1.00
3	Pumps and pipe lines (for afforestation)	1.00
4	Dust Extraction System for Crusher	2.50
5	Stack for DG set	0.30
6	Sewage Treatment Plant	2.00
7	Solid Waste Management	1.30
8	Provision of Covered Belt Conveyor to check Fugitive Emission	Integrated with the capital cost of the belt conveyor
Sub-Total "A"		13.10
B	Provision for Disaster Management plan	
1	Water Hydrant system	1.00
2	Other provisions	3.00
Sub Total "B"		4.00
C	Environmental Monitoring	

S No	Particulars	Total Cost (Rs in million)
1	Air monitoring equipment (High Volume Samplers)	0.25
2	Automatic recording meteorological station	0.20
3	Other Laboratory Equipment	1.00
4	Mobile environmental monitoring van	1.00
5	Respirable dust sampler	0.15
Sub Total "C"		2.60
D	Protection Work	
1	Storm water drains	2.00
2	Drains along roads	0.50
3	Water drain culverts	3.00
Sub Total "D"		3.50
E	Green Belt Development / Afforestation	1.0
Grand Total (A-D)		23.20

Table 8.11 Recurring Cost of Environmental Protection - Monitoring and Implementation of Control Measures

Particulars	(Rs million per annum)
Air Quality Control	3.00
Water Quality and Management	1.00
Solid Waste Management	0.50
Monitoring	3.00
Salary	0.50
Miscellaneous including DMP	1.20
Total	9.20
Afforestation / Green belt development including maintenance	1.0

8.23 RECLAMATION AND CLOSURE

Mine reclamation and closure plan will be derived based on the maximum utilisation potential of the existing structures. The residential areas and the accessory infrastructural facility will not be dismantled but provided to local for use. In the absence of any effective utilisation as mentioned above, the following actions will be taken for individual items:

Magazine for explosives

The structure will be cleared, checked thoroughly and dismantled.

Structures to be dismantled

The following structures / buildings will be dismantled and levelled properly:

- Workshop building including crusher;
- Conveyor belt system;
- Reject bin; and
- Refuelling system.

Structures to be retained

The following buildings / structures will be retained and handed over to the local community for the following social uses:

Mine Office	-	School Building
Ware house	-	Cottage Industry
Workshop	-	Small scale power industry
Hard standing area	-	To be utilised by local villagers.

Connecting roads will be retained for public use.

Sink Hole Garland Drains

The sinkhole will be retained as such. The sinkhole and the surrounding vegetation which has some ecological significance will be left undisturbed during the entire mine life and will be protected as a reserve biodiversity site. The garland drains to retain the surface runoff will be left for certain period of time until the slope stabilises and scope of surface erosion minimises.

The cost of the above closure plan is estimated to be Rs 10 Million and the expenditure is likely to be incurred during end of mine operation