ORISSA MINING CORPORATION LIMITED
GANDHAMARDAN-A IRON ORE MINING PROJECT

ENVIRONMENTAL IMPACT ASSESSMENT
AND
ENVIRONMENTAL MANAGEMENT PLAN

MECON LIMITED
RANCHI - 834002
INDIA

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No. 11.S2.2006.F1800

June, 2006

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Introduction

1.0 INTRODUCTION

1.1 GENERAL

Orissa Mining Corporation Limited (OMCL), a State Government undertaking under Government of Orissa is engaged in mining and processing of iron ore, manganese, limestone, chromite and bauxite in Keonjhar, Sundergarh, Jajpur, Koraput, Dhenkanal, Rayagada, Kalahandi, Nuapara and Mayurbhanj districts of Orissa. At present OMCL posses ore reserves of about 400 Mt of iron ore, 220 Mt of iron bauxite, 28 Mt of chromite, 19 Mt of Manganese and 19 Mt of limestone. OMCL, with employee strength of about 9000, recorded a remarkable growth in 2004-05 with turnover of Rs 758.89 crores.

Gandhamardan hill, located in Keonjhar district, hosts one of the largest iron ore deposits in the State. Gandhamardan-A mine lease is spread over 618.576 ha. Iron ore production from existing Gandhamardan-A project has been planned to be enhanced from present about 3, 00,000 t/yr to 3, 50,000 t/y. The ore from Gandhamardan-A project shall be supplied to various sponge iron and steel plants.

OMCL commissioned MECON Limited, a Public Sector Undertaking under the Ministry of Steel, Govt. of India, for carrying out environmental baseline data generation and preparation of Environmental Impact Assessment (EIA) and Environmental Management Plan (EMP) report for proposed expansion of Gandhamardan-A iron ore project. The EIA/EMP report has been prepared in accordance with the latest stipulations of Orissa Pollution Control Board (OPCB) and Ministry of Environment and Forests (MoEF), Government of India.

1.2 THE PRESENT STUDY

The present EIA/EMP report is intended to obtain environmental clearance for proposed expansion of the Gandhamardan-A mine from statutory authorities.

It was planned to carry out baseline environmental data generation for air, water, noise and soil quality monitoring at the core and buffer zone of the mine site for

three seasons covering four weeks in Post-monsoon (September-November'2005), one full season covering three months of Winter (November'2005, December'2005 and January'2006) and also four weeks in Summer (March - April' 2006). In addition, water quality was planned to be monitored in Monsoon season also.

The present EIA/EMP report has been prepared on the basis of base line environmental data monitored during Post monsoon (2005) and Winter (2005-06) seasons.

1.3 COVERAGE OF THE REPORT

The report covers:

- A brief description of the geology of the deposit, existing opencast operations in float ore, flank ore and hill top main ore body, proposed expansion parameters and allied activities in the lease area.

- A description of the present environmental status covering study of the present environmental conditions including meteorology, air quality, water quality, noise level, soil quality, ecology, land use, socio-economic environment etc in the mine site and also in the 10 km radius buffer area.

- Assessment of the likely impacts due to proposed expansion of Gandhamardan-A mining project and allied activities. This covers identification of impacts of the various activities of the mine on various environmental attributes. A detailed survey of these attributes has been carried out and the probable impacts have been identified and assessed qualitatively and quantitatively.

- Environmental Management Plan including:

  - Integration of environmental standpoints into mine planning.

  - Air, water, noise and soil pollution control.
  - Water management strategy.
  - Mitigation of adverse impacts on land use, socio-economic environment, ecology, water regime etc.

- Manpower and organisation set up for implementation of environmental control measures.
- A scheme for implementation and monitoring of environmental management plan.
- A broad estimate of the cost of environmental management.

1.4 BASIC DATA AND FIELD STUDIES

The report has been prepared based on baseline environmental data generated in Post monsoon (2005) and Winter (2005-06) seasons covering meteorology, air quality, water quality, noise level, soil quality, ecology, land use and socio-economic environment. The modalities of the study have been formulated to meet requirements of Ministry of Environment and Forests, Government of India. All attempts have been made to gather the available data on the present environment status in the study area.

An in-depth analysis of the available data has been made for working out an effective environmental management plan. The restoration plans envisaging environment protection are based on the basic data pertaining to proposed expansion project, which were provided by OMCL.

1.5 ACKNOWLEDGEMENT

MECON Limited wishes to place on record its deep appreciation for the trust reposed in MECON by OMCL and for the active interest and help extended by concerned OMCL officials. Cooperation extended by the officials of State Forest department is also gratefully acknowledged.

Project Profile

2.0 PROJECT PROFILE

2.1 LOCATION AND ACCESSIBILITY

Gandhamardan Iron Ore deposit is located on Gandhamardan hill in Telkoi Tehsil of Keonjhar district of Orissa state. The lease area is well connected with Keonjhar town at a distance of 16 km due west. Keonjhar – Suakati stretch of the road length (11 km) is on NH-6. The nearest railway station is Banspani (on Padapahar-Barajamda-Gua branch line of South Eastern Railway) at a distance of about 85 km from the mine lease. The deposit is covered under survey of India toposheet nos. 73 G/6 and 73 G/10 at latitudes 21°36'00" – 21°37'09"N and longitudes 85°29'20" – 85°31'30"E. The mining lease falls within Gandhamardan PRF and village limits of Daonra and Suakati villages. Location of the lease area is shown in **Drawing No. MEC/Q696/11/S2/(6)1.**

2.2 LEASEHOLD AREA

Gandhamardan-A leasehold area of OMCL measures 618.576 ha under villages Daonra (67.714 ha), Suakati (64.728 ha) and also Gandhamardan PRF (486.576 ha).

The leasehold area consists of forest land (519.7472 ha), waste land (73.002 ha), grazing land (10.3632 ha), agricultural land (11.5548 ha), settlement (1.8968 ha) and roads (2.212 ha).

Gandhamardan–A mine is under operation by OMCL since 1964. The lease was granted on 21.5.1963 for a period of 30 years, the validity of which expired on 21.5.1993. At present the lease renewal application filed on 06.04.1992 is under process. Mining Plan report for the project has been approved by Indian Bureau of Mines (IBM) vide letter no BBS/KJ/Fe/MS-158 dated 01.08.2006. Forest diversion proposal for diversion of 216.3617 ha of forest land (including 64.7242 ha broken up forest land) is under process at the level of Forest and Environment Department, Govt. of Orissa, C.F. Rourkela to C.C.F. (Nodal) Bhubaneshwar vide letter no. 2773/3F (Dis-K)-47/2004, dated 23.08.2004

2.3 NEED OF THE PROJECT

Gandhamardan-A lease area contains an estimated mineable reserve of about 35 Mt of iron ore. The mine was in continuous operation since 1964. Demand of iron ore in the State has increased due to rapid growth in iron and steel sector. A number of new sponge iron and steel plants have been planned in the state. An annual production of 0.35 Mt/y shall partly fulfill the need of sponge iron plants and existing and upcoming steel plants.

The mine shall contribute Rs. 1.33 crores per annum to the state exchequer by way mining revenue (Rs. 0.44 crores) and sales tax (Rs. 0.89 crores).

The proposed stepped up production shall provide an opportunity to generate additional direct employment of about 100 persons in addition to the 377 who are employed in the existing mine. Considering these aspects, namely meeting a bulk of the internal and external demand, need for earning revenue to state exchequer, continuing direct employment of about 500 persons and economic development of a predominantly backward region of the country, continuation of mining operation in enhanced capacity in Gandhamardan-A mining lease, is essential.

2.4 GEOLOGY

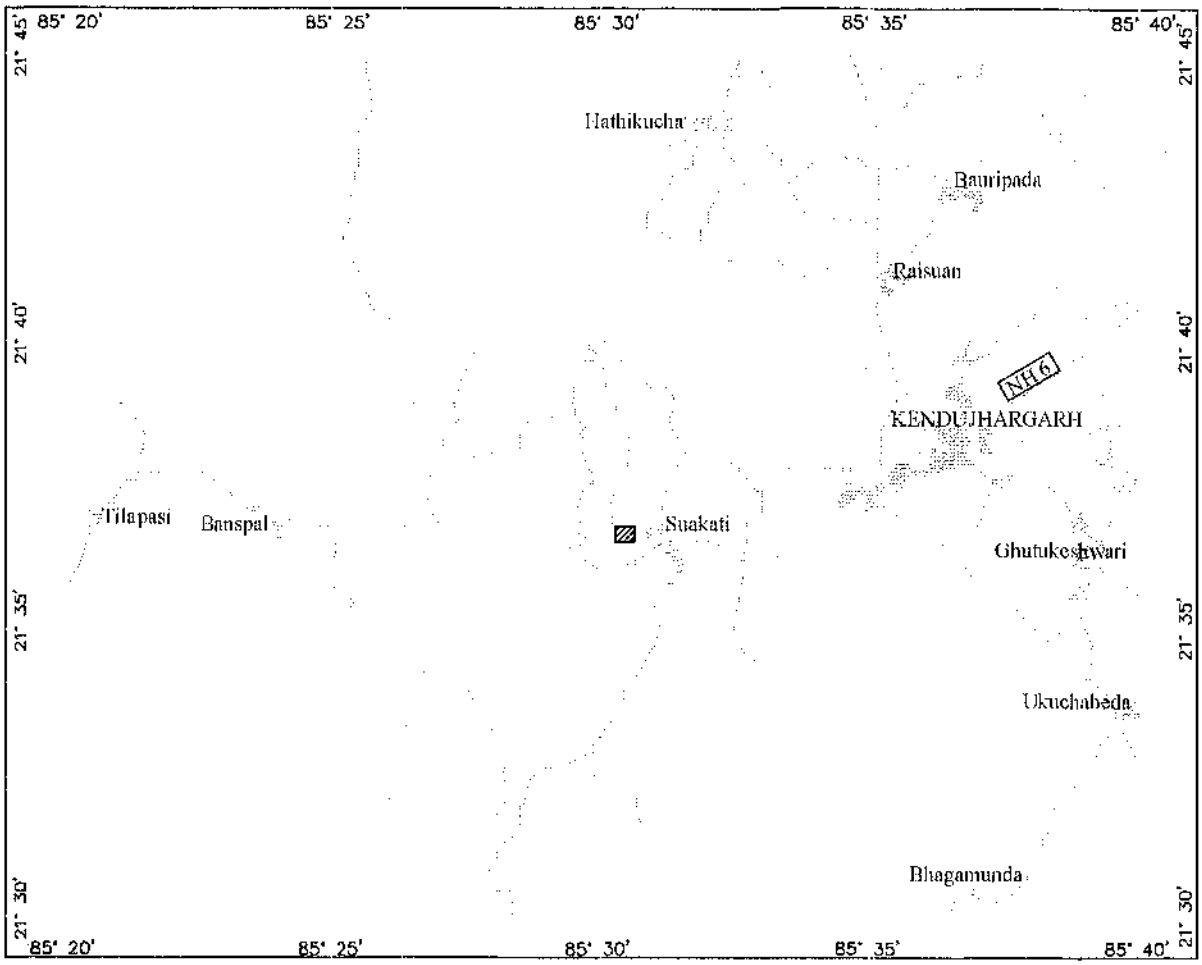
2.4.1 Jamda – Koira Valley Synchlinorium

Jamda – Koira Valley Synchlinorium is one of the principal Banded iron formations (BIF) encircling the Singhbhum Granite Complex. This formation contains an isolated deposit at Gandhamardan hill, which lies southeast of Jamda – Koira valley deposit popularly known as famous horseshoe shaped Singhbhum Bonai Iron Ore Synchlinorium. Gandhamardan-A mining lease area belongs to Bonai iron ore synclinorium. The stratigraphic succession of the area is as follows:

KOLHAN GROUP	**SANDSTONE, CONGLOMERATE – BRECCIA**
---------- UNCONFORMITY ----------	
Mixed Facies Formation	- Basic lava, tuffs and tuffites of volcanic faces - Iron, manganese, lenses of iron formation, chert, and small dolomite patches of chemical facies. - Minor lenses of sandy and silty shale of clastic facies.
Banded Shale Formation	- Upper banded shale member - Lower black shale member - Lower black shale – chert member
Banded Iron Formation	- Finely banded jaspilite member - Coarsely banded jaspilite member
Volcanic Formation	- Tuffaceous shale - Basic lava
Basal Sandstone	- Gritty sandstone, quartzite conglomeratic at places with interbedded lava at top.
---------- UNCONFORMITY ----------	

2.4.2 Local geology

Southern part of the insitu iron ore body/surface ore/ main ore body is located on the hill top and insitu/flank ore in Daonra hill slope deposits. Flank ore deposits are



LEGEND

- ROADS
- MAJOR SETTLEMENTS
- WATER BODIES
- GANDHMARDAN-A LEASE AREA

SOI TOPOSHEET NOS. 73G6 AND 73G10

REFERENCES

SECTION	ENV.ENGG.	
LOCATION	RANCHI	
DESIGNED	MKM	10.05.06
DRAWN	PKDB	12.05.06
CHECKED & VERIFIED	MKM	15.05.06
APPROVED	BS	
	DATE	

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MECON LIMITED

GANDHMARDAN-A IRON ORE PROJECT

ORISSA MINING CORPORATION LIMITED

LOCATION OF LEASE AREA

SCALE : As shown above

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confined to the lower level (as compared to the hill top deposit) between BIF (hanging wall) and shale/volcanics (foot wall).

The main Gandhamardan deposit strikes in north south direction (N5°E – S5°W) with gentle to moderate westerly dipping beds (5° to 30° due west). The strike length of the deposit is 3.625 km and average width is 700 m. The ore body is bulging towards south and tapers down to north. The deposit is surrounded from all sides by Banded Hematite Jasper (BHJ) with laterite capping at the top. Following are the details of ore body:

Roof strata	:	Laterite
Floor strata	:	BHJ
Length	:	3300 m
Width	:	850 m
Maximum depth of occurrence	:	103 m
Minimum depth of occurrence	:	7 m
Average depth of occurrence	:	35.74 m
Average thickness of ore zone	:	35 m
Surface area of ore zone	:	2.805 km^2
Strike direction	:	N5°E – S5°W

Gandhamardan ore shows wide variations in iron content and physical properties like colour, compactness, hardness etc. Based on physical characteristics the ore has been classified as lateritic ore, soft laminated ore, hard laminated ore, massive ore and powdery ore.

Specific gravity and bulk density as determined for different ore types are given in **Table 2.1.**

Table 2.1: Specific Gravity and Bulk Density of Ore

Ore / rock type	Specific gravity	Bulk density
Lateritic ore	2.97	2.53
Soft laminated ore	3.99	3.45
Hard laminated ore	4.34	3.63
Massive ore	4.30	3.75
Powdery ore	3.82	2.52

Geological plan and sections have been shown in **Drawing nos: MEC/Q696/11/S2/(6)2.1** and **MEC/Q696/11/S2/(6)2.2** respectively.

2.5 RESERVES AND QUALITY

Reserves of iron ore in Gandhamardan-A is estimated to be about 35 Mt. Cut off grade of iron ore has been considered to be 58% Fe respectively for the purpose of reserve estimation.

Iron ore is mainly marketed in two forms as lumpy ore and fines. Recovery of iron ore is as follows:

Ore	Grade	Recovery
Lumps	+65% -65%	90% 10%
Fines	-65%	NIL

Chemical composition of associated waste rocks are given in **Table 2.3.**

Table 2.2 : Chemical composition of associated waste rocks

Chemical constituents	BHJ-BHQ	Interburden	Laterite
Fe	37.76	51.33	53.2
SiO_2	40.17	14.20	8.23
Al_2O_3	3.08	5.91	7.65
LOI	1.95	5.69	8.23
FeO	0.78	0.59	0.75
MnO	0.25	0.18	0.14
CaO	0.27	0.15	0.12
MgO	0.13	0.09	0.13
Tio_2	0.06	0.14	0.18
P	0.04	0.10	0.07
S	0.01	0.006	0.02
P_2O_5	0.10	0.25	0.16

2.6 MINING

Gandhamardan Block-A deposit is being (will be) mined by opencast mining method by conventional shovel – dumper combination. Rated production of 0.35 Mt shall be produced from 2006-07.

Mining commenced in the lease area in 1964 and operation since then has opened up only one quarry in flank ore deposit (Daonra quarry/quarry-9) and float ore workings. The maximum development and production have been obtained from flank ore deposits which exposes mainly hard massive iron ore. Old working in main ore

body exposes lateritic, soft laminated, hard laminated, massive and powdery ore as well as friable ore. Parameters of active working quarries are given in **Table 2.3.**

Table 2.3: Parameters of Existing active working quarries

Parameters	Daonra Quarry /Quarry 9	Quarry VD	Hill top - 1
Quarry area	21600 m^2	31440 m^2	19200m^2
Bench height	5 m to 8 m	5 m	2m
Bench width	5 m	10 m	Single bench
Bench slope	Nearly vertical	Nearly vertical	Nearly vertical
Overall slope	45° - 60°	-	-
Adjoining ground level	750 mRL to 840 mRL	720 mRL	970 mRL
Quarry bottom level	750 mRL	720 mRL	968 mRL

Opencast mining will be continued with 0.9 m3 excavators, 10 t capacity trippers and other auxiliary equipments.

At present Daonra quarry (quarry 9), quarry VD and small sporadic excavations at north eastern corner are in operation. Small north eastern quarries shall be exhausted during first five years after which they will be backfilled subsequently. Daonra quarry will be operated to produce 0.22 – 0.28 Mt per annum. Float ore quarries (Quarry VD) will be operated to produce 0.02 – 0.08 Mt per annum. Annual ore production and OB generation programme for first 5 years of expansion period (2006 – 2011) has been given in **Table 2.4** whereas ore production and OB generation programme till end of mining, is given in **Table 2.5**.

Table 2.4: Ore and OB generation till 2011

Year	Ore (t)	OB (m^3)	Interburden (m^3)	Total waste (m^3)
2006-07	300552	29520	37008	66528
2007-08	300552	46440	55368	101808
2008-09	350308	60480	42872	103352
2009-10	351484	74160	32596	106756
2010-11	352044	83160	32596	115756
Total (2006-11)	**1654940**	**293760**	**200440**	**494200**

Table 2.5: Ore production and OB generation till conceptual stage

Ore body / deposit	Ore (t)	OB (m^3)	Interburden (m^3)	Total waste(m^3)
Flank ore quarries	7390488	1964800	527892	2492692
Float ore quarries	1971200	-	844800	844800
Hill top quarries	25744960	424850	1838925	2263775
Total	**35106648**	**2389650**	**3211617**	**5601267**

Futuristic quarry parameters for expansion period have been given at **Table 2.6** quarry wise.

Table 2.6: Quarry parameters under expansion programme

Parameter		Quarry								
		Quarry 9			Quarry VD including other ore quarries			Hill top Quarry		
		1	5	E	1	5	E	1	5	E
Adjoining ground level (mRL)		872	890	970	720	720	630	968	960	905
Quarry bottom level (mRL)		815	815	815	715	715	630	968	960	905
Bench	Number	5			1			1	2	7
	Height	10 m			5 m			2 m	5 m	10m
	Width	10 - 20 m			-			-	5-10m	10-20m
	Slope	Nearly vertical			Nearly vertical			Nearly vertical		
Overall quarry slope		<45°			-			-	-	<45°

* All the quarries will merge at conceptual area. 1,5,E: At the end of 1st, 5th, End of work respectively

Overburden as well as intermediate waste materials will be generated from the ore zone which are laterites and BHJ. Till end of mining 5.60 Mm^3 of waste will be generated which will be mostly backfilled. There is no possibility of generation of sub grade iron ore (<58% Fe) in the lease area. Average haulage distance for hill top quarry shall be 2 km while for flank ore quarries, average distance shall be 1 km.

Table 2.8 : Quarry sizes at ultimate pit limit

Quarry	Area
Quarry 9	113.184
Q-IV A	3.23
Q IVA1	0.42
Q IVB	0.72
Q $IVB_{2\&3}$	12.0
Q IVB_6	3.64
Q IVC_1	0.225
Q IVD	10.365
Q IVC	1.04
Q IVE	4.4
Q IVB5	0.325
Q IVB4	0.12
Q VF	0.66
Q IIIA	0.32
Q VCIIA & IIB	4.44

Working is (will be) carried out for 300 days a year and 3 shifts per day.

List of machineries are given in **Table 2.8.**

Table 2.8 List of Machineries

Operation	Machine	Dia / Capacity	Distribution		
			Flank quarry	Float ore	Hill top
Drilling	IR drill Compressor	100 mm / 150 mm	3	1	1
Excavation & loading	Backhoe	0.9 m^3	2	1	1
Transportation	Tipper	10 t	15	3	3
Mineral processing	Crusher	110 tph	1		
Water sprinkling	Water sprinkler	10 kl	1		

Drill holes are drilled in single rows as well as in multi row on staggered pattern by DTH drills and secondary drilling is carried out by Jack hammers. Drilling and blasting parameters are given at **Table 2.9.**

Table 2.9: Drilling and Blasting Parameters

Sl. No.	Parameters		Hill top quarry (Main Ore body)	Flank ore quarries
1.	Hole diameter		100 mm	100 mm
2.	Drilling pattern	Burden	2 m	2 m
		Spacing	2.5 m	2.5 m
3.	Blasting advance	Blasting in ore round	5 m	5 m
		Sub grade drilling	0.5 m	0.5 m
		Depth of hole	5.5 m	5.5 m
4.	Inclination of blast hole		Vertical	Vertical
5.	Explosive	Type	ANFO & Powergel	ANFO & Powergel
6.	Powder factor		8 t/kg	8 t/kg
7.	Explosive requirement	Quantity / hole	10 kg	10 kg
		Quantity / round	50 kg	50 kg
8.	Initiative agent	Detonator	ED	ED
		Fuse	Cordtex	Cordtex
9.	Frequency of blasting		Once daily	Once daily
10.	Yield per hole		25 m^3	25 m^3

An explosive magazine has been established in the lease area (for both Gandhamardan A & B projects). Explosive wise existing and proposed capacities of the explosive magazine are given in **Table 2.10.**

Table 2.10 : Existing capacity in explosive magazine

Explosive	Class / Division	I	II
Nitroglycerine based explosive	III	3.5 t	10t
Safety fuse	VI / 1	-	-
Detonating fuse	VI / 2	-	50,000
Detonator	VI / 3	40,000 nos.	50,000 nos.

In addition, permission shall be sought for use of ANFO with above indicated high explosives.

Quarries , dumps and surface features in existing stage and also at the end of 2011, 2016 and at conceptual stage are shown in **Drawing**: **MEC/Q696/11/S2/(6)3, MEC/Q696/11/S2/(6)4.1, MEC/11 Q696/S2/ (6)4.2** and **MEC/ Q696/11/S2/(6)4.3** respectively.

2.7 MINERAL PROCESSING

ROM ore raised from quarries are sized into the sizes : + 5 – 18 mm, + 10 – 30 mm and + 10 – 40 mm. For the purpose, Near Quarry 9, a 110 tph crusher & screening plant has been commissioned.

2.8 USE OF MINERALS

Flank ore has high iron content (+66% Fe), with low silica and alumina. Flank ore is, therefore despatched directly to nearby sponge iron plants. Part of ore production is sold to the crushing plant for value addition (in respect of size and grade) for indirect despatch of calibrated iron ore to sponge iron plants. Grade and size wise dispatched iron ore from Gandhamardan – A block are as follows.

Table 2.11: Grade and size wise iron ore dispatches

Type	Grade	Size	Consuming industry
Lumpy and hard iron ore	65% Fe	(+) 10 – 180 mm	Sponge plant
Lumpy and hard iron ore	64% Fe	(+) 10 – 180 mm	Crushing unit
Lumpy and soft iron ore	65% Fe	(+) 10 – 180 mm	Crushing unit
Lumpy and soft iron ore	65% Fe	(+) 10 – 180 mm	Crushing unit
Sized iron ore	64% Fe	+ 10 – 30 mm + 10 – 40 mm	Steel plant
Sized iron ore	65% Fe	+ 5 – 18 mm	Sponge plant

2.9 AUXILIARY SERVICES

The leasehold area hosts statutory facilities viz. crèche, canteen, first-aid centre, vocational training centre etc. and also Administration block, servicing and repairing shops, fuel pump station and a small medical unit. Residential accommodations for 147 nos. of staff and executives (both for Gandhamardan A & B mines) have been provided at camp area near Suakati village and also near Upar Jagar village.

2.10 POWER AND WATER SUPPLY

Power Supply

The mine is worked during day time only and 0.2 MW power is drawn for the small colony from 33 kV line from Keonjhangarh substation of Grid Corporation of India.

Water Requirement

Water requirement for the project in expansion phase is given at **Table 2.12.**

Table 2.12: Water Requirement of Expanded Mine*

	Avg. demand (m^3/d)	Peak demand (m^3/d)
Drilling & spraying	10	15
Dust suppression	12	15
Equipment / vehicle washing	12	15
Pit head bath	15	20
Green belt	100	150
Drinking water requirement at mine site	20	25
TOTAL	**169**	**240**

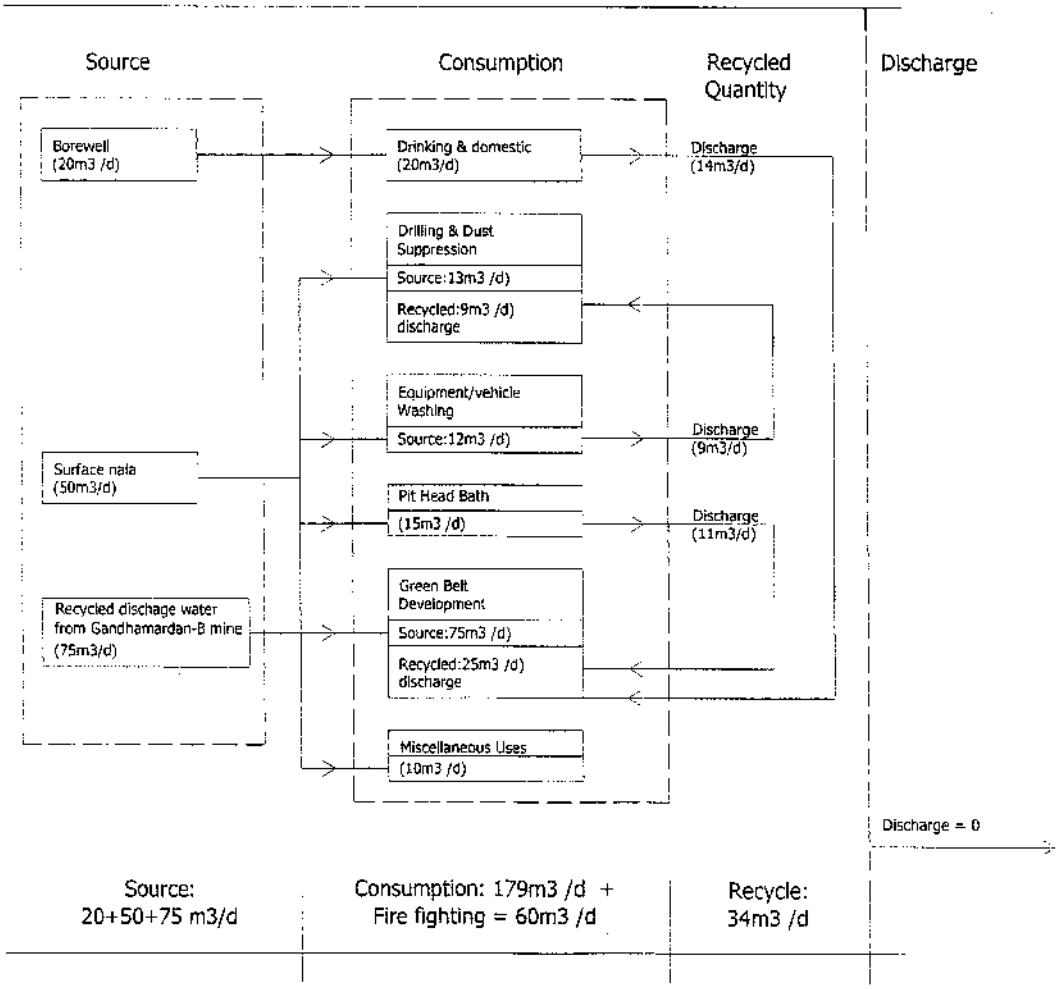
* Water requirement for the colony has been accounted under Gandhamardan B project.

About 20 m^3/d of water for drinking purpose shall be drawn from nearest boring point of OMCL. Industrial water requirement is 49 m^3/d. 34 m^3/d of water discharged water from Gandhamardan-A mine (from vehicle washing/pit and head bath) and 75 m^3/d of discharge water from Gandhamardan-B mine (discharge from township) shall be recycled back for use in Gandhamardan-A mine area after treatment mostly for green belt development necessitating only 50 m^3/d of water to be drawn from nearby perennial nala.

2.11 MANPOWER

Present employee strength of Gandhamardan-A mine is 377. In the expansion phase total direct manpower strength shall increase by 100 persons. In addition, the mine generates indirect employment for about 1500 persons.

Fig 2.1: Water Balance



Present Environmental Status

3.0 PRESENT ENVIRONMENTAL STATUS

Information on the existing environmental status is essential for assessing the likely environmental impacts of the project. The leasehold area where mining and allied activities are concentrated is designated as the core zone. The rest of the study area (10 km radius around the leasehold area) is designated as the buffer zone.

In order to get an idea about the existing state of environment, various environmental attributes such as physiography and drainage, meteorology, air quality, water quality, soil quality, noise level, ecology and socio-economic environment were studied/ monitored.

3.1 MONITORING SCHEDULE

It was planned to carry out baseline environmental data generation for air, water, noise and soil quality at the core and buffer zone of the mine site for three seasons covering four weeks in Post-monsoon (September-October 2005), one full season covering three months of Winter (November'2005, December'2005 and January'2006) and also four weeks in Summer (March - April' 2006). In addition, water quality was monitored in Monsoon season also.

The present EIA/EMP report has been prepared on the basis of base line environmental data monitored during Post monsoon (2005) and Winter (2005-06) seasons.

3.2 PHYSIOGRAPHY AND DRAINAGE

The lease area is centered around a ridge like escarpment – Gandhamadan Paharh, which runs in the north – south direction. The top of the ridge, has a peak at 1009 mRL. The bottom of the escarpment is at about 570 mRL. A number of gullies lead down from the top of the escarpment on both the eastern and western slopes. The lease area lies inside the Gandhamadan Reserve Forest.

Most of the study area is covered with hillocks, which rise to a maximum height of 878 mRL, 7.5 km SE of the lease area. About 2 km NE of the mine lease, there is a small proportion of relatively plain gently sloping area (Slope - 1:92) at 500 – 440 mRL. Nearby hills in the study area include: Dhuliapat Paharh (685 mRL) at 5.5 km N of mine lease, Mahabir Paharh (620 mRL) at 4 km NE of mine lease, Sinduari Paharh (740 mRL) at 1.5 km N of mine lease, Sandi Paharh (841 mRL) at 5.3 km SE of mine lease, Jartuaguru Paharh (700 mRL) at 1.5 km E of mine lease, Chhatrabandha Paharh (640 mRL) at 5 km ENE of mine lease and Chamak Paharh (754 mRL) at 5 km S of mine lease. Almost all of these hills are covered with Reserve Forests or Protected forests.

There is no national park, biosphere reserve, sanctuary, habitat for migratory birds, archeological site, defense installation, and airports within 10 km of the periphery of the lease area. The area does not fall in seismically active or landslide prone zone. Physiographical features of the study area are shown in **Drawing no. MEC/Q696/11/S2/ (6)7**.

The study area has dendritic pattern of drainage because of its hilly topography. The ridge of the Gandhamadan Paharh roughly divides the mine lease area into eastern and western half. The drainage channels emerging from of the eastern half of the lease area flow down to join the Kadal Nadi, which flows northward to join the Ardel Nadi which is a tributary of the Baitarani river. The western half of the lease area is drained by several channels, which form the Patarpagi Nadi and the Bamni Nadi which flow towards WNW and NW respectively. The Patarpagi Nadi joins the Bamni Nadi about 7.8 km NW of the mine lease. The Bamni Nadi flows towards the NW and joins the Baitarani River 19 km NNW of the lease area.

The drainage channels of the relatively plain NE part of the study area join the Machkandana Nadi, which flows towards the north to join the Ardel Nadi which is a tributary of the Baitarani river. The southern part of the study area also has numerous drainage channels which ultimately join the Baitarani river. The Baitarani river, which is 4.6 km SW of the lease area at the nearest point, flows towards NW but subsequently turns towards the north. Existing drainage features of the study area are shown in **Drawing no. MEC/Q696/11/S2/(6)8**.

3.3 CLIMATE AND METEOROLOGY

3.3.1 General Climate

The study area lies in tropical region where climate is characterised by very hot summers and cool winters. Summer is typically from March to June when temperature ranges from a maximum of 47°C during daytime to a minimum of 10°C at night. Winter is from November to February when the maximum temperature during day goes up to 40°C and minimum temperature at night becomes as low as 2.2°C. Monthly Variation in maximum and minimum temperature as recorded at India Meteorological Department's (IMD) observatory at Keonhjar (about 15 km away) is illustrated as **Fig.3.1.**

The average annual rainfall as recorded at IMD observatory at Keonjhar is 1269.1 mm. The Southwest monsoon lasts from mid June to mid September and the area gets more than 80% of the annual rainfall during this period. Monthly Variation in rainfall *vis-a-vis* potential evapotranspiration as recorded at IMD's observatory at Keonjhar and Chaibasa are illustrated as **Fig.3.2.**

3.3.2 Analysis Based on Monitored Meteorological Data

Prevailing micro-meteorological conditions at site regulate the dispersion (and hence dilution) of air pollutants in the atmosphere. Therefore study of meteorological conditions is an integral part of environmental impact assessment studies.

Accordingly, a meteorological station was set up up at Suakati township which is inside the leasehold boundary. The location is marked in **Drawing no. MEC/Q696/11/S2/(6)7**.The following parameters were recorded at hourly intervals continuously during the monitoring season:

- Wind speed
- Wind Direction
- Air Temperature
- Relative Humidity

Rainfall was recorded on daily basis.

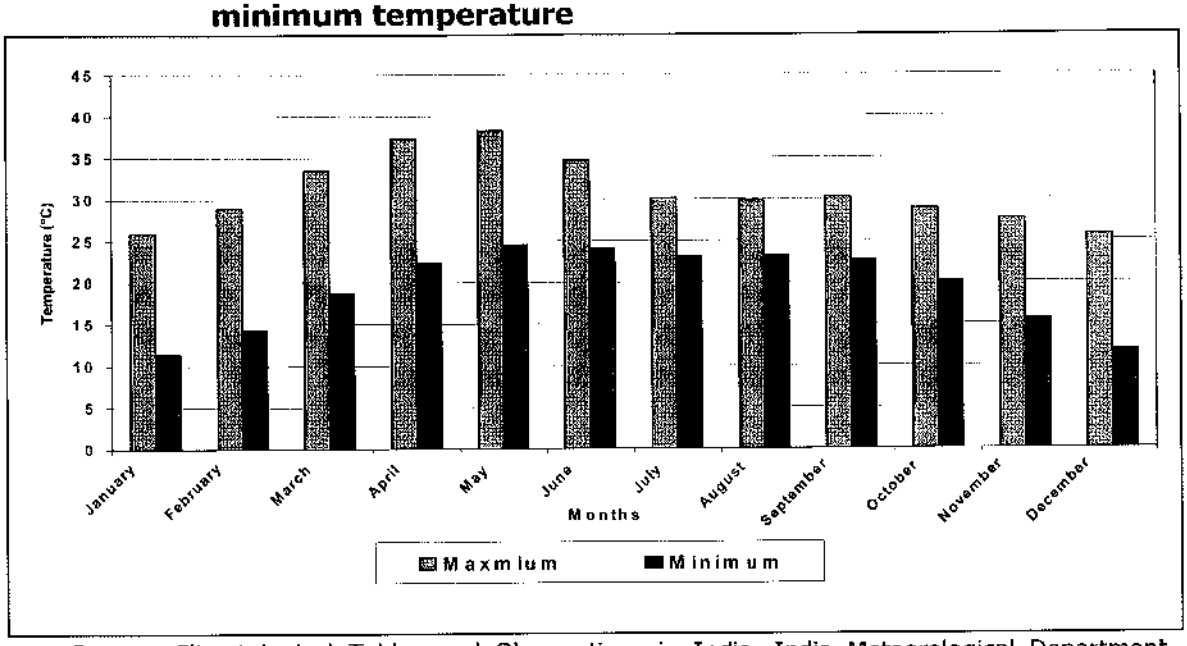
Table 3.1 gives the summary of meteorological data collected during Post-monsoon (2005) and Winter (2005-06).

Table 3.1: Summarised Meteorological Data for Post-monsoon (2005) and Winter (2005-06)

Month	Wind speed (m/s)			Temperature (°C)			Relative humidity (%)			Rainfall (mm)		
	Mean	Max	% of Calm	Mean	Highest	Lowest	Mean	Highest	Lowest	Total	24 hrs. highest	No. of rainy days
Oct'05 (PM)	1.05	3.48	45.21	23.5	31.5	19.5	81.9	96	20	188.43	25.5	12
Nov'05 (Winter	0.031	5.86		18	29	10	68.36	95	26	Nil	Nil	Nil
Dec'05 (Winter)	1.22	4.41	42.05	14.8	26.5	5	66	96	21.5	Nil	Nil	Nil
Jan'06 (Winter)	1.16	6.19		16.1	28.0	4.0	56.85	94	12	Nil	Nil	Nil

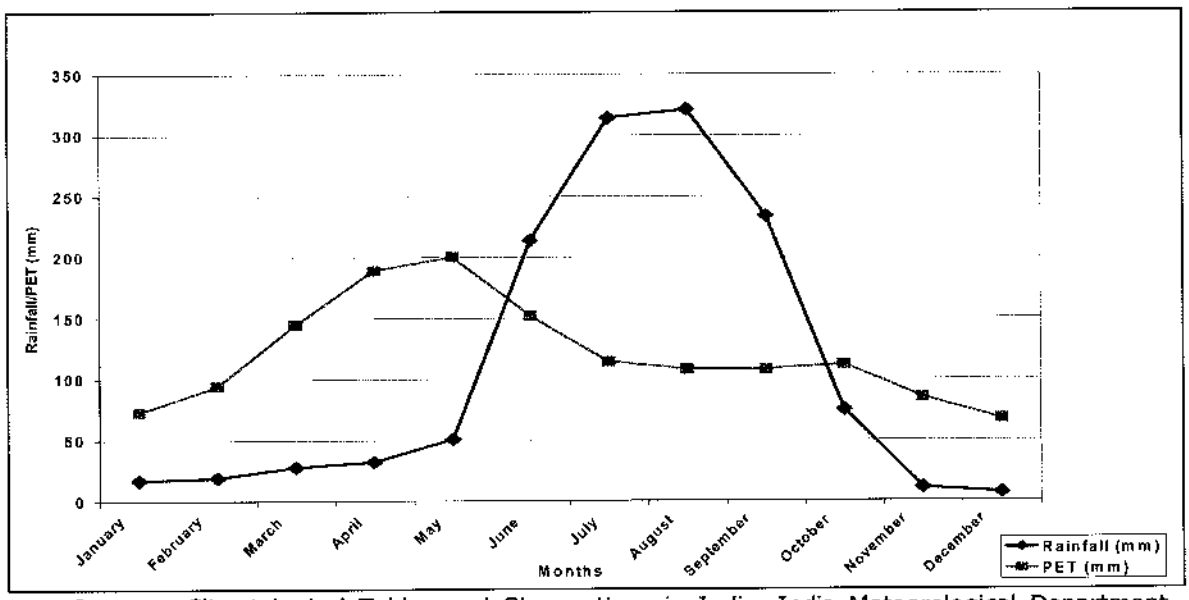
- Annual rainfall is 1269.1 mm and no. of rainy days : 71.4 (observed at IMD observatory, Keonjhargarh)

Fig. 3.1: Monthly variation of daily average of maximum and minimum temperature



Source: Climatological Tables and Observations in India, India Meteorological Department, Keonjhargarh, Chaibasa

Fig.3.2:Monthly variation of Rainfall vis-à-vis Potential evapotranspiration



Source : Climatological Tables and Observations in India, India Meteorological Department, Keonjhargarh, Chaibasa

Table 3.2.1 give wind frequency pattern of day-night (24 hours), day and night as monitored during Post-monsoon (2005).

Table 3.2.1: Wind Frequency Distribution at Suakati, during Postmonsson'2005

A. 24 hours Overall

Direction	Velocity Ranges (m/s)					Sum %
	0.44<V<=2	2<V<=3	3<V<=5	5<V<=6	V>6	
N	5.78	1.88	0.54	0.00	0.00	8.20
NNE	8.47	1.88	1.61	0.13	0.00	12.09
NE	4.70	2.15	1.08	0.27	0.13	8.33
ENE	0.94	0.81	0.00	0.00	0.00	1.75
E	0.67	0.81	0.13	0.13	0.00	1.74
ESE	0.94	0.27	0.13	0.00	0.00	1.34
SE	0.67	0.27	0.00	0.00	0.00	0.94
SSE	1.21	0.27	0.00	0.00	0.00	1.48
S	0.40	0.27	0.00	0.00	0.00	0.67
SSW	2.28	0.13	0.00	0.00	0.00	2.41
SW	1.07	0.27	0.13	0.00	0.00	1.47
WSW	1.88	0.94	0.13	0.00	0.00	2.95
W	1.48	0.81	0.00	0.00	0.00	2.29
WNW	1.88	0.27	0.00	0.00	0.00	2.15
NW	3.63	0.54	0.13	0.13	0.00	4.43
NNW	1.88	0.67	0.00	0.00	0.00	2.55
SUM %	37.88	12.24	3.88	0.66	0.13	54.79
CALM % (V< 0.44 m/s) = 45.21						

B. Day Time (0600 – 1800 Hrs.)

Direction	Velocity Ranges (m/s)					Sum %
	0.44<V<=2	2<V<=3	3<V<=5	5<V<=6	V>6	
N	4.04	1.90	0.00	0.00	0.00	5.94
NNE	7.36	1.19	1.66	0.23	0.00	10.44
NE	4.28	2.14	1.43	0.23	0.00	8.08
ENE	1.66	0.71	0.00	0.00	0.00	2.37
E	1.19	1.19	0.23	0.23	0.00	2.84
ESE	0.95	0.48	0.00	0.00	0.00	1.43
SE	0.95	0.48	0.00	0.00	0.00	1.43
SSE	1.43	0.48	0.00	0.00	0.00	1.91
S	0.48	0.48	0.00	0.00	0.00	0.96
SSW	0.00	0.00	0.00	0.00	0.00	0.00
SW	2.14	0.48	0.23	0.00	0.00	2.85
WSW	3.33	1.66	0.23	0.00	0.00	5.22
W	1.19	1.19	0.00	0.00	0.00	2.38
WNW	1.19	0.48	0.00	0.00	0.00	1.67
NW	2.38	0.71	0.00	0.00	0.00	3.09
NNW	2.85	1.19	0.00	0.00	0.00	4.04
SUM %	35.42	14.76	3.78	0.69	0.00	54.65
CALM % (V< 0.44 m/s) = 45.35						

C. Night time (1800 – 0600 Hrs.)

Direction	Velocity Ranges (m/s)					Sum %
	0.44<V<=2	2<V<=3	3<V<=5	5<V<=6	V>6	
N	7.49	1.73	1.15	0.00	0.00	10.37
NNE	9.22	2.54	1.44	0.00	0.00	13.20
NE	4.90	2.02	0.58	0.29	0.29	8.08
ENE	0.00	0.86	0.00	0.00	0.00	0.86
E	0.00	0.29	0.00	0.00	0.00	0.29
ESE	0.86	0.00	0.29	0.00	0.00	1.15
SE	0.29	0.00	0.00	0.00	0.00	0.29
SSE	0.86	0.00	0.00	0.00	0.00	0.86
S	0.29	0.00	0.00	0.00	0.00	0.29
SSW	4.90	0.29	0.00	0.00	0.00	5.19
SW	2.31	0.00	0.00	0.00	0.00	2.31
WSW	0.00	0.00	0.00	0.00	0.00	0.00
W	1.73	0.29	0.00	0.00	0.00	2.02
WNW	2.59	0.00	0.00	0.00	0.00	2.59
NW	4.90	0.29	0.29	0.29	0.00	5.77
NNW	4.90	0.00	0.00	0.00	0.00	4.90
SUM %	45.24	8.31	3.75	0.58	0.29	58.17
CALM % (V< 0.44 m/s) = 41.83						

The table shows that predominant wind direction is found to be from North-eastern sector. During day time, North North East (NNE) is the predominant wind direction (prevailing for about 10.44 % of the time) followed by NE (8.08 %) and N (5.94 %). Calm conditions prevailed for 45.35 % of the time. During night also the predominant wind direction is NNE (13.2 %), followed by N (10.37 %) and NE (8.08 %). Calm condition prevailed for 41.83 % of the time. Overall (24 hours), the predominant wind direction is NNE (12.09 %) followed by NE (8.33 %) and N (8.2 %). Calm conditions prevailed for 45.21 % of the time. During the entire monitoring period the predominant wind speeds were in the range of 0.44-2.0 m/s.

Figs. 3.3.1, 3.3.2 and **3.3.3** give the wind-rose diagrams of post monsoon season (2005) at Suakati township (Suakati-2) separately for day-night, day and night time respectively, based on the monitored data.

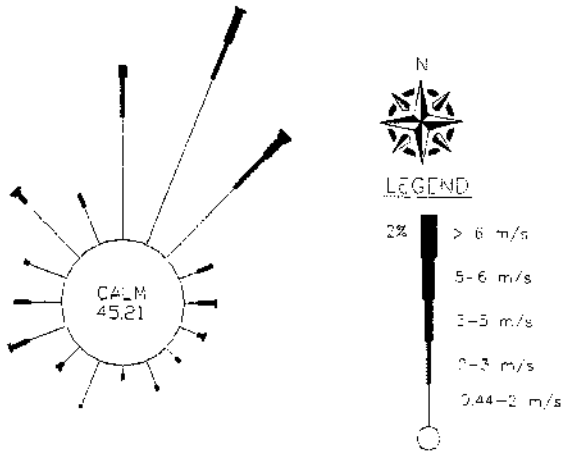


Fig.3.3.1: Wind Rose at Suakati, Post Monsoon'2005 (24 hours)

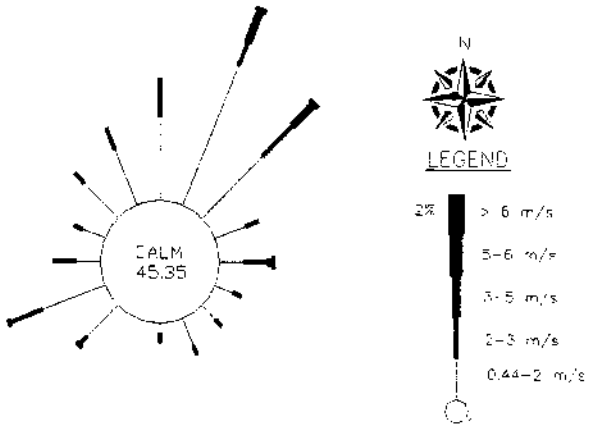


Fig. 3.3.2: Wind Rose at Suakati, Post Monsoon'2005 (Day)

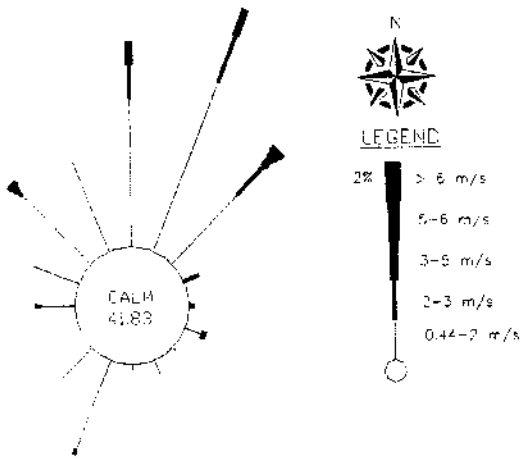


Fig.3.3.3: Wind Rose at Suakati, Post Monsoon'2005 (Night)

Table 3.2.2 give wind frequency pattern of day-night (24 hours), day and night as monitored during Winter (2005-06).

Table 3.2.2: Wind Frequency Distribution at Suakati during Winter 2005-06

A. 24 hours Overall

Direction	Velocity Ranges (m/s)					Sum %
	0.44<V<=2	2<V<=3	3<V<=5	5<V<=6	V>6	
N	3.52	1.97	1.10	0.00	0.09	6.68
NNE	2.29	1.83	0.73	0.09	0.00	4.94
NE	4.34	2.24	1.23	0.00	0.00	7.81
ENE	0.23	0.05	0.14	0.05	0.00	0.47
E	1.10	0.55	0.32	0.00	0.00	1.97
ESE	0.55	0.41	0.00	0.00	0.00	0.96
SE	0.55	0.23	0.05	0.00	0.00	0.83
SSE	0.27	0.05	0.05	0.00	0.00	0.37
S	0.59	0.05	0.09	0.05	0.00	0.78
SSW	0.55	0.23	0.05	0.00	0.00	0.83
SW	2.47	0.91	1.05	0.00	0.00	4.43
WSW	2.97	0.87	0.59	0.00	0.00	4.43
W	2.61	0.73	0.59	0.05	0.00	3.98
WNW	2.51	0.41	0.37	0.00	0.00	3.29
NW	7.54	1.28	1.51	0.00	0.09	10.42
NNW	4.48	0.91	0.37	0.00	0.00	5.76
Sum %	36.57	12.72	8.24	0.24	0.18	57.95
CALM % (V< 0.44 m/s) = 42.05						

B. Day Time (0600 – 1800 Hrs.)

Direction	Velocity Ranges (m/s)					Sum %
	0.44<V<=2	2<V<=3	3<V<=5	5<V<=6	V>6	
N	2.29	2.10	0.64	0.00	0.18	5.21
NNE	2.56	2.56	1.01	0.09	0.00	6.22
NE	4.48	2.56	1.64	0.00	0.00	8.68
ENE	0.09	0.00	0.09	0.09	0.00	0.27
E	1.46	0.64	0.55	0.00	0.00	2.65
ESE	1.01	0.64	0.00	0.00	0.00	1.65
SE	0.91	0.37	0.00	0.00	0.00	1.28
SSE	0.37	0.09	0.09	0.00	0.00	0.55
S	0.64	0.09	0.09	0.09	0.00	0.91
SSW	1.01	0.18	0.00	0.00	0.00	1.19
SW	2.65	1.19	0.64	0.00	0.00	4.48
WSW	2.92	0.64	0.46	0.00	0.00	4.02
W	2.10	0.64	0.46	0.09	0.00	3.29
WNW	2.10	0.46	0.46	0.00	0.00	3.02
NW	3.20	0.91	0.55	0.00	0.18	4.84
NNW	3.02	0.64	0.27	0.00	0.00	3.93
Sum %	30.81	13.71	6.95	0.36	0.36	52.19
CALM % (V< 0.44 m/s) = 47.81						

C. Night time (1800 – 0600 Hrs.)

Direction	Velocity Ranges (m/s)					Sum %
	0.44<V<=2	2<V<=3	3<V<=5	5<V<=6	V>6	
N	4.75	1.83	1.56	0.00	0.00	8.14
NNE	2.04	1.10	0.46	0.09	0.00	3.69
NE	4.21	1.92	0.82	0.00	0.00	6.95
ENE	0.37	0.09	0.18	0.00	0.00	0.64
E	0.73	0.46	0.09	0.00	0.00	1.28
ESE	0.09	0.18	0.00	0.00	0.00	0.27
SE	0.18	0.09	0.09	0.00	0.00	0.36
SSE	0.18	0.00	0.00	0.00	0.00	0.18
S	0.55	0.09	0.09	0.00	0.00	0.73
SSW	0.09	0.27	0.09	0.00	0.00	0.45
SW	2.28	0.64	1.46	0.00	0.00	4.38
WSW	3.02	1.10	0.73	0.00	0.00	4.85
W	3.11	0.82	0.73	0.00	0.00	4.66
WNW	2.93	0.36	0.27	0.00	0.00	3.56
NW	11.88	1.65	2.47	0.00	0.00	16.0
NNW	5.94	1.19	0.46	0.00	0.00	7.59
Sum %	42.35	11.79	9.50	0.09	0.00	63.73
CALM % (V< 0.44 m/s) = 36.27						

During day time, North East (NE) is the predominant wind direction (prevailing for about 8.68 % of the time) followed by NNE (6.22 %), and N (5.21 %). Calm conditions prevailed for 47.81 % of the time. During night the predominant wind direction is NW (16.0 %), followed by N (8.14 %) and NNW (7.59 %). Calm condition prevailed for 36.27 % of the time. Overall (24 hours) also, the predominant wind direction is also NW (10.42 %), followed by NE (7.81 %) and N (6.68 %). Calm

conditions prevailed for 42.05 % of the time. During the entire monitoring period the predominant wind speeds were in the range of 0.44-2.0 m/s.

Figs. 3.4.1, 3.4.2 and **3.4.3** give the wind-rose diagrams of Winter season (2005-06) at Suakati township (Suakati-2) separately for day-night, day and night time respectively, based on the monitored data.

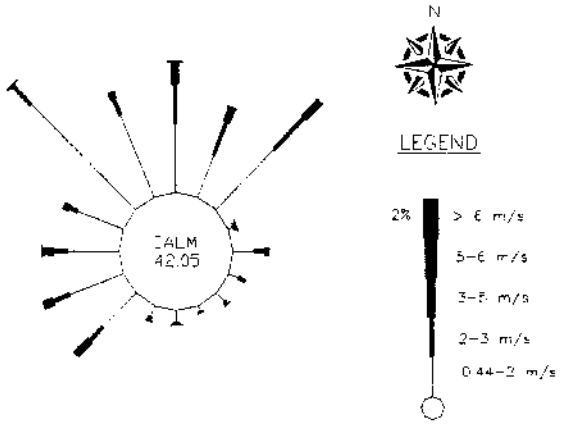


Fig.3.4.1: Wind Rose at Suakati, Winter'2005-06 (24 hours)

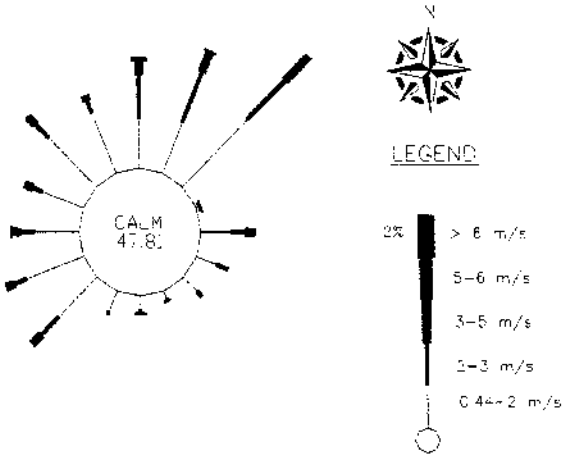


Fig. 3.4.2: Wind Rose at Suakati, Winter'2005-06 (Day)

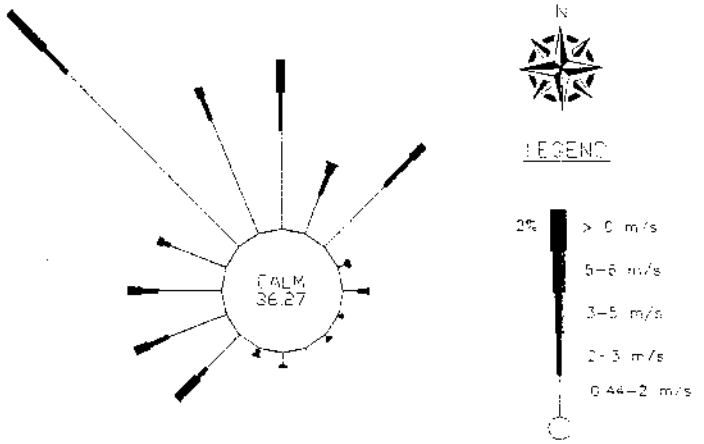


Fig. 3.4.3: Wind Rose at Suakati, Winter'2005-06 (Night)

3.4 AIR QUALITY

To quantify the impact of the mining and allied activities on the ambient air quality, it is necessary at first to evaluate the existing ambient air quality of the core and the buffer zones. The existing ambient air quality, in terms of Suspended Particulate Matter (SPM), Respirable Particulate Matter (RPM), Sulphur-dioxide (SO_2), Oxides of Nitrogen (NOx), Carbon Monoxide (CO), Lead (Pb) in SPM and Dust Fall has been measured through a planned field monitoring.

3.4.1 Monitoring Stations' Location

To assess the ambient air quality level, 14 (fourteen) monitoring stations were set up. Of these fourteen stations, one was within the mining core zone, while the rest were outside the mining lease up to a maximum distance of 6.5 km from core zone limit. **Table 3.3** gives location of the ambient air quality monitoring stations.

Table 3.3: Ambient Air Quality (AAQ) Monitoring Stations

Sl. No.	Location	Stn. Code	Distance & Direction from center of lease
1	Amjor	A28	5.0 Km ENE
2	Jaudihi	A29	4.2 Km ESE
3	Kainsari	A30	3.0 Km NE
4	Jamudihi	A31	3.5 Km SE
5	Suakati-2	A32	1.5 Km SE
6	Lunghar	A33	3.0 Km S
7	Daunra	A34	2.0 Km SW
8	Taljagar	A35	4.0 Km W
9	Uperjagar	A36	4.5 Km NW
10	Urumunda	A37	6.5 Km NW
11	Laupada	A38	6.5 Km N
12	Upar Kainsari	A39	5.5 Km NNE
13	Ichinda	A40	4.0 Km NE
14	Suakati-1	A41	Core zone

The stations are also marked in **Drawing No. MEC/Q696/11/S2/(6)7.**

In absence of any stack, the ambient air quality is expected to be affected in and around the mining areas up to a limited distance. Keeping this in view, air quality of core and nearby buffer zone (up to 6.5 km) has been monitored. Stations were set up in the nearby settlements / villages surrounding the mine lease.

3.4.2 Monitoring schedule

As mentioned earlier, the EIA report has been prepared based on Ambient Air Quality data generated at the core and buffer zone of the mine site for two seasons covering four weeks in Post-monsoon (September-October 2005) and one full season covering three months of Winter (November'2005, December'2005 and January'2006). Dust fall was recorded as 30 days average at each AAQ monitoring station. Samples of 24 hourly duration were taken for monitoring SPM, SO_2 and NO_x whereas for CO three one hourly samples were taken on each monitoring day. RPM and lead were measured in selected samples.

3.4.3 Methods of Sampling and Analysis

The methods of sample collection, equipment used and analysis procedure as followed are given in **Table 3.4**.

Table 3.4: Methodology of Sampling & Analysis and Equipment used

Sl. No.	Parameters	Instrument/ Apparatus used	Method followed	Reference
1.	Suspended Particulate Matter (SPM)	Respirable Dust Sampler (RDS/ HVS), Balance	Gravimetry	CPCB Notification of 11.4.94
2.	Respirable Particulate Matter (RPM)	Respirable Dust Sampler (RDS), Balance	Gravimetry	CPCB notification of 11-4-94
3.	Nitrogen Oxides (NOx)	RDS/HVAS with Impinger tubes, spectrophotometer	Jacobs and Hochheiser modified (Na-arsenite) Method	CPCB notification of 11-4-94
4.	Sulphur di-Oxide (SO_2)	RDS/HVAS with Impinger tubes, spectrophotometer	Improved West & Gaecke method	CPCB notification of 11-4-94
5.	Lead in SPM	RDS/HVAS, Atomic Absorption Spectrophotometer (AAS)	Gravimetric followed by AAS	CPCB notification of 11-4-94
6.	Carbon Monoxide	CO Analyser	NDIR Method	CPCB notification of 11-4-94.

3.4.4 Results and Discussions

From the monitored data, the summarised results are given in **Table 3.5.** The results when compared with National Ambient Air Quality Standards (NAAQS) of Central Pollution Control Board (CPCB) indicate that SPM and RPM are within the standard barring a few readings in certain villages due to dusts raised in unpaved village roads on vehicle movement. All other parameters are well within NAAQS.

Table 3.5 : Summarised Ambient Air Quality results

Name of monitoring equipment used		SPM			RPM			SO_2			NO_x			CO			Pb		
		High volume Air Sampler (HVAS)			Respirable Dust Sampler (RDS)			RDS/HVAS & Spectrophotometer			RDS/HVAS & Spectrophotometer			Tedler bag & Gas Chromatograph			HVAS & Atomic Absorption Spetrophotometer		
Equipment sensitivity		Detection Limit : 1 $\mu g/m^3$			Detection Limit : 1 $\mu g/m^3$			Detection Limit :10 $\mu g/m^3$			Detection Limit: :10 $\mu g/m^3$			Detection Limit: 114 $\mu g/m^3$			Detection Limit: 0.003 $\mu g/m^3$		
Permissible AAQ standard (CPCB)	R	200			100			80			80			4000			1.0		
	I	500			150			120			120			10000			1.5		
	S	150			75			30			30			2000			0.75		
Season (Period)	Monitoring Location	Category* (R, I, S)	Min.	Max.	Mean	Min.	Max.	Mean	Min.	Max.	Mean	Min.	Max.	Mean	Min.	Max.	Mean	Min.	Max.	Mean
Post monsoon (2.10.2005 – 31.10.2005)	Amjor	R	128	209	178	30	86	70	10.3	11.8	11.3	16.1	16.7	16.4	2288	2288	2288	0.011	-	-
	Jaudihi	R	147	206	177	74	103	91	10.9	12.1	11.2	15.7	17.4	16.9	1716	2289	1798	0.117	0.12	0.118
	Kansari	R	118	265	167	22	179	89	10.1	10.8	10.5	14.9	17.1	16	1144	3433	2288	0.094	-	-
	Jamudihi	R	167	201	188	67	109	96	10.1	11.5	10.6	15.1	16.7	16.2	1144	1716	1430	0.100	-	-
	Suakati-2	R	127	282	176	28	160	76	10.6	11.8	11.1	16.1	20.7	17.3	1144	2289	2146	0.120	0.125	0.122
	Lunghar	R	171	217	180	45	88	71	10.0	-	-	16.0	-	-	1144	-	-	0.100	-	-
	Daunra	R	95	211	182	22	101	91	10.4	12	11.2	16.4	17.8	17.1	1144	3432	2718	0.122	0.124	0.123
	Taljagar	R	155	258	211	57	160	106	10.3	11.8	11.1	15.7	17.6	16.6	2289	3223	2432	0.124	0.127	0.126
	Uperjagar	R	163	213	192	70	167	114	10.3	11.2	11.1	16.1	16.8	16.5	1716	3432	2431	0.087	-	-
	Urumunda	R	167	198	187	81	104	91	10.9	12.8	11.9	17.1	18.5	17.7	1145	2289	2003	0.127	-	-
	Laupada	R	175	201	191	98	123	106	10.3	11.5	11.1	15.7	20.7	17.1	1716	2289	2217	0.125	0.127	0.126
	Upar Kainsari	R	181	257	211	73	134	101	11.3	12.6	12.1	17.1	19.1	17.9	1716	2289	2146	0.113	-	-
	Ichinda	R	173	206	199	86	176	120	10.9	12.8	11.7	17.5	18.6	17.7	1716	2289	1859	0.125	0.13	0.127
	Suakati-1	R	103	203	197	59	129	89	10.9	12.6	11.6	17.2	17.5	17.4	2289	2289	2289	0.110	-	-
Winter	Amjor	R	159	258	239	74	128	118	<10	13.5	-	17.8	25.1	20.5	1945	2288	2074	0.044	0.066	0.051

Season (Period)	Monitoring Location	Category* (R, I, S)	Min.	Max.	Mean	Min.	Max.	Mean	Min.	Max.	Mean	Min.	Max.	Mean	Min.	Max.	Mean	Min.	Max.	Mean
(1.11.2005 – 31.01.2006)	Jaudihi	R	144	194	163	74	96	81	<10	10.7	-	15.0	20.9	17.1	1029	1144	1105	0.066	0.088	0.075
	Kansari	R	161	228	182	78	110	89	<10	14.1	-	16.1	23.4	18.4	1144	1373	1296	0.035	0.071	0.050
	Jamudihi	R	149	164	157	70	80	76	10.2	12.4	11.5	16.7	22.0	19.2	1144	1144	1144	0.036	0.053	0.047
	Suakati-2	R	150	171	160	75	86	81	<10	14.6	-	15.7	23.1	17.3	1144	1258	1182	0.071	0.128	0.103
	Lunghar	R	159	279	236	102	157	118	11.3	15.3	13.1	17.8	24.1	21.1	1467	1716	1560	0.036	0.085	0.065
	Daunra	R	189	223	191	94	101	96	11.3	16.3	13.0	18.1	24.8	21.6	1716	2288	2088	0.042	0.056	0.047
	Taljagar	R	121	215	194	76	104	98	10.2	13.0	11.6	16.1	23.1	19.6	1144	1373	1220	0.097	0.128	0.115
	Uperjagar	R	186	242	201	106	153	123	<10	11.3	-	17.1	17.8	17.5	1373	1602	1449	0.035	0.074	0.051
	Urumunda	R	152	220	187	69	110	92	<10	11.3	-	16.1	20.6	17.8	1144	1373	1220	0.088	0.114	0.099
	Laupada	R	135	201	158	69	98	78	<10	10.7	-	16.1	18.8	17.3	1029	1144	1106	0.075	0.085	0.081
	Upar Kainsari	R	162	213	181	78	103	88	<10	14.6	-	16.1	23.4	19.7	1144	1373	1220	0.035	0.066	0.051
	Ichinda	R	169	216	192	86	105	95	<10	11.3	-	16.7	19.5	17.9	1144	1373	1220	0.036	0.097	0.059
	Suakati-1	R	59	153	115	34	76	61	<10	11.3	-	15.7	17.4	16.4	1144	1144	1144	0.032	0.053	0.044

3.4.5 Dust Fall

Dust fall rates were recorded as 30 days average during monitoring period at all fourteen (14) AAQ monitoring stations. The results are given in **Table 3.6.**

Table 3.6: Measurement of Dust Fall Rate

Monitoring Location	1		2		3		4	
	Post-Monsoon	Winter	Post-Monsoon	Winter	Post-Monsoon	Winter	Post-Monsoon	Winter
Amjor	58.80	57.40	36.40	39.20	95.21	96.60	40.60	37.8
Jaudihi	59.07	50.83	39.84	38.84	98.91	89.67	37.09	34.34
Kansari	56.17	52.06	32.88	41.10	89.05	93.16	36.99	34.25
Jamudihi	56.99	55.60	36.14	36.14	93.13	91.74	41.70	34.75
Suakati mines	51.64	58.62	37.68	39.08	89.32	97.70	36.29	33.50
Lunghar	50.34	55.93	34.96	40.55	85.29	96.48	37.75	37.76
Daunra	52.17	53.58	40.89	38.07	93.07	91.65	33.84	40.89
Taljagar	53.73	55.11	33.07	42.71	86.80	97.82	39.95	35.82
Uperjagar	60.29	50.48	35.05	43.46	95.35	93.94	39.26	37.86
Urmunda	54.91	53.54	35.69	38.44	90.60	91.98	41.18	38.44
Laupada	53.52	57.75	38.03	42.25	91.54	100.0	42.25	32.39
Upar Kainsari	54.28	59.85	38.97	40.36	93.26	100.21	38.97	36.19
Ichinda	58.99	54.78	40.73	35.11	91.30	89.89	39.33	37.92
Suakati	49.76	51.14	33.18	34.56	82.94	85.70	34.56	33.17

Figures in mg/m²/day

Note 1:Total undissolved matter, 2: Total dissolved matter 3: Total solids 4: Ash content

In absence of Indian Norms, the results have been compared with the German norm published in TA Luft, 1986 which is as follows:

98 percentile value : 0.65 g/m²/d

The above results indicate that the dust fall rates at all the stations are within the compared German standard.

3.4.6 Work Zone Air Quality

One 8 hourly sample was collected to assess work zone air quality. The summarised results are given in **Table 3.7.**

Table 3.7: Summarised Results of Work Zone Air Quality Monitoring (Winter season)

Location	SPM	RPM	SO_2	NO_x	CO
Hill top quarry	112	25	11	14	<50

Figures are in μg/m³

The Work Zone Air Quality has been compared with the following norms:

SPM: 10,000 $\mu g/m^3$ (after American Council of Government Industrial Hygienists)
SO_2: 5,000 $\mu g/m^3$ (after Indian Factories Act)
NO_x: 6,000 $\mu g/m^3$ (after Indian Factories Act)
CO: 40,000 $\mu g/m^3$ (after Indian Factories Act)

It can be seen that the Work Zone Air Quality is well within the norms.

3.5 WATER SOURCES AND QUALITY

Sources of water in the study area are surface water in streams and river and ground water. Substantial amount of annual ground water recharge takes place in the study area. In order to study the impact on surface and ground water due to the mining project only the sub-water shed confining the contributing and receiving streams of hydrologic regime has been marked in **Drawing No. MEC/Q696/11/S2/(6) 8** and studied. Existing drainage in lease hold area is shown in **Drawing No. MEC/Q696/11/S2/(6) 5**.Characteristics of the sub-water shed have been given in **Table 3.8.**

Table 3.8: Physical Characteristics Sub-watershed

Area (sq. km)	171.703
Drainage density (km/sq.km)	5.29
Elevation variation (mRL)	440 - 1060

Water table in the area is confined to banded shale and tuff formations underlying the BHJ formation and the springs have originated mostly from the contact zones off these formations where water table cuts the BHJ formations. In the flat terrain the ground water table occurs at an average depth of 5 m below the ground level.

Water balance of the area has been approximated by Thronwaite's book keeping method, which is given in **Table 3.9.** Rainfall and Potential Evapotranspiration data of nearby IMD observatory at Keonjhargarh and Chaibasa have been used.

Table 3.9: Monthly Water Balance by Thronwaite's Method

	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual Mean
Rain fall	11.7	22.6	28.6	32.4	70.9	169.6	251.9	309.2	262.5	90.9	12.7	6.1	1269.1
Potential Evapotranspiration	69.5	88.6	137.0	162.4	176.5	128.7	100.8	95.7	94.1	103.1	80.8	64.8	1302.2
Actual Evapotranspiration	22.7	22.6	28.6	32.4	70.9	128.7	100.8	95.7	94.1	103.1	80.8	64.8	845.2
Soil moisture change						40.9	150	150	150	137.8	69.7	11	
Moisture surplus (Surface run off + deep storage as aquifer recharge							42	213.5	168.4				423.9

Table 3.9 indicates annual water balance in the region as shown below:

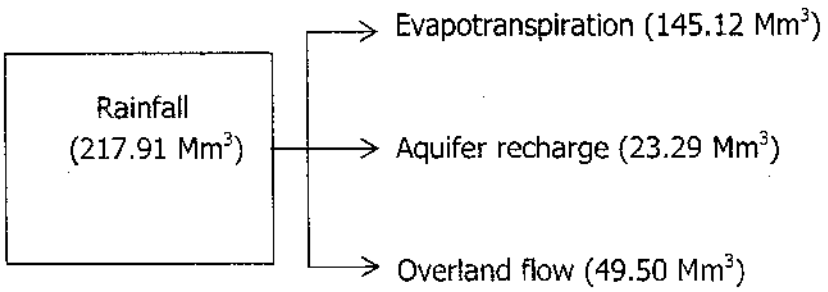
Rainfall (1269.1 mm) = Actual Evapotranspiration (845.2 mm)
+
Moisture surplus (423.9 mm)

The soil moisture surplus (423.9 mm) is an aggregate of (i) surface run-off and (ii) sub-surface ground water storage as aquifer recharge.

Considering a monsoon surface run-off coefficient of 0.35 for this type of area as indicated by Barlow (Source: Engineering Hydrology by R.S. Varshney, 1974) total monsoon run off discharge is calculated to be 288.26 mm (months with surface run off only are considered vide **Table 3.9**) which results in 135.64 mm (water head) annual aquifer recharge.

Annual water balance in the sub-water shed is summarised in **Fig. 3.5.**

Fig 3.5: Annual Water Balance in sub-water shed



3.5.1 Water Quality Monitoring stations, Frequency and Mode of Sampling

Water samples have been collected thrice during end-Monsoon (2005), Post monsoon (2005) and Winter (2005-06) from ten (10) locations, which are listed in **Table 3.10**.

All these locations are marked in **Drawing No. MEC/Q696/11/S2/(6)8**. Samples were collected from all these locations in October, 2005 and February, 2006.

Table 3.10: Water Sampling Locations

Sl. No.	Location	Stn. No.	Distance & direction from lease area	Type	Significance
1.	Ground water from Suakati on southern side of lease area	GW21	2.0 km S	Ground water	Downstream with respect to mine lease
2.	Ground water from Jamudihi	GW22	3.0 km SE	Ground water	Downstream with respect to mine lease
3.	Ground water from Daunra	GW23	1.7 km SW	Ground water	Downstream with respect to mine lease
4	Ground water at Taljagar	GW24	3.3 km NW	Ground water	Downstream of lease area
5.	Ground water from Urumunda	GW25	6.5 km NW	Ground water	Downstream of lease area
6.	Ground water from Laupada	GW26	6.2 km N	Ground water	Downstream of lease area
7.	Surface water from stream on Northern side of lease area at Upar Kainsari	SW12	5.6 km NEN	Surface water	Down-gradient of lease area
8.	Surface water from Nala on Eastern side of lease area near Amjor	SW13	6.0 km ESE	Surface water	Down-gradient of lease area
9	Surface water from stream before confluence with Sanjaladihi Nala	SW14	2.0 km S	Surface water	Down-gradient of lease area
10.	Surface water from Chamda Nala on SW side of lease area after confluence with Sanjaladihi Nala	SW15	4.5 km SW	Surface water	Down-gradient of lease area

3.5.2 Water Quality

The results of analysis of surface water are given in **Tables 3.11.1**, **3.11.2**, **3.11.3** and **3.11.4**. The results have been compared with the standards

specified in IS:10500 (1993) as well as Water Quality Criteria specified by Central Pollution Control Board (as given in **Table 3.12**).

Table 3.11.1: Results of Surface Water Analysis for SW12

Sl. No.	Parameter	Norms*		Surface water from Stream on Northern side of lease area at Upar Kainsari SW12		
		Desirable limits **	Permissible limits ***	Monsoon	Post Monsoon	Winter
				05.10.2005	26.10.2005	23.02.2006
	Essential Characteristics					
1	Colour, Hazen units, Max.	5	25	<5	<5	<5
2	Turbidity, NTU, Max.	5 max.	10	5	<5	<5
3	pH Value	6.5-8.5	6.5 – 8.5	7.3	7.2	7.3
4	Total Hardness (as CaCO3), mg/l, Max.	300	600	28	26	38
5	Iron (as Fe), mg/l, Max.	0.3	1	1.4	1.3	1.66
6	Chloride (as Cl), mg/l, Max.	250	1000	11	9	12
7	Fluoride (as F) mg/L, Max.	1	1.5	0.1	0.09	0.15
	Desirable Characteristics					
8	Dissolved Solids mg/l, Max.	500	2000	108	92	95
9	Calcium (as Ca), mg/l, Max.	75	200	10	8	10
10	Magnesium (as Mg), mg/L, Max.	30	100	1	1	3
11	Copper (as Cu), mg/l, Max.	0.05	1.5	<0.01	<0.01	<0.01
12	Manganese (as Mn), mg/l, Max.	0.1	0.3	0.01	0.01	0.032
13	Sulphate (as SO4), mg/l, Max.	200	400	16	10	9
14	Nitrate (as NO3), mg/l, Max.	45	100	0.6	0.41	0.73
15	Phenolic Compounds (as C6 H5OH), mg/l Max.	0.001	0.002	<0.001	<0.001	<0.001
16	Mercury (as Hg), mg/l, Max.	0.001	0.001	<0.0005	<0.0005	<0.0005
17	Cadmium (as Cd), mg/l, Max.	0.01	0.01	<0.005	<0.005	<0.005
18	Selenium (as Se), mg/l, Max.	0.01	0.01	<0.005	<0.005	<0.005
19	Arsenic (as As), mg/l, Max.	0.05	0.05	<0.03	<0.03	<0.03
20	Cyanide (as CN), mg/l, Max.	0.05	0.05	<0.01	<0.01	<0.01
21	Lead (as Pb), mg/l, Max.	0.05	0.05	<0.05	<0.05	<0.05
22	Zinc (as Zn), mg/l, Max.	5	15	0.04	0.04	0.041
23	Anionic detergent (as MBAS) mg/l, Max.	0.2	1	<0.1	<0.1	<0.1
24	Chromium (as Cr6 +), mg/l, Max.	0.05	0.05	<0.05	<0.05	<0.01
25	Mineral oil mg/l, Max.	0.01	0.03	<0.1	<0.1	<0.1
26	Alkalinity (as CaCO3) mg/l, Max.	200	600	36	32	36
27	Aluminium (as Al) mg/l, Max.	0.03	0.2	0.01	0.01	<0.01
	Additional Characteristics					
28	Dissolved Oxygen (as O_2), mg/l	-	-	5.1	5.4	5.3
29	BOD,3 days at 27° C, mg/l	-	-	2	2	1
30	Coliform organisms, MPN/100ml	-	-	700	500	350
31	Sodium Absorption Ratio	-	-	0.42	0.39	0.38

* Drinking Water Specification, IS : 10500 (1991) & Amendment no.1, January'1993
** Requirement (desirable limits) *** Permissible limits in the absence of alternate source

Table 3.11.2: Results of Surface Water Analysis for SW13

Sl. No.	Parameter	Norms*		Surface water from Nala on Eastern side of lease area near Amjor SW13		
		Desirable limits **	Permissible limits ***	Monsoon	Post Monsoon	Winter
				05.10.2005	26.10.2005	23.02.2006
	Essential Characteristics					
1	Colour, Hazen units, Max.	5	25	<5	<5	<5
2	Turbidity, NTU, Max.	5 max.	10	5	<5	<5
3	pH Value	6.5-8.5	6.5 – 8.5	7.4	7.7	7.5
4	Total Hardness (as CaCO3), mg/l,Max.	300	600	36	34	42
5	Iron (as Fe), mg/l, Max.	0.3	1	2.5	2.2	1.53
6	Chloride (as Cl), mg/l, Max.	250	1000	19	16	18
7	Fluoride (as F) mg/L, Max.	1	1.5	1.1	1	0.6
	Desirable Characteristics					
8	Dissolved Solids mg/l, Max.	500	2000	98	107	1.1
9	Calcium (as Ca), mg/l, Max.	75	200	2	2	9
10	Magnesium (as Mg), mg/L, Max.	30	100	8	6	5
11	Copper (as Cu), mg/l, Max.	0.05	1.5	0.03	0.03	<0.01
12	Manganese (as Mn), mg/l, Max.	0.1	0.3	<0.01	0.039	0.041
13	Sulphate (as SO4), mg/l, Max.	200	400	1	1	1
14	Nitrate (as NO3), mg/l, Max.	45	100	0.54	0.46	0.51
15	Phenolic Compounds (as C6 H5OH), mg/l Max.	0.001	0.002	<0.001	<0.001	<0.001
16	Mercury (as Hg), mg/l, Max.	0.001	0.001	<0.0005	<0.0005	<0.0005
17	Cadmium (as Cd), mg/l, Max.	0.01	0.01	<0.005	<0.005	<0.005
18	Selenium (as Se), mg/l, Max.	0.01	0.01	<0.005	<0.005	<0.005
19	Arsenic (as As), mg/l, Max.	0.05	0.05	<0.03	<0.03	<0.03
20	Cyanide (as CN), mg/l, Max.	0.05	0.05	<0.01	<0.01	<0.01
21	Lead (as Pb), mg/l, Max.	0.05	0.05	<0.05	<0.05	<0.05
22	Zinc (as Zn), mg/l, Max.	5	15	0.05	0.05	0.055
23	Anionic detergent (as MBAS) mg/l, Max.	0.2	1	<0.1	<0.1	<0.1
24	Chromium (as Cr6 +), mg/l, Max.	0.05	0.05	0.01	0.02	<0.01
25	Mineral oil mg/l, Max.	0.01	0.03	<0.1	<0.1	<0.1
26	Alkalinity (as CaCO3) mg/l, Max.	200	600	34	40	38
27	Aluminium (as Al) mg/l, Max.	0.03	0.2	0.02	0.01	<0.01
	Additional Characteristics					
28	Dissolved Oxygen (as O_2), mg/l	-	-	5.4	5.3	5.6
29	BOD,3 days at 27° C, mg/l	-	-	1	2	1
30	Coliform organisms, MPN/100ml	-	-	1100	900	600
31	Sodium Absorption Ratio	-	-	0.37	0.5	0.53

* Drinking Water Specification, IS : 10500 (1991) & Amendment no.1, January'1993
** Requirement (desirable limits) *** Permissible limits in the absence of alternate source

Table 3.11.3: Results of Surface Water Analysis for SW14

Sl. No.	Parameter	Norms*		Surface water from stream before confluence with Sanjaladihi Nala SW14		
		Desirable limits **	Permissible limits ***	Monsoon	Post Monsoon	Winter
				05.10.2005	26.10.2005	23.02.2006
	Essential Characteristics					
1	Colour, Hazen units, Max.	5	25	<5	<5	<5
2	Turbidity, NTU, Max.	5 max.	10	5	<5	<5
3	pH Value	6.5-8.5	6.5 – 8.5	7.8	7.5	7.4
4	Total Hardness (as CaCO3), mg/l,Max.	300	600	220	215	218
5	Iron (as Fe), mg/l, Max.	0.3	1	2.1	1.9	1.3
6	Chloride (as Cl), mg/l, Max.	250	1000	22	19	16
7	Fluoride (as F) mg/L, Max.	1	1.5	0.1	0.1	0.35
	Desirable Characteristics					
8	Dissolved Solids mg/l, Max.	500	2000	320	333	339
9	Calcium (as Ca), mg/l, Max.	75	200	43	41	44
10	Magnesium (as Mg), mg/L, Max.	30	100	27	24	26
11	Copper (as Cu), mg/l, Max.	0.05	1.5	0.02	0.02	<0.01
12	Manganese (as Mn), mg/l, Max.	0.1	0.3	<0.01	0.013	0.046
13	Sulphate (as SO4), mg/l, Max.	200	400	8	6	5
14	Nitrate (as NO3), mg/l, Max.	45	100	0.11	0.14	0.26
15	Phenolic Compounds (as C6 H5OH), mg/l Max.	0.001	0.002	<0.001	<0.001	<0.001
16	Mercury (as Hg), mg/l, Max.	0.001	0.001	<0.0005	<0.0005	<0.0005
17	Cadmium (as Cd), mg/l, Max.	0.01	0.01	<0.005	<0.005	<0.005
18	Selenium (as Se), mg/l, Max.	0.01	0.01	<0.005	<0.005	<0.005
19	Arsenic (as As), mg/l, Max.	0.05	0.05	<0.03	<0.03	<0.03
20	Cyanide (as CN), mg/l, Max.	0.05	0.05	<0.01	<0.01	<0.01
21	Lead (as Pb), mg/l, Max.	0.05	0.05	<0.05	<0.05	<0.05
22	Zinc (as Zn), mg/l, Max.	5	15	0.09	0.09	0.073
23	Anionic detergent (as MBAS) mg/l, Max.	0.2	1	<0.1	<0.1	<0.1
24	Chromium (as Cr6 +), mg/l, Max.	0.05	0.05	0.02	0.03	<0.01
25	Mineral oil mg/l, Max.	0.01	0.03	<0.1	<0.1	<0.1
26	Alkalinity (as CaCO3) mg/l, Max.	200	600	190	200	210
27	Aluminium (as Al) mg/l, Max.	0.03	0.2	0.01	0.01	<0.01
	Additional Characteristics					
28	Dissolved Oxygen (as O2), mg/l	-	-	5.6	5.3	5.4
29	BOD,3 days at 27° C, mg/l	-	-	1	1	1
30	Coliform organisms, MPN/100ml	-	-	1200	1100	900
31	Sodium Absorption Ratio	-	-	0.19	0.26	0.24

* Drinking Water Specification, IS : 10500 (1991) & Amendment no.1, January'1993
** Requirement (desirable limits) *** Permissible limits in the absence of alternate source

Table 3.11.4: Results of Surface Water Analysis for SW15

Sl. No.	Parameter	Norms*		Surface water from Chamba Nala on SW side of lease area after confluence with Sanjladihi Nala SW15		
		Desirable limits **	Permissible limits ***	Monsoon	Post Monsoon	Winter
				05.10.2005	26.10.2005	23.02.2006
	Essential Characteristics	-	-			
1	Colour, Hazen units, Max.	5	25	5	<5	<5
2	Turbidity, NTU, Max.	5 max.	10	5	<5	<5
3	pH Value	6.5-8.5	6.5 – 8.5	7.4	7.3	7.2
4	Total Hardness (as CaCO3), mg/l, Max.	300	600	20	18	36
5	Iron (as Fe), mg/l, Max.	0.3	1	1.2	0.99	1.58
6	Chloride (as Cl), mg/l, Max.	250	1000	14	12	18
7	Fluoride (as F) mg/L, Max.	1	1.5	0.1	0.1	0.12
	Desirable Characteristics					
8	Dissolved Solids mg/l, Max.	500	2000	86	74	89
9	Calcium (as Ca), mg/l, Max.	75	200	6	5	6
10	Magnesium (as Mg), mg/L,Max.	30	100	1	1	5
11	Copper (as Cu), mg/l, Max.	0.05	1.5	0.07	0.06	<0.01
12	Manganese (as Mn), mg/l, Max.	0.1	0.3	0.04	0.04	0.057
13	Sulphate (as SO4), mg/l, Max.	200	400	7	3	4
14	Nitrate (as NO3), mg/l, Max.	45	100	0.2	0.12	0.37
15	Phenolic Compounds (as C6 H5OH), mg/l Max.	0.001	0.002	<0.001	<0.001	<0.001
16	Mercury (as Hg), mg/l, Max.	0.001	0.001	<0.0005	<0.0005	<0.0005
17	Cadmium (as Cd), mg/l, Max.	0.01	0.01	<0.005	<0.005	<0.005
18	Selenium (as Se), mg/l, Max.	0.01	0.01	<0.005	<0.005	<0.005
19	Arsenic (as As), mg/l, Max.	0.05	0.05	<0.03	<0.03	<0.03
20	Cyanide (as CN), mg/l, Max.	0.05	0.05	<0.01	<0.01	<0.01
21	Lead (as Pb), mg/l, Max.	0.05	0.05	<0.05	<0.05	<0.05
22	Zinc (as Zn), mg/l, Max.	5	15	0.053	<0.005	0.054
23	Anionic detergent (as MBAS) mg/l,Max.	0.2	1	<0.1	<0.1	<0.1
24	Chromium (as Cr6 +), mg/l,Max.	0.05	0.05	0.02	0.04	<0.01
25	Mineral oil mg/l, Max.	0.01	0.03	<0.1	<0.1	<0.1
26	Alkalinity (as CaCO3) mg/l, Max.	200	600	22	20	30
27	Aluminium (as Al) mg/l, Max.	0.03	0.2	0.02	0.01	<0.01
	Additional Characteristics					
28	Dissolved Oxygen (as O_2), mg/l	-	-	5.4	6	5.4
29	BOD,3 days at 27° C, mg/l	-	-	2	1	2
30	Coliform organisms, MPN/100ml	-	-	700	600	500
31	Sodium Absorption Ratio	-	-	0.43	0.59	0.28

* Drinking Water Specification, IS : 10500 (1991) & Amendment no.1, January'1993
** Requirement (desirable limits) *** Permissible limits in the absence of alternate source

The results show surface water meets the criteria specified in IS:10500, except for slightly higher level of iron content. When compared with Water Quality Criteria specified by Central Pollution Control Board, the water sources meet criteria specified for Class B or Class C.

Table 3.12: Water Quality Criteria as per Central Pollution Control Board

Parameters	Class A	Class B	Class C	Class D	Class E
1. pH	6.5–8.5	6.5–8.5	6.0-9.0	6.5–8.5	6.0–8.5
2. Dissolved oxygen (as O_2), mg/l, min	6	5	4	4	-
3. BOD, 3 days at 27° C, max	2	3	3	-	-
4. 4.Total coliform organism, MPN/100 ml, max	50	500	5000	-	-
5. Free ammonia (as N), mg/l, max	-	-	-	1.2	-
6. Electrical conductivity, µmhos/cm, max	-	-	-	-	2250
7. Sodium absorption ratio, max.	-	-	-	-	26
8. Boron (as B), mg/l, max.	-	-	-	-	2

Class A: Drinking water source without conventional treatment but after disinfection

Class B: Outdoor bathing (organised)

Class C: Drinking water source after conventional treatment and after disinfection

Class D: Propagation of Wild life and Fisheries

Class E: Irrigation, Industrial Cooling, and Controlled Waste Disposal

Below E: Not meeting A, B, C, D & E Criteria

The results of analysis of ground water are given as **Tables 3.13.1, 3.13.2, 3.13.3, 3.13.4, 3.13.5** and **3.13.6.** The results have been compared with the drinking water quality standards specified in IS 10500. From the results it is obvious that the all the ground water quality parameters meet the prescribed norms except slightly higher level of iron content. The excess iron content of water is because of the presence of iron in the host rock itself.

Table 3.13.1: Results of Ground Water Analysis for sample GW21

Sl. No.	Parameters	Norms*		Ground water from Suakati on sothern side of lease area GW21		
		Desirable limits **	Permissible limits ***	Monsoon	Post Monsoon	Winter
	Essential Characteristics			05.10.2005	26.10.2005	23.02.2006
1	Colour, Hazen Units. Max.	5	25	5	5	<5
2	Odour	Unobjectionable	-	Unobjectionable	Unobjectionable	Unobjectionable
3	Taste	Agreeable	-	Agreeable	Agreeable	Agreeable
4	Turbidity, NTU, Max.	5	10	5	5	<5
5	pH value	6.5 to 8.5	No relaxation	7	7.2	7.1
6	Total Hardness(as CaCO3), mg/l, max	300	600	120	150	160
7	Iron (as Fe), mg/l, max.	0.3	1	9.8	7.4	7.5
8	Chloride (as Cl),mg/l, max.	250	1000	16	13	16
9	Fluoride (as F), mg/l, max.	1	1.5	0.2	0.29	0.16
	Desirable characteristics					
10	Total Dissolved Solids, mg/l, max.	500	2000	226	258	258
11	Calcium (as Ca), mg/l, max.	75	200	27	26	30
12	Magnesium(as Mg), mg/l, max.	30	100	13	12	19
13	Copper(as Cu), mg/l, max.	0.05	1.5	0.04	0.03	<0.01
14	Manganese (as Mn), mg/l, max.	0.1	0.3	0.1	0.09	0.15
15	Sulphate (as SO4), mg/l, max.	200	400	8	6	6
16	Nitrate (as NO3), mg/l, max.	45	100	0.2	0.1	0.52
17	Phenolic compounds(as C6H5OH), mg/l, max.	0.001	0.002	<0.001	<0.001	<0.001
18	Mercury,(as Hg), mg/l, max.	0.001	No relaxation	<0.0005	<0.0005	<0.0005
19	Cadmium (as Cd), mg/l, max.	0.01	No relaxation	<0.005	<0.005	<0.005
20	Selenium (as Se), mg/l, max.	0.01	No relaxation	<0.005	<0.005	<0.005
21	Arsenic (as As), mg/l, max.	0.05	No relaxation	<0.03	<0.03	<0.03
22	Cyanide (as CN), mg/l, max.	0.05	No relaxation	<0.01	<0.01	<0.01
23	Lead (as Pb), mg/l, max.	0.05	No relaxation	<0.05	<0.05	<0.05
24	Zinc (as Zn), mg/l, max.	5	15	0.5	0.4	0.46
25	Anionic Detergents (as MBAS), mg/l, max.	0.2	1	<0.1	<0.1	<0.1
26	Chromium (as Cr6 +), mg/l, Max.	0.05	No relaxation	<0.01	<0.01	<0.01
27	Mineral oil mg/l, Max.	0.01	0.03	<0.1	<0.1	<0.1
28	Alkalinity(as CaCO3), mg/l	200	600	120	148	155
29	Aluminium (as Al), mg/l	0.03	0.2	0.01	<0.01	<0.01
30	Boron (as B), mg/l, max.	1	5	0.01	<0.01	<0.01

* Drinking Water Specification, IS : 10500 (1991) & Amendment no.1, January'1993
** Requirement (desirable limits) *** Permissible limits in the absence of alternate source

Table 3.13.2: Results of Ground Water Analysis for sample GW22

Sl. No.	Parameters	Norms*		Ground water from Jamudihi GW22		
		Desirable limits **	Permissible limits ***	Monsoon	Post Monsoon	Winter
	Essential Characteristics			05.10.2005	26.10.2005	23.02.2006
1	Colour, Hazen Units. Max.	5	25	<5	<5	<5
2	Odour	Unobjectionable	-	Unobjectionable	Unobjectionable	Unobjectionable
3	Taste	Agreeable	-	Agreeable	Agreeable	Agreeable
4	Turbidity, NTU, Max.	5	10	<5	<5	<5
5	pH value	6.5 to 8.5	No relaxation	7.8	7.9	7.5
6	Total Hardness(as CaCO3), mg/l, max	300	600	92	87	95
7	Iron (as Fe), mg/l, max.	0.3	1	1.6	1.4	1.7
8	Chloride (as Cl),mg/l, max.	250	1000	17	13	20
9	Fluoride (as F), mg/l, max.	1	1.5	0.1	0.1	0.17
	Desirable characteristics					
10	Total Dissolved Solids, mg/l, max.	500	2000	210	202	171
11	Calcium (as Ca), mg/l, max.	75	200	34	32	32
12	Magnesium(as Mg), mg/l, max.	30	100	2	2	4
13	Copper(as Cu), mg/l, max.	0.05	1.5	0.06	0.05	<0.01
14	Manganese (as Mn), mg/l, max.	0.1	0.3	0.1	0.07	0.12
15	Sulphate (as SO4), mg/l, max.	200	400	1	1	1
16	Nitrate (as NO3), mg/l, max.	45	100	3	0.26	0.56
17	Phenolic compounds(as C6H5OH), mg/l, max.	0.001	0.002	<0.001	<0.001	<0.001
18	Mercury,(as Hg), mg/l, max.	0.001	No relaxation	<0.0005	<0.0005	<0.0005
19	Cadmium (as Cd), mg/l, max.	0.01	No relaxation	<0.005	<0.005	<0.005
20	Selenium (as Se), mg/l, max.	0.01	No relaxation	<0.005	<0.005	<0.005
21	Arsenic (as As), mg/l, max.	0.05	No relaxation	<0.03	<0.03	<0.03
22	Cyanide (as CN), mg/l, max.	0.05	No relaxation	<0.01	<0.01	<0.01
23	Lead (as Pb), mg/l, max.	0.05	No relaxation	<0.05	<0.05	<0.05
24	Zinc (as Zn), mg/l, max.	5	15	0.3	0.2	0.39
25	Anionic Detergents (as MBAS), mg/l, max.	0.2	1	<0.1	<0.1	<0.1
26	Chromium (as Cr6 +), mg/l, Max.	0.05	No relaxation	0.03	0.03	0.03
27	Mineral oil mg/l, Max.	0.01	0.03	<0.1	<0.1	<0.1
28	Alkalinity(as CaCO3), mg/l	200	600	112	108	88
29	Aluminium (as Al), mg/l	0.03	0.2	<0.01	<0.01	<0.01
30	Boron (as B), mg/l, max.	1	5	<0.01	<0.01	<0.01

* Drinking Water Specification, IS : 10500 (1991) & Amendment no.1, January'1993
** Requirement (desirable limits) *** Permissible limits in the absence of alternate source

Table 3.13.3: Results of Ground Water Analysis for sample GW23

Sl. No.	Parameters	Norms*		Ground water from Daunra GW23		
		Desirable limits **	Permissible limits ***	Monsoon	Post Monsoon	Winter
	Essential Characteristics			**05.10.2005**	**26.10.2005**	**23.02.2006**
1	Colour, Hazen Units. Max.	5	25	<5	<5	<5
2	Odour	Unobjectionable	-	Unobjectionable	Unobjectionable	Unobjectionable
3	Taste	Agreeable	-	Agreeable	Agreeable	Agreeable
4	Turbidity, NTU, Max.	5	10	<5	<5	<5
5	pH value	6.5 to 8.5	No relaxation	7.4	7.1	7.2
6	Total Hardness(as CaCO3), mg/l, max	300	600	52	49	55
7	Iron (as Fe), mg/l, max.	0.3	1	0.78	0.47	0.68
8	Chloride (as Cl),mg/l, max.	250	1000	20	16	16
9	Fluoride (as F), mg/l, max.	1	1.5	0.4	0.36	0.14
	Desirable characteristics					
10	Total Dissolved Solids, mg/l, max.	500	2000	189	217	118
11	Calcium (as Ca), mg/l, max.	75	200	10	8	14
12	Magnesium(as Mg), mg/l, max.	30	100	7	6	5
13	Copper(as Cu), mg/l, max.	0.05	1.5	<0.01	<0.01	<0.01
14	Manganese (as Mn), mg/l, max.	0.1	0.3	0.01	0.01	0.05
15	Sulphate (as SO4), mg/l, max.	200	400	7	6	5
16	Nitrate (as NO3), mg/l, max.	45	100	2.9	2.1	1.42
17	Phenolic compounds(as C6H5OH), mg/l, max.	0.001	0.002	<0.001	<0.001	<0.001
18	Mercury,(as Hg), mg/l, max.	0.001	No relaxation	<0.0005	<0.0005	<0.0005
19	Cadmium (as Cd), mg/l, max.	0.01	No relaxation	<0.005	<0.005	<0.005
20	Selenium (as Se), mg/l, max.	0.01	No relaxation	<0.005	<0.005	<0.005
21	Arsenic (as As), mg/l, max.	0.05	No relaxation	<0.03	<0.03	<0.03
22	Cyanide (as CN), mg/l, max.	0.05	No relaxation	<0.01	<0.01	<0.01
23	Lead (as Pb), mg/l, max.	0.05	No relaxation	<0.05	<0.05	<0.05
24	Zinc (as Zn), mg/l, max.	5	15	0.04	<0.005	0.12
25	Anionic Detergents (as MBAS), mg/l, max.	0.2	1	<0.1	<0.1	<0.1
26	Chromium (as Cr6 +), mg/l, Max.	0.05	No relaxation	0.01	<0.01	0.01
27	Mineral oil mg/l, Max.	0.01	0.03	<0.1	<0.1	<0.1
28	Alkalinity(as CaCO3), mg/l	200	600	90	109	54
29	Aluminium (as Al), mg/l	0.03	0.2	0.01	0.01	<0.01
30	Boron (as B), mg/l, max.	1	5	<0.01	<0.01	<0.01

* Drinking Water Specification, IS : 10500 (1991) & Amendment no.1, January'1993.
** Requirement (desirable limits) *** Permissible limits in the absence of alternate source

Table 3.13.4: Results of Ground Water Analysis for sample GW24

Sl. No.	Parameters	Norms*		Ground water from Taljagar GW24		
		Desirable limits **	Permissible limits ***	Monsoon	Post Monsoon	Winter
	Essential Characteristics			05.10.2005	26.10.2005	23.02.2006
1	Colour, Hazen Units. Max.	5	25	5	5	<5
2	Odour	Unobjectionable	-	Unobjectionable	Unobjectionable	Unobjectionable
3	Taste	Agreeable	-	Agreeable	Agreeable	Agreeable
4	Turbidity, NTU, Max.	5	10	5	5	<5
5	pH value	6.5 to 8.5	No Relaxation	7.4	7.5	7.3
6	Total Hardness(as CaCO3), mg/l, max	300	600	192	185	203
7	Iron (as Fe), mg/l, max.	0.3	1	0.6	0.22	0.5
8	Chloride (as Cl),mg/l, max.	250	1000	14	12	15
9	Fluoride (as F), mg/l, max.	1	1.5	0.03	0.03	0.04
	Desirable characteristics					
10	Total Dissolved Solids, mg/l, max.	500	2000	315	277	215
11	Calcium (as Ca), mg/l, max.	75	200	40	35	49
12	Magnesium(as Mg), mg/l, max.	30	100	22	19	19
13	Copper(as Cu), mg/l, max.	0.05	1.5	<0.01	<0.01	<0.01
14	Manganese (as Mn), mg/l, max.	0.1	0.3	0.09	0.07	0.12
15	Sulphate (as SO4), mg/l, max.	200	400	1	1	1
16	Nitrate (as NO3), mg/l, max.	45	100	3.6	3.4	2.19
17	Phenolic compounds(as C6H5OH), mg/l, max.	0.001	0.002	<0.001	<0.001	<0.001
18	Mercury,(as Hg), mg/l, max.	0.001	No relaxation	<0.0005	<0.0005	<0.0005
19	Cadmium (as Cd), mg/l, max.	0.01	No relaxation	<0.005	<0.005	<0.005
20	Selenium (as Se), mg/l, max.	0.01	No relaxation	<0.005	<0.005	<0.005
21	Arsenic (as As), mg/l, max.	0.05	No relaxation	<0.03	<0.03	<0.03
22	Cyanide (as CN), mg/l, max.	0.05	No relaxation	<0.01	<0.01	<0.01
23	Lead (as Pb), mg/l, max.	0.05	No relaxation	<0.05	<0.05	<0.05
24	Zinc (as Zn), mg/l, max.	5	15	0.5	0.47	0.38
25	Anionic Detergents (as MBAS), mg/l, max.	0.2	1	<0.1	<0.1	<0.1
26	Chromium (as Cr6+), mg/l, Max.	0.05	No relaxation	<0.01	<0.01	<0.01
27	Mineral oil mg/l, Max.	0.01	0.03	<0.1	<0.1	<0.1
28	Alkalinity(as CaCO3), mg/l	200	600	180	160	190
29	Aluminium (as Al), mg/l	0.03	0.2	0.01	<0.01	<0.01
30	Boron (as B), mg/l, max.	1	5	0.01	<0.01	<0.01

* Drinking Water Specification, IS : 10500 (1991) & Amendment no.1, January'1993
** Requirement (desirable limits) *** Permissible limits in the absence of alternate source

Table 3.13.5: Results of Ground Water Analysis for sample GW25

Sl. No.	Parameters	Norms*		Ground water from Urumunda GW25		
		Desirable limits **	Permissible limits ***	Monsoon	Post Monsoon	Winter
	Essential Characteristics			05.10.2005	26.10.2005	23.02.2006
1	Colour, Hazen Units. Max.	5	25	<5	<5	<5
2	Odour	Unobjectionable	-	Unobjectionable	Unobjectionable	Unobjectionable
3	Taste	Agreeable	-	Agreeable	Agreeable	Agreeable
4	Turbidity, NTU, Max.	5	10	<5	<5	<5
5	pH value	6.5 to 8.5	No Relaxation	7.5	7.6	7.5
6	Total Hardness(as CaCO3), mg/l, max	300	600	48	39	53
7	Iron (as Fe), mg/l, max.	0.3	1	8.5	7.6	6.4
8	Chloride (as Cl),mg/l, max.	250	1000	19	15	18
9	Fluoride (as F), mg/l, max.	1	1.5	2.4	2.1	0.92
	Desirable characteristics					
10	Total Dissolved Solids, mg/l, max.	500	2000	157	149	115
11	Calcium (as Ca), mg/l, max.	75	200	15	14	12
12	Magnesium(as Mg), mg/l, max.	30	100	11	9	6
13	Copper(as Cu), mg/l, max.	0.05	1.5	<0.01	<0.01	<0.01
14	Manganese (as Mn), mg/l, max.	0.1	0.3	0.2	0.16	0.18
15	Sulphate (as SO4), mg/l, max.	200	400	1	1	2
16	Nitrate (as NO3), mg/l, max.	45	100	2.2	1.8	2.32
17	Phenolic compounds(as C6H5OH), mg/l, max.	0.001	0.002	<0.001	<0.001	<0.001
18	Mercury,(as Hg), mg/l, max.	0.001	No relaxation	<0.0005	<0.0005	<0.0005
19	Cadmium (as Cd), mg/l, max.	0.01	No relaxation	<0.005	<0.005	<0.005
20	Selenium (as Se), mg/l, max.	0.01	No relaxation	<0.005	<0.005	<0.005
21	Arsenic (as As), mg/l, max.	0.05	No relaxation	<0.03	<0.03	<0.03
22	Cyanide (as CN), mg/l, max.	0.05	No relaxation	<0.01	<0.01	<0.01
23	Lead (as Pb), mg/l, max.	0.05	No relaxation	<0.05	<0.05	<0.05
24	Zinc (as Zn), mg/l, max.	5	15	0.22	<0.005	0.16
25	Anionic Detergents (as MBAS), mg/l, max.	0.2	1	<0.1	<0.1	<0.1
26	Chromium (as Cr6 +), mg/l, Max.	0.05	No relaxation	<0.01	<0.01	<0.01
27	Mineral oil mg/l, Max.	0.01	0.03	<0.1	<0.1	<0.1
28	Alkalinity(as CaCO3), mg/l	200	600	60	56	48
29	Aluminium (as Al), mg/l	0.03	0.2	<0.01	<0.01	<0.01
30	Boron (as B), mg/l, max.	1	5	<0.01	<0.01	<0.01

* Drinking Water Specification, IS : 10500 (1991) & Amendment no.1, January'1993

** Requirement (desirable limits) *** Permissible limits in the absence of alternate source

Table 3.13.6: Results of Ground Water Analysis for sample GW26

Sl. No.	Parameters	Norms*		Ground water from Laupada GW26		
		Desirable limits **	Permissible limits ***	Monsoon	Post Monsoon	Winter
	Essential Characteristics			**05.10.2005**	**26.10.2005**	**23.02.2006**
1	Colour, Hazen Units. Max.	5	25	<5	<5	<5
2	Odour	Unobjectionable	-	Unobjectionable	Unobjectionable	Unobjectionable
3	Taste	Agreeable	-	Agreeable	Agreeable	Agreeable
4	Turbidity, NTU, Max.	5	10	<5	<5	<5
5	pH value	6.5 to 8.5	No Relaxation	7.4	7.5	7.4
6	Total Hardness(as CaCO3), mg/l, max	300	600	84	79	93
7	Iron (as Fe), mg/l, max.	0.3	1	3.9	2.7	2.9
8	Chloride (as Cl),mg/l, max.	250	1000	12	11	13
9	Fluoride (as F), mg/l, max.	1	1.5	1.4	1	0.46
	Desirable characteristics					
10	Total Dissolved Solids, mg/l, max.	500	2000	190	168	168
11	Calcium (as Ca), mg/l, max.	75	200	29	25	26
12	Magnesium(as Mg), mg/l, max.	30	100	3	3	7
13	Copper(as Cu), mg/l, max.	0.05	1.5	<0.01	<0.01	<0.01
14	Manganese (as Mn), mg/l, max.	0.1	0.3	0.01	0.01	0.06
15	Sulphate (as SO4), mg/l, max.	200	400	29	24	1
16	Nitrate (as NO3), mg/l, max.	45	100	0.96	0.81	1.99
17	Phenolic compounds(as C6H5OH), mg/l, max.	0.001	0.002	<0.001	<0.001	<0.001
18	Mercury,(as Hg), mg/l, max.	0.001	No relaxation	<0.0005	<0.0005	<0.0005
19	Cadmium (as Cd), mg/l, max.	0.01	No relaxation	<0.005	<0.005	<0.005
20	Selenium (as Se), mg/l, max.	0.01	No relaxation	<0.005	<0.005	<0.005
21	Arsenic (as As), mg/l, max.	0.05	No relaxation	<0.03	<0.03	<0.03
22	Cyanide (as CN), mg/l, max.	0.05	No relaxation	<0.01	<0.01	<0.01
23	Lead (as Pb), mg/l, max.	0.05	No relaxation	<0.05	<0.05	<0.05
24	Zinc (as Zn), mg/l, max.	5	15	0.126	0.11	0.11
25	Anionic Detergents (as MBAS), mg/l, max.	0.2	1	<0.1	<0.1	<0.1
26	Chromium (as Cr6 +), mg/l, Max.	0.05	No relaxation	<0.01	<0.01	<0.01
27	Mineral oil mg/l, Max.	0.01	0.03	<0.1	<0.1	<0.1
28	Alkalinity(as CaCO3), mg/l	200	600	80	68	86
29	Aluminium (as Al), mg/l	0.03	0.2	0.01	0.01	<0.01
30	Boron (as B), mg/l, max.	1	5	<0.01	<0.01	<0.01

* Drinking Water Specification, IS : 10500 (1991) & Amendment no.1, January'1993
** Requirement (desirable limits) *** Permissible limits in the absence of alternate source

3.6 NOISE LEVELS

In order to have an idea about the existing noise level of the study area, noise monitoring has been carried out at nine villages listed in **Table 3.14**. These stations are also marked in **Drawing No. MEC/Q696/11/S2/(6)7**. In addition, work zone noise was also monitored at two locations, which are listed in **Table 3.15**.

Table 3.14: Ambient Noise Monitoring Stations

Stn. No.	Location	Core Zone/ Buffer Zone	Distance & Direction (from Centre of proposed project)
N25	Suakati-1	Core zone	-
N26	Suakati-2	Buffer zone	1.8 Km SES
N27	Lunghar	Buffer zone	2.5 Km S
N28	Daunra	Buffer zone	1.8 Km SW
N29	Taljagar	Buffer zone	3.5 Km NW
N23	Ichinda	Buffer zone	3.5 NEN
N30	Laupada	Buffer zone	6.0 Km N
N22	Amjor	Buffer zone	5.7 Km NE
N24	Jaudihi	Buffer zone	4 Km NE

Table 3.15: List of Work Zone Noise Monitoring Stations

Stn. No.	Location
WZN-1	Near Mine Office
WZN-2	Near mining operation at Suakati Mines

3.6.1 Noise Monitoring Frequency

Monitoring was carried out during Post monsoon and Winter seasons. At each ambient noise monitoring station, Leq. noise level was recorded at hourly intervals for 24 hours continuously by operating the noise-recording instrument for fifteen (15) minutes during each hour. At work-zone noise monitoring stations, Leq noise was recorded at hourly intervals for 8 hours continuously by operating the noise-recording instrument for fifteen (15) minutes during each hour.

3.6.2 Results and Discussions

The summarised results of ambient noise monitoring are given in **Table 3.16**. The results have been compared with the standard specified in Noise 2000 Standards of Environmental Protection Rules given in **Table 3.17**.

Table 3.16: Summarised Results of Noise Monitoring

Season	Station No.	Location	Results					
			Day (0600-2200 hr.)			Night (2200-0600 hr.)		
			Max.	Min.	Leq.*	Max.	Min.	Leq.*
Post-Monsoon	N22	Amjor	52.3	44.7	48.2	38.5	32.7	35.6
	N23	Ichinda	59.7	43.1	55.3	46.8	39.5	42.2
	N24	Jaudihi	47.6	41.6	44.8	38.9	33.2	35.8
	N25	Suakati-1(Core zone)	52.1	37.6	48.0	45.8	33.4	39.9
	N26	Suakati-2	56.7	45.2	51.6	46.3	39.3	42.8
	N27	Lunghar	52.0	39.8	47.7	45.4	34.1	40.3
	N28	Daunra	47.2	41.4	44.1	38.0	33.8	35.8
	N29	Taljagar	48.9	32.7	44.6	40.3	34.2	36.8
	N30	Laupada	48.2	37.2	45.5	42.2	31.3	37.5
Winter	N22	Amjor	56.5	39.8	50.7	47.9	38.7	43.6
	N23	Ichinda	62.1	44.9	58.5	53.9	35.7	45.8
	N24	Jaudihi	51.1	39.5	46.1	42.1	32.9	37.0
	N25	Suakati-1(Core Zone)	64.5	46.2	56.9	45.1	35.1	41.5
	N26	Suakati -- 2	54.3	44.2	51.9	44.3	37.3	41.6
	N27	Lunghar	53.1	37.9	49.2	43.2	33.9	37.8
	N28	Daunra	50.7	41.9	46.8	40.5	35.9	37.9
	N29	Taljagar	47.9	39.1	43.7	38.9	33.9	36.8
	N30	Laupada	49.1	37.9	45.5	41.1	32.1	36.0

** Leq of day time/night time hourly values.* *All Values in dB (A).*

Table 3.17: Ambient Air Quality norms in respect of Noise

Type of Area	Day (0600 - 2200 hrs).	Night (2200 – 0600 hrs.)
Industrial Area	75	70
Commercial Area	65	55
Residential Area	55	45
Silence Zone	50	40

All Values in dB (A)

The table shows noise level in general, is within Noise 2000 standard. The summarised results of Work Zone Noise Monitoring are given in **Table 3.18**.

Table 3.18: Summarised Results of Work Zone Noise Monitoring

Season	Stn. No.	Location	Noise Level in dB(A)		
			Max.	Min.	Avg.
	WZN-1	Near Mine Office	56.1	45.1	52.6
	WZN-2	Near mining operation at Suakati Mines	68.2	52.9	63.7
Winter	WZN-1	Near Mine Office	73.7	66.8	71.5
	WZN-2	Near mining operation at Suakati Mines	72.6	66.5	70.4

Noise level at Work zone are well within the DGMS standard of 90 dB(A) for 8 hours exposure.

3.7 SOIL CHARACTERISTICS

To assess the quality of soil in and around the mining area, soil samples were collected from six locations during Post monsoon (2005) and Winter (2005-06) for physico-chemical analysis. **Table 3.19** lists the soil sampling locations. These locations are also marked in **Drawing No. MEC/Q696/11/S2/(6)8.**

Table 3.19: List of Soil Sampling Locations

Sample No.	Location	Type of Land
S29	Jaudihi	Agricultural Land
S32	Suakati (Core zone)	Agricultural Land
S33	Suakati (Core zone)	Barren Land
S34	Daunra	Agricultural land
S35	TalJagar	Agricultural land
S36	Laupada	Forest Land

The analysed results of analysis are given in **Tables 3.20, 3.21, 3.22, 3.23** and **3.24**.

Table 3.20: Physical Properties of Soil

Sample No.	Colour		Texture		Water Holding Capacity (%)	
	Post-Monsoon	Winter	Post-Monsoon	Winter	Post-Monsoon	Winter
S29	Red	Reddish Brown	Loamy	Loamy	23.9	26
S32	Red	Reddish Brown	Loamy	Loamy	40.5	42
S33	Red	Reddish Brown	Loamy	Loamy	28.4	33
S34	Red	Reddish Brown	Loamy	Loamy	42.1	41
S35	Red	Reddish Brown	Loamy	Loamy	30.4	33
S36	Red	Reddish Brown	Loamy	Loamy	38.0	37

Table 3.21: Chemical Properties of Soil

Parameters	Samples											
	S29		S32		S33		S34		S35		S36	
	Post-Monsoon	Winter	Post-Monsoon	Winter	Post-	Winter	Post-Monsoon	Winter	Post-Monsoon	Winter	Post-Monsoon	Winter
pH	6.8	6.9	7.5	7.1	6.9	6.8	7.2	7.0	6.9	6.8	7.0	6.9
Electrical Conductivity (μ mhos/cm)	103	97	75	82	63	73	88	84	92	93	64	86

Soil pH plays an important role in the availability of nutrients. Soil microbial activity is also dependent on pH. In the soil samples the soil pH is neutral (6.8 < pH <7.5). Electrical conductivity (EC) is a measure of the soluble salts and ionic activity in the soil. In the collected soil samples the conductivity ranged from 64 to 103 μ mhos/cm. In core zone electrical conductivity ranges from 63-82 μs/cm.

Table 3.22: Available NPK contents in soil

Parameters	Samples											
	S29		S32		S33		S34		S35		S36	
	Post-Monsoon	Winter	Post-Monsoon	Winter	Post-Monsoon	Winter	Post-Monsoon	Winter	Post-Monsoon	Winter	Post-Monsoon	Winter
Available Nitrogen (kg/ha) and rating	985 H	849 H	846 H	808 H	322 M	306 M	2421 H	2038 H	1817 H	1362 H	1693 H	1209 H
Available Phosphorus (kg/ha) and rating	50 H	42 H	10 M	8 L	13 M	12 M	8.0 L	9.0 L	4.0 L	7.0 L	5.0 L	7.0 L
Available Potassium (kg/ha) and rating	1210 H	858 H	289 H	267 M	336 H	358 H	242 M	230 M	264 M	286 H	370 H	343 H
Organic carbon (%) and rating	0.3 L	0.25 L	0.3 L	0.20 L	0.4 L	0.60 M	0.7 M	0.63 M	0.4 L	0.32 L	1.0 H	0.72 H
Organic matter %	1.2	0.43	0.52	0.35	0.69	1.04	1.9	1.09	1.1	0.55	2.4	1.25

Rating based on :						
Available Nitrogen (Kg/Ha)	<280 - Low;	280- 560	Medium;	>560	- High	
Available Phosphorus (Kg/Ha)	<10 - Low;	10 - 25	Medium;	>25	- High	
Available Potassium (Kg/Ha)	<120 - Low;	120 - 280	Medium;	>280	- High	
Organic carbon (%)	<0.50- Low;	0.5-0.75	Medium;	> 0.75 – High		

Phosphorus and Nitrogen are limiting nutrients, especially phosphorus. In the tested soil samples, availability of phosphorus is mostly low. Available Nitrogen is high. Organic carbon content is low to high while potassium content is medium to high.

Table 3.23: Exchangeable Cations

Parameters	Samples											
	S29		S32		S33		S34		S35		S36	
	Post-Monsoon	Winter	Post-Monsoon	Winter	Post-Monsoon	Winter	Post-Monsoon	Winter	Post-Monsoon	Winter	Post-Monsoon	Winter
Calcium (meq/100gm)	12.0	9.0	6.0	7.0	5.0	6.0	12	13	4.0	6.0	3.0	5.0
% contribution to the Base Saturation	69.76	60.08	62.5	64.22	65.78	61.22	68.18	70.27	51.94	56.6	44.77	57.47
Magnesium (meq/100gm)	4.0	5.0	3.0	3.0	2.0	3.0	5.0	5.0	3.0	4.0	3.0	3.0
% contribution to the Base Saturation	23.25	33.38	31.25	27.52	26.31	30.61	28.4	27.03	38.96	37.74	44.77	34.48
Sodium (meq/100gm)	0.3	0.26	0.3	0.5	0.3	0.3	0.3	0.2	0.3	0.3	0.2	0.3
% contribution to the Base Saturation	1.16	1.74	3.12	4.59	3.94	3.06	1.7	1.08	3.89	2.83	2.98	3.45
Potassium (meq/100gm)	0.9	0.7	0.3	0.4	0.3	0.5	0.3	0.3	0.4	0.3	0.5	0.4
% contribution to the Base Saturation	5.23	4.81	3.12	3.67	3.94	5.10	1.7	1.62	5.19	2.83	7.46	4.6

The above results show that the tested soil samples have moderate quantities of calcium and magnesium whereas levels of exchangeable sodium and potassium were relatively low.

Table 3.24: Available Micro-nutrients in Soil

Parameters	S29		S32		S33		S34		S35		S36	
	Post-Monsoon	Winter	Post-Monsoon	Winter	Post-Monsoon	Winter	Post-Monsoon	Winter	Post-Monsoon	Winter	Post-Monsoon	Winter
Copper	2	1.8	1	0.8	1	0.9	2	1.6	1	1.2	1	1.3
Zinc	5	4.6	2	1.6	5	4.7	2	1.7	5	4.6	2	2.3
Iron	6	5.2	2	1.8	4	3.5	4	3.8	4	4.2	4	4.1
Manganese	8	6.7	10	7.5	67	49.8	12	9.2	44	37.5	13	10.6

(Values in mg/ kg)

Soil micro-nutrients also play an important role in plant growth and can act as limiting nutrients. Soil micro-nutrient analysis can be employed as a diagnostic tool for predicting the possibility of deficiency of a nutrient and the profitability of its application. For this, it is essential to fix the critical limits. The critical limit of micro-nutrient in a soil is that content of extractable nutrient at or below which plantation practiced on it will produce a positive response to its application. The critical limits of copper, zinc and iron are 0.20-0.66 mg/kg, 0.50-0.65 mg/kg and 4.5-6.0 mg/kg respectively. From the above Table it can be seen that in all the soil samples, micro-nutrient levels, especially that of copper and zinc are high. Excessive micro-nutrients are detrimental to plant growth as excess of one more micro-nutrients adversely affects the uptake of other micro-nutrients. Excess of copper affects uptake of Molybdenum, another micro-nutrient. Excess of Zinc, Manganese and Copper affect Iron uptake. Thus due to the antagonistic effect of some micro-nutrients, uptake of other nutrients is adversely affected which hampers plant growth i.e. the fertility of soils in the study area are low.

3.8 LAND USE PATTERN

3.8.1 Land use pattern in the study area

Existing land use in the study area has been studied through Satellite image processing with Satellite data (Resourcesat LISS III, November 2005) of 23.5 m resolution. Existing land use in the study area is shown in **Table 3.25.** The table shows that forest land is the predominant land use covering about 62.19% of the study area. Agricultural land covers 20.32% of the study area, grazing land covers 14.6% of the study area, built up area covers 1.41% of the study area, waste land covers 0.55% of the study area and surface water bodies occupy 0.96% of the area. Land use coverage is shown in **Drawing No. MEC/Q696/11/S2/(6)9.**

Table 3.25: Approximate land use in Study Area

Land use category	Area (ha)	Percentage
1. Built up area	**514**	**1.38**
• Urban settlement	174	0.47
• Rural settlement	340	0.91
2. Agricultural land	**7565**	**20.32**
3. Forest land	**23153**	**62.20**
• Dense forest	9893	26.58
• Open forest	9186	24.68
• Scrub forest	4074	10.94
4. Waste land	**204**	**0.55**
• Land with scrub	096	0.26
• Land without scrub (Quarries & Dumps)	108	0.29
5. Grazing land	**5432**	**14.6**
6. Water bodies	**357**	**0.96**

3.8.2 Land Use Pattern in the Lease Area

Present mode of utilization of land in the lease area is given in **Table 3.26.**

Table 3.26: Existing land use in lease area

Land Use Category	Pre-mining stage	Existing stage
Forest land	519.75	455.026
Settlement	1.70	1.696
Agricultural land	11.55	11.55
Road	2.21	2.212
Grazing land	10.36	10.196
Waste land ▪ Natural waste land • Generated waste land due to quarrying	 73.00 0.00	 64.59 73.29
	618.576	**618.576**

Table 3.26 indicates that most of the lease area is under forest land. At present only about 73.29 ha land (64.72 ha forest land and 8.56 ha non forest land) is broken area occupied by small quarries, dumps etc. Agricultural land occupies 1.86% of the total land. However, agricultural yield is poor due to low soil fertility and want of water at hill top. Existing land use coverage of lease hold area is shown in **Drg. No. MEC/Q696/11/S2/(6)6.**

3.9 ECOLOGY

The study area lies in the Eastern Highlands sub-zone of the Eastern Plateau and Hills agro-climatic zone. Most of the area is hilly. Most the entire area is rural. As mentioned earlier, the lease area lies mostly within Gandhamadan Reserved Forest. In addition there are a number of other Reserved Forests (R.Fs.) within the study area, which are as follows:

1. Sanchagara R. F.: 1.8 km NE of Gandhamadan "A" Lease
2. Amjor R. F. : 0.8 km E of Gandhamadan "A" Lease
3. Sidhamatha R.F. : 3 km E of Gandhamadan "A" Lease
4. Suakati R.F. : 2 km SE of Gandhamadan "A" Lease
5. Lungar R.F. : 2 km S of Gandhamadan "A" Lease
6. Rajpur R.F. : 3.5 km S of Gandhamadan "A" Lease
7. Bayakumutia R.F. : 6 km S of Gandhamadan "A" Lease
8. Khejurmundi R.F. : 3.5 km SW of Gandhamadan "A" Lease
9. Kumundi P.F.: 2.5 km WNW of Gandhamadan "A" Lease
10. Raiguda R.F.: 7.2 km WNW of Gandhamadan "A" Lease
11. Jagar P.F. : 3 km NW of Gandhamadan "A" Lease
12. Amuni R.F. : 7.5 km NNW of Gandhamadan "A" Lease

These forests are classified as Moist Peninsular Valley Sal Forests, sub-group of Northern Tropical Moist Deciduous Forests. In the plain areas, Dry Deciduous Scrub Forests have developed due to biotic influences.

Methodology of the Ecology Study

The list of flora and fauna found in the region was prepared by discussions with Forest Range Officer, Anjar Range (in which the study area lies) and by conducting field survey using the list available in the Working Plan as a base. Density and diversity of vegetation in the forest areas was determined by field surveys in selected areas.

Flora

The important plants found in the study area are given in **Table 3.27**.

Table 3.27: List of Plants Found in the Study Area

Sl. No.	Local Name	Scientific Name
1.	Amla	*Embelica officinalis*
2.	Kasi	*Bridelia retusa*
3.	Sala	*Boswellia serrata*
4.	Char	*Buchanania lanzan*
5.	Bata	*Ficus bengalensis*

Sl. No.	Local Name	Scientific Name
6.	Khair	*Acacia catechu*
7.	-	*Elaeodendron glaucum*
8.	-	*Dillenia pentagyna*
9.	Korai	*Hollarhena antidyssentrica*
10.	-	*Kydia calycina*
11	Siddha	*Mitragyna parvifolia*
12.	-	*Bursera serrata*
13.	Bans	*Dendrocalamus strictus*
14.	Babul	*Acacia nilotica*
15.	Semal	*Bombax ceiba*
16.	Arjun	*Terminalia arjuna*
17.	Dhav	*Anogeissus latifolia*
18.	Kandior	*Garuga pinnata*
19.	Karam	*Pongamia pinnata*
20.	Asun	*Terminalia tomentosa*
21.	-	*Lannea coromandelica*
22.	Bija	*Pterocarpus marsupium*
23.	Imli	*Tamarindus indica*
24.	Kanthal	*Artocarpus heterophylla*
25.	-	*Albizzia odoratissima*
26	Kusum	*Schleichera oleosa*
27.	Gamhar	*Gmelina arborea*
28.	Tendu	*Diospyros melanoxylon*
29.	Sisoo	*Dalbergia latifolia*
30.	Khajur	*Phoenix acaulis*
31.	-	*Gardenia spp.*
32.	Jamun	*Syzygium cumini*
33.	Kurum	*Adina cordifolia*
34.	Harida	*Amoora rohituka*
35.	Kumbhi	*Careya arborea*
36.	-	*Cochlospermum gossypium*
37.	Lowa	*Ficus glomerata*
38.	Bel	*Aegele marmelos*
39.	Bahara	*Terminalia bellirica*
40.	Mahul	*Madhuca indica*
41.	-	*Soymida febrifuga*
42.	-	*Chloroxylon swietiana*
43.	Palas	*Butea frondosa*
44.	Neem	*Azadirachta indica*
45.	Pandrai	*Albizzia procera*
46.	Pasu	*Cleissanthus collinus*
47.	-	*Zizyphus spp.*
48.	Sal	*Shorea robusta*
49.	Sekri	*Lagerstroemia parviflora*
50.	Bhalia	*Semecarpus anacardium*
51.	Aam	*Mangifera indica*
52.	Harra, Harida	*Terminalia chebula*
53.	Sidha	*Lagerstroemia parviflora*
54.	Aswatta	*Ficus religiosa*
55.	-	*Acacia torta*
56.	Palandu	*Combretum decandrum*

Sl. No.	Local Name	Scientific Name
57.	-	*Bauhinia vahlii*
58.	-	*Butea superba*
59.	-	*Wendlandia exserta*
60.	-	*Spatholobus roxburghii*
61.	-	*Woodfordia fruticosa*
62.	-	*Indigofera spp.*
63.	-	*Flemingia chappar*
64.	Water Hyacinth	*Eicchornia crassipes*
65.	-	*Ipomea spp.*
66.	-	*Lantana camara*
67.		*Ricinus communis*
68	-	*Nyctanthes arbotristis*
69.	Spear Grass	*Andropogon contortus*
70.	Sabai	*Eulaleopsis binnata*
71.	Broom Grass	*Thysanolaena agrostis*
72.		*Cynodon dactylon*
73.		*Calotropis spp.*
74.		*Desmodium spp.*
75.	-	*Jatropha spp.*
76.	-	*Mimosa pudica*
77.	-	*Argemone mexicana*
78.	- (Fish-tail palm)	*Caryota urens*
79.	Tal	*Borassus flabellifer*

Core Zone flora:

The core zone includes Forest Land, Waste Land and Settlements. As mentioned earlier, most of the core zone lies in the Gandhamadan R.F. This forest can be classified as "Northern Tropical Moist deciduous Forest". The maximum tree density is around 2100 trees/ha. Sal (*Shorea robusta*) is the predominant species. Kusum (*Schleichera oleosa*), Asun (*Terminalia tomentosa*), Dhav (*Anogeissus latifolia*), Char (*Buchanania lanzan*), Harida (*Terminalia chebula*), Kendu (*Diospyros melanoxylon*), Mahul (*Madhuca indica*), Mango (*Mangifera indica*) etc. are the common associates. The sal trees growing in the forest appear to be mostly of secondary origin but a few mature sal trees are also observed. It was also observed that the proportion of Sal trees was significantly less higher up the hill than on the lower parts of the hill. The phyto-sociological features of the forest trees growing in the forest areas are shown in **Tables 3.28.1** and **3.28.2**.

Table 3.28.1: Composition of Forests growing in the Core Zone

Sl. No.	Species	No. of Quadrats (10 m X 10 m)										
		1	2	3	4	5	6	7	8	9	10	Total
1	*Shorea robusta*	6	8	5	7	5	4	4	4	9	4	56
2	*Mangifera indica*	-	1	2	1	1	-	1	-	-	-	6
3	*Diospyros melanoxylon*	2	1	1	1	2	1	-	1	-	1	10
4	*Terminalia tomentosa*	-	1	-	-	1	1	-	1	-	-	4
5	*Buchanania lanzan*	1	-	-	-	1	-	-	-	2	-	4
6	*Terminalia chebula*	2	-	-	1	-	-	-	1	-	-	4
7	*Schleichera oleosa*	1	2	-	-	-	1	1	-	1	-	6
8	*Pterocarpus marsupium*	-	-	-	-	-	1	1	-	-	-	2
9	*Syzygium cuminiii*	-	-	-	-	-	-	-	2	-	-	2
10	*Embelica officinalis*	-	-	-	1	-	-	-	-	-	-	1
11	*Acacia catechu*	-	1	-	1	1	-	-	-	-	-	3
12	*Bombax ceiba*	-	1	-	1	-	-	1	-	-	-	3
13	*Madhuca indica*	1	-	-	-	-	1	-	-	-	-	2
14	*Ficus bengalensis*	-	-	-	-	1	-	-	-	-	-	1
15	*Anogeissus latifolia*	2	2	-	-	-	-	-	-	3	-	7
16	*Bauhinia spp.*	-	-	-	-	-	-	-	-	1	-	1
17	*Gmelina arborea*	-	-	-	-	-	-	-	1	1	-	2
18	*Lagerstroemia parviflora*	-	-	-	2	-	-	-	-	-	-	2
19	*Mitragyna parviflora*	-	-	-	-	-	1	-	1	-	-	2
20	*Tamarindus indica*	-	-	-	1	-	-	-	-	-	-	1
21	*Dalbergia sissoo*	-	-	-	-	1	-	-	-	2	-	3
22	*Bridelia retusa*	1	-	-	-	-	-	-	2	-	-	3
23	*Oogenia oojeinensis*	-	-	-	-	-	-	-	1	1	-	2
24	*Ficus glomerata*	-	-	-	1	-	-	-	-	1	1	3
25	*Butea spp.*	1	-	-	-	-	-	-	-	-	-	1
26	*Miscellaneous*	1	1	1	1	1	2	-	1	-	-	8
	TOTAL	18	18	9	18	15	12	8	15	21	5	139

Table 3.28.2: Phyto-Sociological features of Core Zone Forests

Sl. No.	Species	Frequency (%)	Density (Nos./ha)	Abundance	R.F. (%)	R.D. (%)	IVI	Diversity
1	*Shorea robusta*	100	560	5.60	12.82	46.95	58.99	
2	*Mangifera indica*	50	60	1.20	6.41	2.44	7.26	
3	*Diospyros melanoxylon*	80	100	1.25	10.26	7.19	17.45	
4	*Terminalia tomentosa*	40	40	1.0	5.13	1.88	7.01	
5	*Buchanania lanzan*	30	40	1.33	3.85	1.88	5.73	
6	*Terminalia chebula*	30	40	1.33	3.85	1.88	5.73	
7	*Schleichera oleosa*	50	60	1.20	6.41	4.32	10.73	
8	*Pterocarpus marsupium*	20	20	1.0	2.56	1.44	4.00	
9	*Syzygium cuminili*	10	20	2.0	1.28	1.44	2.72	
10	*Embelica officinalis*	10	10	1.0	1.28	0.72	2.00	
11	*Acacia catechu*	30	30	1.0	3.85	2.16	6.01	
12	*Bombax ceiba*	30	30	1.0	3.85	2.16	6.01	
13	*Madhuca indica*	20	20	1.0	2.56	1.44	4.00	
14	*Ficus bengalensis*	10	10	1.0	1.28	0.72	2.00	3.559
15	*Anogeissus latifolia*	30	70	2.33	3.85	5.04	8.89	
16	*Bauhinia spp.*	10	10	1.0	1.28	0.72	2.00	
17	*Gmelina arborea*	20	20	1.0	2.56	1.44	4.00	
18	*Lagerstroemia parviflora*	10	20	1.0	1.28	1.44	2.72	
19	*Mitragyna parviflora*	20	20	1.0	2.56	1.44	4.00	
20	*Tamarindus indica*	10	10	1.0	1.28	0.72	2.00	
21	*Dalbergia sissoo*	20	30	1.33	2.56	2.16	4.72	
22	*Bridelia retusa*	20	30	1.50	2.56	2.16	4.72	
23	*Oogenia oojeinensis*	20	20	1.0	2.56	1.44	4.00	
24	*Ficus glomerata*	30	30	1.0	3.85	2.16	6.01	
25	*Butea spp.*	10	10	1.0	1.28	0.72	2.00	
26	*Miscellaneous*	70	80	1.43	8.97	5.76	14.73	
	TOTAL	780	1390	-	100	100	200	

R.F. – Relative Frequency; R.D – Relative Density; IVI – Importance Value Index

In the mine lease at some locations due to inadequate soil cover, waste lands have developed. Waste land have also developed due to mining and allied activities. The vegetation of these areas is restricted to grasses, shrubs such as *Lantana camara, Calotropis spp., Combretum decandrum, Argemone mexicana, Jatropha* spp. etc. and a few stunted trees. There are a few settlements in the mine lease. The vegetation around these villages is restricted to common herbs and shrubs and trees like Mango, Neem, Jackfruit etc.

Buffer Zone:

The buffer zone includes Forest Lands (mostly on the hills), Waste Lands, Agricultural Lands and settlements. The brief characteristics of the various R.Fs and P.Fs in the area are as follows:

- Raiguda P.F.: This is a large tract of mixed jungle and varies from open forest (tree density – about 400 trees / ha) to dense forest (tree density – about 2000 trees / ha). The dominant species is Sal, especially on the lower slopes of the hills. Mango, Mahul, Kusum, Dhaura, Asun, Tendu and Char are the common associated species.

- Jagar P.F.: This is a small patch of Sal forest. Kusum, Dhaura, Asun and Char are also present. The tree density is about 1500 trees / ha.

- Kumundi P.F.: This is a patch of dense Sal forest. Several mature sal trees are also present. Mango and Mahul are present in significant numbers.

- Khejurmundi R.F.: This is a patch of dense mixed jungle (tree density about 1500 – 2000 trees /ha). Sal is the dominant species.

- Suakati R.F.: This is a large tract of forest ranging from open forest to very dense forest. Sal is dominant on the lower slopes constituting more than 75% of the trees on the lower slopes. The proportion of sal decreases higher up the hill slopes and were observed to be absent in some patches. Several Fish-tail Palms (*Caryota urens*) were obeserved in a patch near Champei village about 5 km SE of the mine lease.

- Kaipur R.F. and Bayakumutia R.F.: These adjoin Suakati R.F. and are of similar nature.

- Sidhamatha R.F.: This also adjoins Suakati R.F. and is similar in character.

- Sanachagara R.F. and Chinda R.F.: These lie east of the Gandhamadan Hill. These too are sal forests. Most of the trees appear to be of secondary growth.

The phyto-socio-logical features of the forest trees growing in the above buffer zone forest areas are shown in **Tables 3.29.1** and **3.29.2**.

Table 3.29.1: Composition of Forests growing in the Buffer Zone

Sl. No.	Species	No. of Quadrats (10 m X 10 m)																						
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**Total**
1	*Shorea robusta*	4	3	5	7	2	4	12	11	5	1	2	-	4	6	8	-	1	4	6	1	7	6	99
2	*Diospyros melanoxylon*	1	2	2	1	-	-	3	1	1	1	-	3	1	2	2	3	1	-	-	1	1	1	27
3	*Mangifera indica*	-	1	-	-	1	1	-	-	-	-	-	-	2	-	-	1	1	2	-	-	-	-	9
4	*Madhuca indica*	-	-	1	-	1	-	-	-	-	-	-	-	2	-	-	-	1	-	2	-	-	-	7
5	*Anogeissus latifolia*	-	1	-	-	-	1	3	2	2	5	-	4	-	1	1	3	1	-	-	6	1	2	33
6	*Schleichera oleosa*	1	-	1	1	1	-	1	1	1	1	1	-	-	1	1	1	-	-	1	-	-	-	12
7	*Terminalia tomentosa*	1	1	-	2	-	-	1	2	-	4	-	-	-	-	-	2	-	-	-	3	2	-	18
8	*Acacia catechu*	-	-	-	-	-	-	-	1	-	-	-	1	-	1	-	-	-	-	-	-	-	-	3
9	*Gmelina arborea*	-	-	-	-	-	-	-	-	1	-	-	1	-	1	-	-	-	-	-	-	-	-	3
10	*Bombax ceiba*	-	-	1	-	-	1	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	4
11	*Tamarindus indica*	-	1	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	1	3
12	*Syzygium cuminii*	-	-	-	-	-	1	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	3
13	*Buchanania lanzan*	1	1	-	2	-	-	-	2	2	3	-	-	-	1	-	2	-	-	1	2	-	-	18
14	*Mitragyna parviflora*	-	-	1	1	-	1	1	-	-	-	-	2	-	-	-	1	-	1	-	1	-	-	9
15	*Oogenia oojeinensis*	-	-	1	-	-	-	-	-	-	-	-	1	-	2	-	2	-	-	-	-	-	-	6
16	*Dalbergia sissoo*	-	-	-	-	-	-	-	-	-	1	-	-	-	1	-	-	-	-	-	-	-	1	3
17	*Ficus bengalensis*	-	-	-	-	-	1	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	3
18	*Artocarpus spp.*	-	1	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	1	-	-	-	-	3
19	*Embelica officinalis*	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	3
20	*Terminalia chebula*	-	-	1	-	-	2	-	-	1	2	-	-	-	-	-	-	-	-	-	2	-	-	8
21	*Pterocarpus marsupium*	-	-	1	2	-	1	-	-	1	-	-	-	-	-	-	-	-	-	-	2	1	-	8
22	*Bridelia retusa*	-	-	1	-	-	-	-		-	-	-	1	-	-	-	-	-	2	-	-	-	-	4
23	*Azadirachta indica*	-	1	-	-	-	-	-	-	-	-	1	-	-	-	-	1	-	-	1	-	-	1	5
24	Miscellaneous	-	-	-	-	-	1	-	-	-	1	-	3	1	-	-	1	-	-	-	1	1	-	9
	TOTAL	8	12	15	16	5	15	21	20	15	19	6	18	12	16	12	17	5	12	12	19	13	11	299

Tables 3.29.2: Phyto-Sociological features of Buffer Zone Forests

Sl. No.	Species	Frequency (%)	Density (Nos./ha)	Abundance	R.F. (%)	R.D. (%)	IVI	Diversity
1	*Shorea robusta*	90.91	450	4.95	12.50	33.11	45.61	
2	*Diospyros melanoxylon*	77.27	127.73	1.59	10.62	9.40	20.02	
3	*Mangifera indica*	31.82	20.91	1.29	4.37	3.01	7.38	
4	*Madhuca indica*	22.73	31.82	1.40	3.13	2.34	5.47	
5	*Anogeissus latifolia*	63.64	150.0	2.36	8.75	11.04	19.79	
6	*Schleichera oleosa*	59.09	54.55	1.33	8.12	4.01	12.13	
7	*Terminalia tomentosa*	40.91	81.82	2.0	5.63	6.02	11.65	
8	*Acacia catechu*	13.64	13.64	1.0	1.88	1.0	2.88	
9	*Gmelina arborea*	13.64	13.64	1.0	1.88	1.0	2.88	
10	*Bombax ceiba*	18.18	18.18	1.0	2.50	1.34	3.84	
11	*Tamarindus indica*	13.64	13.64	1.0	1.88	1.0	2.88	
12	*Syzygium cuminii*	13.64	13.64	1.0	1.88	1.0	2.88	
13	*Buchanania lanzan*	45.45	81.82	1.80	6.25	6.02	12.27	3.361
14	*Mitragyna parviflora*	36.36	40.91	1.13	5.0	3.01	8.01	
15	*Oogenia oojeinensis*	18.18	27.27	1.50	2.50	2.01	4.51	
16	*Dalbergia sissoo*	13.64	13.64	1.0	1.88	1.0	2.88	
17	*Ficus bengalensis*	13.64	13.64	1.0	1.88	1.0	2.88	
18	*Artocarpus spp.*	13.64	13.64	1.0	1.88	1.0	2.88	
19	*Embelica officinalis*	9.09	13.64	1.50	1.25	1.0	2.88	
20	*Terminalia chebula*	22.73	36.36	1.60	5.0	2.68	7.68	
21	*Pterocarpus marsupium*	27.27	36.36	1.33	5.0	2.68	7.68	
22	*Bridelia retusa*	13.64	18.18	1.33	2.50	1.34	3.84	
23	*Azadirachta indica*	22.73	22.73	1.0	3.13	1.67	4.80	
24	Miscellaneous	31.82	40.91	1.29	4.37	3.01	7.38	
	TOTAL	727.3	1348.67	-	100	100	200	
R.F. – Relative Frequency; R.D – Relative Density; IVI – Importance Value Index								

Fauna

The animals found in the study area are listed in **Table 3.30.**

Table 3.30: List of Terrestrial Animals found in the Study Area

Sl. No.	Common Name / Local Name	Scientific Name	Schedule of Wild Life Protection Act in Which Listed
Mammals			
1.	Common Mongoose / Hatia Neula	*Herpestres edwardsii*	IV
2.	Kuji Neula	*Herpestres javanicus*	IV
3.	Jackal / Bilua	*Canis aureus*	II, V
4.	Common house Rat / Musa	*Rattus rattus*	V
5.	Sloth Bear / Bhalu	*Melursus ursinus*	I
6	Jungle Cat / Bana Biradi	*Felis chaus*	II
7.	Wild Boar / Barha	*Sus scrofa*	III
8.	Indian hare / Thekua	*Lepus nigricollis ruficaudatus*	IV
9.	Indian Porcupine / Jhinka	*Hystrix indica*	IV
10.	Indian Field Mouse	*Mus booduga*	V

Sl. No.	Common Name / Local Name	Scientific Name	Schedule of Wild Life Protection Act in Which Listed
11.	House Rat / Mus	*Rattus rattus*	V
12.	Common Langur / Hanuman	*Presbytis entellus*	II
13.	Rhesus Macaque / Pati	*Macaca mulatta*	II
14.	Indian Elephant / Hati	*Elephas maximus*	I
15.	Hyaena / Heta Bagha	*Hyaena hyaena*	III
16.	Small Indian Civet/ Saliapatani	*Viverricula indica*	II
17.	Barking Deer / Kutra	*Muntiacus muntjak*	III
18.	Indian Mole Rat / Gatua musa	*Bandicota bengalensis*	IV
19.	Squirrel / Gundichimusa	*Funambulus pennanti*	IV
Reptiles			
1.	Monitor Lizard	*Varanus spp.*	II
2.	Common Krait / Kaudia chiti	*Bungarus caeruleus*	
3.	Russel's Viper / Chandraboda	*Vipera russelii*	II
4.	Cobra / Gokhra	*Naja naja*	II
5	Yellow Rat Snake / Dhamena	*Ptyas mucosus*	II
6	Saw Scaled Viper / Chiti	*Echis carinatus*	IV
7	Banded Krait / Rana	*Bungarus fasciatus*	IV
8	Checkered Keelback / Dhanda	*Natrix (Xenochrophis) piscator*	IV
9	Buffstriped / Kandanala	*Natrix (Amphiesma) stolata*	IV
10	Russel's Earth Boa / Domundia	*Eryx conicus*	IV
11	Chameleon / Pohala endua	*Chameleon zeylanicus*	II
12	Common Skink	*Mabuya carinata*	-
13	Garden Lizard	*Calotes versicolor*	-
Birds			
1	Pariah Kite / Chilla	*Milvus migrans*	-
2	Common Crow / Patikau	*Corvus splendens*	V
3	Jungle Crow / Damarakau	*C. marorhynchos*	IV
4	House Sparrow / Gharchatia	*Passer domesticus*	-
5	Wagtail	*Motacilla spp.*	IV
6	Rose Ringed Parakeet	*Psittacula krameri*	IV
7	Common Mynah / Bani	*Acridotheres tristis*	IV
8	Pied Mynah	*Sturnus contra*	IV
9	Cattle Egret / Baga	*Bubulcus ibis*	IV
10	Pond Heron	*Ardeola grayii*	IV
11	Little Egret / Baga	*Egretta garzetta*	IV
12	Small Green Bee-eater	*Merops orientalis*	-
13	Drongo / Kajalapati	*Dicrurus adsimilis*	IV
14	Crow Pheasant / Kumbhatua	*Centropus sinensis*	IV
15	Doves	*Streptopelia spp.*	IV
16	Indian Roller	*Coracias benghalensis*	IV
17	White Breasted Kingfisher	*Halcyon smyrnensis*	IV
18	Chestnut Headed Bee-eater	*Merops leschenaulti*	IV
19	Red Vent Bulbul	*Pycnonotus cafer*	IV

Sl. No.	Common Name / Local Name	Scientific Name	Schedule of Wild Life Protection Act in Which Listed
20	Koel / Koili	*Eudynamis scolopacea*	IV
21	Weaver Bird / Bayachadhei	*Ploceus spp*	IV
22	Tailor Bird	*Orthotomus sutorius*	IV
23	Magpie Robin	*Copsychus saularis*	IV
24	House Swift / Chatak	*Micropus affinis*	IV
25	Purple Sunbird	*Nectarinia asiatica*	IV
26	Tree Pie	*Dendrocitta vagabunda*	IV
27	Shrikes	*Lanius spp*	IV
28	Partridge / Teetri	*Francolinus spp.*	IV
29	Black Headed Oriole / Haldibasanta	*Oriolus xanthornus*	IV
30	Small Indian Cormorant	*Phalacrocorax niger*	IV
31	White Breasted Water Hen / Dahuka	*Amaurornis phoenicurus*	IV
32	Red Jungle Fowl / Banakukuda	*Gallus gallus*	IV
33	Shikra / Baja-pakhi	*Accipiter badius*	IV
34	Painted spur-fowl	*Galloperdix lunulata*	IV
35	Black Ibis	*Pseudibis papillosa*	IV
36	Bank Myna / Ghukalika	*Acridotheres ginginianus*	IV
37	Blue Rock Pegion / Deuliapara	*Columba livia*	IV
38	Jungle Bush Quail	*Perdicula asiatica*	IV
39	White-necked Stork	*Ciconia episcopus*	IV
40	Pied Crested Cuckoo	*Clammator jacobinus*	IV
41	Yellow Cheeked Tit	*Parus xanthogenys*	IV
42	Jungle Babbler / Kundachadei	*Turdoides striatus*	IV
43	Spotted Babbler	*Pellorneum ruficeps*	IV
44	Quaker Babbler	*Alcippe poioicephala*	IV
45	Common Iora	*Aegithina tiphia*	IV
46	White Cheeked Bulbul	*Pycnonotus leucogenys*	IV
47	Spotted Owlet / Pecha	*Athene brama*	IV
48	Serpent Eagle	*Spilornis cheela*	IV
49	Kestrel	*Falco tinnunculus*	IV

Due to mining and allied activities, the only animals found in the core zone are few rodents, reptiles and birds. Large mammals listed above are found in forests in the buffer zone only and that too several kilometers away from the core zone.

Due to lack of suitable habitat and large scale mining activities, diversity of animals is low.

Fishes found in the study area are listed in **Table 3.31.**

Table 3.31: List of fishes Found in the Study Area

Common Name	Scientific Name
Rohi	*Labeo rohita*
Bhakura	*Catla catla*
Pohal	*Cirrhina reba*
Denga Pohala	*Labeo bata*
Serana	*Barbus sarana*
Chitala	*Notopterus chitala*
Phali	*Notopterus notopterus*
Balia	*Wallago attu*
Magura	*Clarias batrachus*
Jalanga	*Pungasius pungasius*
Seula	*Ophiocephalus striatus*
Chenga	*Ophiocephalus gachua*
Godei	*Ophiocephalus punctatus*
Kau	*Anabas testudinius*
Singhi	*Heteropneustes fossilis*
Kantia	*Mystus cavasius*
Kerandi	*Barbus spp.*
Kuchia	*Amphipnous cuchia*

3.10 SOCIO-ECONOMIC STUDY

The proposed expansion of the mining project is expected to introduce a set of new activities, which will definitely influence socio-economic condition of the people of the area surrounding it. Such impacts may be marginal or non-marginal depending on the extent of change caused by the project to alter the existing equilibrium of the socio-economic system. The present project is likely to bring benefits for the local people. However, possibility of certain obvious hardships having social cost cannot also be ruled out. With this background, the present socio-economic impact assessment of the project has been carried out with respect to the following objectives:

- To assess the impact of the project on the agricultural situation
- To assess the impact of the project on the pattern of demand
- To estimate employment and income effects of the project
- To ascertain the impact of the project on the consumption behaviour
- To explore the impact of the projects on educational status in that locality

3.10.1 Brief Outline of the Study Area

The study area has a number of hillocks and mostly unfertile land. Population and occupational pattern of the study area, as per 2001 census, are given in **Table 3.32.**

From the table it evident that population density is about 300 persons/sq.km in the study area. General population density mostly in rural areas is very low, in the order of 100 persons /sq.km, but due to the semi urban town of Nandipada (population : 73861) overall population density in the study area appears comparatively higher. So far sex ratio is concerned, there are about 981 females per 1000 males. 60.93% of the people in the study area are literates. Working population constitute about 33.13% of the total population. Details of village-wise demographic pattern is given in **Table 3.33.** The demographic statistics are based on Census 2001 data where population and other statistics of many of the villages are absent and as such could not be taken into account.

3.10.2 Analytical framework

3.10.2.1 Sampling Design

The study area is divided into four strata. The sample of villages from each strata as well as the respondent/house-holds within each sampled village has been selected by two-stage stratified random sampling. On the first stage; villages from each stratum are selected and on the second stage; households/ respondents are selected from sampled village by simple random sampling. From each selected village, at least two respondents are selected randomly to account intra-village variability among the respondents.

Using the above design a sample of 31 respondents was selected from the study area. The sample families, in fact, covered a population size of 137.

Table 3.32 : Demographic pattern of the study area

Sl. No	Item	Study area	Share in total population (%)
1.0	Population		
1.1	Total	107923	21.22
1.2	Male	54466	50.47
1.3	Female	53457	49.53
2.0	Households	22904	21.22
3.1	SC	24815	22.99
3.2	ST	21868	20.26
4.0	Literates	65753	60.93
5.0	Working population	35760	33.13
5.1	Main workers	25571	23.69
5.1.1	Cultivators	13543	12.55
5.1.2	Agril labourers	5724	5.30
5.1.3	HH industry	458	0.42
5.1.4	Others	5846	5.42
6.0	Marginal workers	10189	9.44

Source: Census 2001 data

Table 3.33: Details of village-wise demographic pattern

S.I. No	NAME	No of household	Total population	Total Male	Total Female	SC	ST	Literates	Total workers	Main workers	Main cultivators	Main Agril labourers	Main Household industry	Main Others	Marginal workers	Non working population
1	Bali	110	538	274	264	0	480	138	289	144	127	9	3	5	145	249
2	Banabiharipur	95	511	253	258	53	318	253	252	99	47	37	5	10	153	259
3	Baradapal	191	879	402	477	113	444	328	500	31	22	4	0	5	469	379
4	Bayakumutia	219	1112	537	575	14	877	322	589	384	196	119	18	51	205	523
5	Bhaliadal	74	420	210	210	0	270	135	115	112	85	8	1	18	3	305
6	Bhalughara	132	642	340	302	0	429	213	345	13	4	1	1	7	332	297
7	Bila	69	309	150	159	0	10	135	190	146	105	14	1	26	44	119
8	Danara	424	2130	1072	1058	445	33	1693	614	448	359	37	5	47	166	1516
9	Danardanpur	271	1401	703	698	117	912	597	472	170	124	0	2	44	302	929
10	Dhatika	175	846	428	418	126	575	409	445	114	20	2	49	43	331	401
11	Dumuridiha	41	201	102	99	0	0	151	60	53	39	2	0	12	7	141
12	Ichinda	148	707	356	351	12	24	440	294	197	160	9	1	27	97	413
13	Jamudiha	138	679	338	341	99	286	407	285	60	10	0	0	50	225	394
14	Kainpura	212	942	464	478	68	182	650	336	205	75	10	2	118	131	606
15	Kainsiari	73	347	174	173	61	6	251	77	57	36	12	0	9	20	270
16	Kamagaon	78	426	185	241	1	413	76	202	93	84	0	5	4	109	224
17	Kapundi	270	1147	594	553	337	300	634	406	273	138	48	17	70	133	741
18	Karangadihi	110	603	294	309	0	529	178	325	236	212	9	0	15	89	278
19	Katarapali	241	1069	526	543	182	531	428	419	193	37	80	24	52	226	650
20	Kumundi(KHA)	263	1239	631	608	12	902	256	566	296	203	30	4	59	270	673
21	Lunga	141	694	339	355	6	267	371	284	178	85	67	0	26	106	410
22	Machhabhanda	97	444	220	224	0	39	214	137	124	97	13	3	11	13	307
23	Mahadeijoda	383	1845	943	902	111	790	874	630	302	239	3	3	57	328	1215
24	Medinipur	136	669	348	321	57	579	340	422	233	171	50	0	12	189	247
25	Nandipada	15825	73861	37425	36436	22161	3704	51539	22182	17893	9465	4657	261	3510	4289	51679
26	Nitigotha	23	125	57	68	0	86	49	57	24	18	1	0	5	33	68

S.I. No	NAME	No of household	Total population	Total Male	Total Female	SC	ST	Literates	Total workers	Main workers	Main cultivators	Main Agril labourers	Main Household industry	Main Others	Marginal workers	Non working population
27	Nuasahi	12	74	38	36	0	63	13	34	19	11	7	0	1	15	40
28	Padakasada	206	1001	495	506	66	768	127	536	438	311	112	6	9	98	465
29	RatanamaraR.F.	42	168	89	79	0	111	30	82	0	0	0	0	0	82	86
30	Rugudi	176	695	356	339	88	288	227	249	185	64	24	0	97	64	446
31	Rugudidihi	108	476	249	227	27	282	148	202	137	14	0	0	123	65	274
32	Sahadapur	216	1065	533	532	0	352	669	449	190	106	23	1	60	259	616
33	Sarukudara	71	325	163	162	12	284	29	149	124	10	101	10	3	25	176
34	Suakati	595	2648	1370	1278	466	1192	1393	746	622	47	36	15	524	124	1902
35	Talajagar	237	1125	538	587	24	737	302	494	214	135	14	2	63	280	631
36	Tentuli	329	1531	757	774	20	1218	561	656	492	109	149	7	227	164	875
37	Tikarapada	370	2081	1051	1030	13	1243	625	580	309	292	1	0	16	271	1501
38	Uparajagara	236	1088	563	525	90	887	262	370	294	22	26	0	246	76	718
39	Urumunda	367	1860	899	961	34	1457	286	720	469	264	9	12	184	251	1140
	TOTAL	**22904**	**107923**	**54466**	**53457**	**24815**	**21868**	**65753**	**35760**	**25571**	**13543**	**5724**	**458**	**5846**	**10189**	**72163**

3.10.2.2 Composition of the questionnaire

Households/respondents were interviewed with the structured questionnaire specifically designed for this study keeping in view the objectives of the study. The questionnaire consists of following major sections :

- Composition and size of family
- Educational status
- Homestead
- Information on agricultural situation (holding size,
- Land use, cropping pattern, productivity, net return etc.)
- Employment (sources of employment)
- Income (income from various sources
- Information on family budget
- Consumption and saving
- Family asset base
- Peoples' willingness to use the proposed road.
- Respondents' perception about the project

3.10.2.3 Analytical Framework

The major methods used as tools of analysis in this study are as given below :

1. Regression:

Simple linear regression of the following type is considered

$$Yi = a + b X_i + U_i$$

(Where, U is the stochastic error term having its usual properties)

The model is fitted to data applying Ordinary Least Square (OLS) to obtain estimated demand and consumption functions.

2. Fitted regression model is used to work out

i) Elasticity of demand with respect to disposable income in case of demand functions :

$$e = (dy / dx) . (y/x)$$

ii) Marginal propensity to consume (MPC) from consumption function:

$$MPC = dC / Dy$$

3. Frequency distribution of peoples' perception, educational status, land holding etc.

3.10.2.4 Prediction and Impacts

Agricultural Situation

The present survey reveals that agriculture is not the major source of livelihood for the people of the study area. Climatic conditions are also not conducive for agriculture. Even then a good farming community is there in the study area. **Table 3.34** depicts the holding-size wise distribution of households in the study area. The table reveals that about 63% of the households are marginal farmers whereas about 18% are small. Thus, these two categories jointly account for about 81% of the total households in the study area. There are a few medium and large formers. These two categories together account for about 18% of the households.

Table 3.34: Distribution of households by holding size

Sl No	Holding Size (Acre)	Households (%)
1.	Marginal (<2.5)	63.6
2.	Small (2.5 - 5.0)	18.2
3.	Medium (5.0 - 10.0)	9.1
4.	Large (>= 10.0)	9.1
	TOTAL	100.0

Agriculture is characterized by mono-crop culture. Paddy is the major crop grown in this area. Area for other crops is negligible. The cropping intensity is quite low (about 93.3%). This indicates that the total land holding is not utilized for cultivation and fallow land is there.

With rising costs of cultivation, farm families are utilising some part of the income from other sources e.g. service, wage labour, self-employment, small business, service etc. to invest in agriculture so as to obtain at least rice from own land. Even then, agricultural remained as backward as it was. Overall assessment of the agricultural situation leads to the conclusion that the project is not going to cause any damage the agricultural situation of the area in stead, it is likely benefit the farming community by way of supplementary income through non-farm sources.

Consequently, investment in agriculture will increase leading to higher crop production which will be used to meet their own demand. Hence, the impact of the project on agriculture situation of the study area is expected to be good.

Pattern of demand

The survey reveals that the respondents spend major portion of their disposable income on food items. However, there has been a growing tendency among the respondents, of higher expenditure allocation on non-food items than before. To go to the details of their pattern of demand, income elasticity of demand is calculated by fitting demand functions. **Table 3.35** presents the results of the regression analysis conducted for fitting the demand functions. It is observed that all the demand functions give uniformly good fits to the data because R^2 in all the cases are found to be quite high. Moreover, as indicated by t-test, the relevant parameter of the demand functions is found to be statistically significant at 1% level. The income elasticity of demand as measured from the fitted functions are 0.73 and 0.79 for food and non-food items respectively. The inelastic demand for food and non-food items indicates their strong necessity of these items. The magnitude of elasticity in case of non-food items is indicating their tendency to shift the demand in favour of non-food items as their income increases.

Table 3.35: Demand Functions For Food And Non-Food Items

Form of the fit	Item	Regression parameters		
		Ln a	b	R^2
$D_{ij} = a * Y^b_j * U$	Food	0.853	0.726	0.868
(Where,D_{ij} =Demand for the ith item by jth respondent.			(13.8)*	
Y_j=Disposable income of the jth respondent	Non-food	1.534	0.79	0.624
			(6.9)*	

Figures in ( ) indicate t – values * Significant at 1% level.

With the implementation of the project and further development of the locality new type of demand pattern may emerge which is likely to place more importance on modern consumer goods and quality products. Hence, the impact of the project on the pattern of demand can be reasonably predicted as a shift from food to non-food items i.e., a consumer behaviour which may closely follow the Engel law. This is not a bad indication provided considerable income is earned by them; otherwise, if the shift is a substitution of necessary food requirements then it is not desirable in true socio-economic sense.

Employment and Income effect

Occupational structure of the people of the study area reveals that about 12% have cultivation as primary source of income. Majority of them are engaged in service (66%). For 16% of the people business the source of livelihood.

During the phase of mine expansion, substantial amount of employment and income are going to be created. A large portion of these is likely to trickle down to the local people. Besides this it is expected that for yearly operation of the project local people will get employment in various mining activities in accordance with their qualification, skill and experience. Besides direct employment, the project is expected to generate substantial indirect employment in semi-skilled labour, casual labour as also skilled labour in other sectors e.g. in the small scale industrial units and service centres etc. which are existing at present and also expected to come in the vicinity of the projects. The indirect employment and income effects are likely to be much larger than the direct effects of the proposed project.

Overall assessment of the employment and income effects indicates that the project has strong positive direct as well as indirect impact on employment and income generation.

Consumption Behaviour

Table 3.36 presents the source-wise distribution of average family consumption. It is observed that the major portion of consumption (54.1%) goes to meet the need for food items. This is followed by clothing (13.7%). Average expenditure on education is found to be quite low compared many other Indian states (5.6%).

Table 3.36: Source-Wise Distribution of family consumption

Total	Food	Education	Clothing	Medical	Others
Percentage distribution	25617 (54.1)	2669 (5.6)	6514 (13.7)	2914 (6.2)	9663 (20.4)

Figures in ( ) indicate % in total consumption (Rs/yr)

To investigate the consumption behaviour of the respondents in detail, Marginal Propensity to Consume (MPC) is calculated by fitting the consumption function. The results of the regression analysis performed for fitting the consumption function are presented in **Table 3.37**. It is observed that the function gave uniformly good fit to data because R^2 is high and parameters are also found to be statistically significant

at 1% level. The MPC worked out on the basis of the fitted consumption function is 0.379.

Table 3.37: Fitted Consumption Function

Form of the fit	Regression parameters		
	a	B	R^2
$C_j = a + b Y_j + U_j$ Where, C j=Consumption of jth respondent Y-Gross income of the jth respondent	14980.8	0.379 (14.04)*	0.872

Figures in ( ) indicate t-values * Significant at 1% level

Attempt has been made here to work out the multiplier effect of investment on the people of the study area. The calculations are done using the following model :

Considering that the consumption behavoiur of the respondents closely follow the following type of consumption function :

$$C = a + bY \quad (1)$$

We know that, in equilibrium

$$Y = C + I \quad (2)$$

Where, Y = Gross income
C = Consumption
I = Investment

Putting (1) in (2) one gets,

$$Y = a + bY + I$$

$$\Rightarrow \quad Y = [1/(1-b)]^* (a + I) \quad (3)$$

Where, 1 / (1-b) is the multiplier .

Assuming that consumption behaviour of the people in the study area closely follow this fitted consumption function, one can easily see that existing size of the multiplies is 1.6 Hence, investment on this project and the consequent generation of additional income will have strong multiplies effect in raising average

consumption. The proposed project is going to inject huge amount money in the area and consequently, the multiplier effect is expected to lead to an overall increase in average income, consumption and savings of the people of the study area. Therefore, one can conclude that the impact of the project on consumption behaviour of the local people is likely to be satisfactory and positive.

Educational status

The existing educational status of members of the households is depicted in **Table 3.38.** The table, however, reveals an optimistic picture. From the table it is clear that a substantial number of people of the study area has higher qualification such technical education, graduation etc. About 15% and 18% of the members have education at primary level and middle school level respectively. In the high school and intermediate levels there are about 10% and 29% persons respectively. Survey further reveals a very encouraging fact that about 13% of the members are graduates and around 7% are technical school going children. As reported by the respondents, their thrust towards education has been increasing due to the lure of getting jobs specially in the non-agricultural sources which are going to come up in this region as a result of the mining projects. The construction of roads is expected to increase such aspirations by bringing opportunities of some direct & indirect employment for the local people. The general awareness towards the importance of education is expected to increase as a result of the new projects and hence, it can be said that the project has a strong positive impact on the level of education of the people of the study area.

Table 3.38: Educational Status of the people of the Study Area

Sl.No.	Level of education	No of persons (%)	
1.	Illiterate*	21	(15.3)
2.	Primary	21	(15.3)
3.	Middle schooling	25	(18.2)
4.	High schooling	13	(9.5)
5.	Intermediate	39	(28.5)
6.	Graduation	18	(13.1)
7.	Technical education	9	(6.6)
Total		137	(100.0)

Figures in ( ) indicate % in total number of persons. * Includes very small non-school going children

Scoping of EIA

4.0 SCOPING OF EIA

4.1 GENERAL

An essential step in Environmental Impact Assessment (EIA) is to identify all potential environmental impacts. These are then examined critically and the identified major impacts (both beneficial and adverse) are subsequently studied and analyzed in detail.

4.2 IDENTIFICATION OF IMPACTS

The environmental attributes that are subjected to test for having impact on them by the project by varying degree include ambient air quality, water resources & quality, noise levels, flora and fauna (ecology), soil and land-use, socio-economic environment and infrastructural development, health etc. Various activities causing impacts have been considered under various stages *viz.* siting, operation of opencast mines and secondary activities and also post operational phase.

4.2.1 Siting

Site selection has little relevance with respect to a mining project, which is mainly guided by the deposit geology. The present mine lease covers 618.576 ha of land, which consists of forest land, agricultural land, waste land, grazing land, settlements and roads. Areas mined so far since 1964 covers a small fraction of the total lease area. 73.29 ha of land (64.72 ha forest land) has already been utilized for mining and allied activities. Total 241.35 ha land (216.36 ha forest land) shall be dereserved till end of mining under the present proposal. Diversion of this forest land may have some impacts on the ecology of the area.

4.2.2 Operational Stage

As described in Chapter 2, main operation at mine site in the operational phase involves opencast extraction, handling of ore and overburden, handling and transportation of ore. These activities may affect the environment in varying degrees through natural resource depletion *viz.*, forest depletion and pollution *viz.* release of particulates due to transportation, contamination of surface and ground water source etc. Mining on hill may have bearing on the adjoining natural surface drainage. During working life of mine air, water, noise and land use may be affected due to mining and associated activities, in general.

In opencast mining blocks the critical areas under surveillance are impacts on land use, drainage and ecology.

Allied operations e.g. transportation of materials, operations of workshop and garage, canteen etc. may also affect slightly air and noise environment. Green belt development has positive impact not only on flora and fauna but also on air quality, noise and soil characteristics.

Positive impacts on socio-economic environment are expected due to employment, further infrastructural development and also due to socio-economic development activities to be taken up by the mine authorities (OMCL).

4.2.3 Persisting Impacts in the Post-Operational Phase

Mining and allied operations will be carried out till 2023. There is all likelihood of increased transport facilities and industrial and associated development. These will have beneficial impacts on socio-economic environment but adverse impacts on ecology and the physical environment.

4.3 SCREENING OF IDENTIFIED IMPACTS

Some of the impacts identified in various phases are insignificant and do not warrant much attention whereas some other are very important especially with respect to the present project. The objective is to identify those impacts, which are significant and require a detailed analysis for decision making or formulating adequate management measures.

Land use in the core zone, impact on local drainage, availability of fresh water, forest depletion etc. are important with respect to the present project.

Environmental Impact Assessment

5.0 IMPACT ASSESSMENT

The identified impacts (refer Chapter 4) due to mining and associated activities have been studied in relation to the following areas:

- Topography and landscape
- Drainage system
- Land use alteration
- Water environment
- Air environment
- Noise level
- Blast induced vibration, noise and fly rock throw
- Flora and fauna
- Socio economics

5.1 TOPOGRAPHY AND LANDSCAPE

The leasehold area has already undergone topographical changes to some extent, due to open cast excavations and external dumping since 1964. As explained in chapter 3, the leasehold area is in a plateau, which approximately forms north-south axis of the lease area with peak at 1009 mRL and the bottom of the escarpment at 570 mRL. A number of small quarries were opened all-around the lease area except at the central main ore body. A cluster of small excavations in float ore exist near north-east boundary which shall be exhausted by 2011. Among other excavations prominent are Quarry 9 and Quarry VD on float ore section, near western side between 800W-1200W and 2200S-2800S gridlines. A small excavation exists in Central main ore body now. Existing depth of all these quarries range from 6 -10 m. In the expansion stage almost entire central part ranging from southern to northern part will be occupied by the excavation of main ore body. Quarry VD and 9 will expand and merge with the main ore quarry.

Existing and futuristic excavation levels are as follows:

Table 5.1: Existing and futuristic land degradation in major quarries

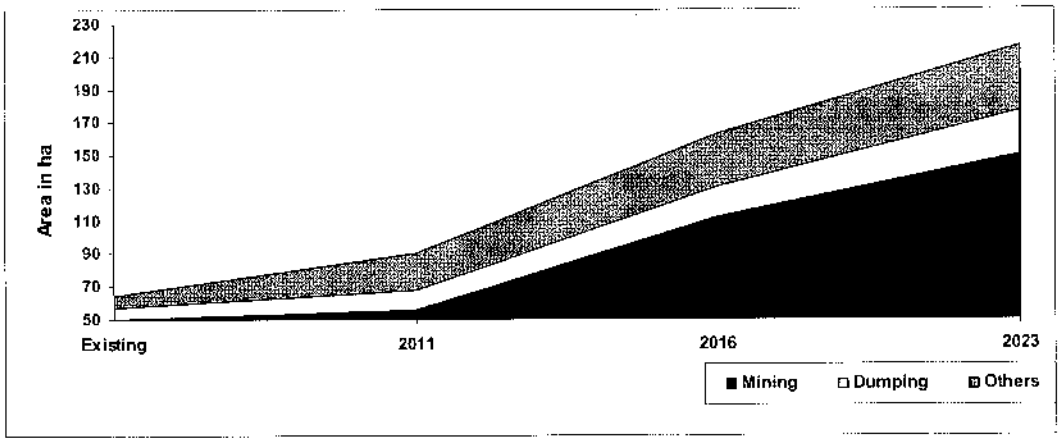
Parameter	Existing	At the end of 2011	At the end of 2016	At the end of mining at 2023
I. Hill top Quarry				
Adjoining ground level (mRL)	950	950	800	660-960*
Quarry bottom (mRL)	968	968	910-965	
II. Quarry 9				
Adjoining ground level (mRL)	850	850	733-945	*
Quarry bottom (mRL)	815	813		
III. Quarry VD				
Adjoining ground level (mRL)	750	650-750	*	
Quarry bottom (mRL)	720-735	733-735		

* Note: 1. Quarry 9 and Quarry VD will merge with Main ore quarry at this stage
2. Small quarries at north eastern side which will be exploited upto 2011 has not been accounted here. The quarries are later backfilled.

The plateau will undergo severe topographical changes with quarry excavation areas in Quarry 9, VD and Hill top quarry increasing at the end of 2011, 2016 and at ultimate pit level in 2023, respectively. In 2016-2023 stage main ore quarry shall merge with Quarry 9 and Quarry VD. Working in the composite main ore quarry shall be continued till 2023. External dump areas will occupy 26.63 ha (with 5-10 m height) only at ultimate pit limit. Substantial backfilling will be possible since number of small abandoned quarries will be available. 21.57 ha areas of abandoned quarries shall be backfilled.

Considering that the lease area is in a plateau where forest will be improved/grown in about 49% of the lease area mostly in non-excavated balance land, forest buffers around the abandoned quarries shall not leave pronounced physiographical impact. Backfilled abandoned quarries and external dumps will be forested. At the end of mining, a landscape with predominance of forested land merged with existing dense hilly forests on natural hill slopes shall emerge.

Fig. 5.1: Phase-wise Forest land degradation



5.2 DRAINAGE

In the core zone hilly region, a few seasonal drainage channels are flowing down to meet the natural streams at the bottom of the hilly area. The natural drainage channels have been subjected to some degree of impact, as the courses of some of these channels have been diverted due to formation / enlargement of the quarries and dumps. In the expansion stage also some impacts are anticipated on these local seasonal streamlets. However, water courses shall be managed in a manner such that the overall drainage of the core zone hilly region is not affected. Preservation of directional flow in the streams is important to regulate water flow in the disturbed area in a systematic manner. Water management scheme described in chapter 6 will help to regulate water flow in drains and channels in a systematic manner.

The storm water discharge coming out of quarries and dumps is expected to contain solid particulates. These solid particulates will be removed before leading this water to natural streams flowing below the core zone hilly area. Storm water shall get collected in settling pits through a network of garland drains. Only the clear overflow of the settling pits shall be discharged.

In buffer zone there shall be no change in drainage system due to the mining project.

5.3 LAND USE ALTERATION

As indicated earlier, 519.7472 ha area (84.02%) is designated forest land out of 618.58 ha lease area. Existing land use in lease area is given in **Table 3.26. Table 5.2** shows that at present 73.29 ha (11.8%) out of 618.576 ha leasehold area is utilized. Out of 519.7472 ha forest land only 64.7242 ha

(12.45%) has been broken. Remaining broken non forest land was mostly agricultural and waste land.

Table 5.2:Land area already broken-up/utilized

Pattern of Utilization	Forest Area	Non-Forest Area			Total Area
		Waste land	Grazing land	Total	
Mining	49.92	0.00	0.16	0.16	50.08
Dumping	6.97	0.00	0.00	0.00	6.97
Ore stack	0.00	0.00	0.00	0.00	0.00
Process Plant	0.00	0.00	0.00	0.00	0.00
Transport	7.34	2.24	0.00	2.24	9.58
Workshop, garage, Magazine	0.19	0.17	0.00	0.17	0.36
Township, office	0.30	6.00	0.00	6.00	6.30
Others	0.00	0.00	0.00	0.00	0.00
Total	**64.72**	**8.40**	**0.16**	**8.57**	**73.29**

Figures are in ha

Table 5.3 shows land excavation schedule in expansion stage. The table shows that 241.35 ha (39.01% of the total lease area) shall be utilized till end of mining. Total 216.36 ha forest land shall be utilized. 24.99 non forest land shall also be broken which are at present mostly waste land. Remaining unutilized area in the lease has been kept for exploration and future mining proposal (not contained in the present EIA report).

Table 5.3: Proposed land excavation planning

Pattern of Utilization	Forest Area	Non-Forest Area			Total Area
		Waste land	Grazing land	Total	
Mining	150.08	0.00	0.16	0.16	150.24
Dumping	26.63	0.00	0.00	0.00	26.63
Ore stack	0.00	0.00	0.00	0.00	0.00
Process Plant	0.00	0.00	0.00	0.00	0.00
Transport	10.30	2.24	0.00	2.24	12.54
Workshop, garage, Magazine	29.06	10.89	0.00	10.89	39.95
Township, office	0.30	11.70	0.00	11.70	12.00
Others	0.00	0.00	0.00	0.00	0.00
Total	**216.36**	**24.83**	**0.16**	**24.99**	**241.35**

Figures are in ha

216.36 ha forest land shall undergo diversion to mining uses over a long period till end of mining under present proposal. Five yearly forest land extraction vis-à-vis

artificial forest generation is shown in **Table 6.3.** The table shows that artificial forest shall be generated elsewhere in the lease at a rate faster than the forest depletion.

Although substantial land can be regenerated through backfilling of overburden, backfilling on north eastern side quarries can be taken up only during 2011-2016 stage since the quarries will remain operative till 2011. Afforestation on the backfilled land shall be taken up after 2016. The planned massive afforestation on back-filled land (of available abandoned quarries), overburden dumps and other areas shall match well with the forests in the study area to the maximum possible extent, to provide a uniform land use befitting to the location. Afforestation has been planned in a manner, which will actually increase the bio-diversity of the local ecosystem. Positive impacts on land use due to subsequent artificial forest land generation shall come in view from 2010-11 when initial green belt attains height. The planned tree density of 1600 trees per ha is comparable to the dense forests in the study area.

Some of the civil construction shall remain after cessation of active mining. These infrastructure facilities shall benefit the site as the roads will form a much better communication link with the outside compared to the existing unpaved roads and the office buildings etc. may be used by the State government or Central government agencies or can be developed as a school/primary health centre etc in the region. Land use change in the leasehold area has been summarized in the **Table 5.4.**

Table 5.4: Stage-wise land use alteration

Pattern of Utilization	Forest Area			Non-Forest Area						
	Natural	Artificial #	Total	Settlement	Agricultural	Waste land		Grazing land	Road	Total
						Natural	Generated *			
Pre-mining land use	519.75	0.00	519.75	1.70	11.55	73.00	0.00	10.36	2.21	98.83
Existing land use	455.02	0.00	455.02	1.70	11.55	64.60	73.29	10.20	2.21	163.55
Interim land use in 2011	428.71	0.00	428.71	1.70	11.55	55.51	108.69	10.20	2.21	189.86
Interim land use in 2016	356.27	16.04	372.31	1.70	11.55	52.08	200.60	10.20	2.21	278.35
Post mining land use (under present proposal)	303.39	61.44	364.82	1.70	11.55	48.18	179.92	10.20	2.21	253.75

Figures are in ha

Afforestation in backfilled area & external dump;

* Unfilled quarried void and land extrated due to infrastructures;

The table indicates that artificial forest shall be generated in 61.44 ha land in backfilled area, external dump and non-forest areas. In addition, improvement of forest land shall be carried out in 262.86 ha area. Land use alteration has been further analyzed in detail at **Table 5.5.**

Table 5.5: Land Use change between Pre-mining & Post-mining scenario

Pattern of Utilization	Forest Area		Non-Forest Area						
	Natural	Artificial #	Settle-ment	Agri cultural	Waste land		Grazing land	Road	Total
					Natural	Generated *			
Pre-mining land use	519.75	0.00	1.70	11.55	73.00	0.00	10.36	2.21	98.83
Post mining land use (under present proposal)	303.39	61.44	1.70	11.55	48.18	179.92	10.20	2.21	253.75
Land use Alteration	-216.36	61.44	0.00	0.00	-24.83	179.92	-0.16	0.00	154.93

Afforestation in backfilled area & external dump;
* Unfilled quarried void and land extrated due to infrastructures;
Figures are in ha

Table 5.5 shows that due to mining at Gandhamardan-A mine, 216.36 ha of forest land 24.83 ha of waste land and 0.16 ha of grazing land will be converted to 179.92 ha of quarried void and infrastructures and 61.44 ha of artificial forests (in backfilled land, overburden dump and non-forest areas). Upper benches of quarried void will be afforestated.

Due to spurt of activities in this iron ore belt, some change in land use in nearby buffer zone also is anticipated due to increased economic activities, urbanisation etc. which is viewed as a positive change because existing amenities are poor in the region.

5.4 IMPACT ON WATER ENVIRONMENT

As indicated in Chapter 2, water is required for the project is 179 m^3/day. For industrial use average water demand is 49 m^3/day whereas drinking water need in at work place is 20 m^3/day. Industrial water requirement shall be met from Chanda nala which is a perrenial stream and its flow is sufficient to supply the required quantity of water for the project. Thus water drawal for the project will have little impact on water availability in the study area.

Bore-holes drilled at least up to 30 m below the ultimate planned pit depth have not encountered ground water. Therefore there will not be any ground

water release due to mining till ultimate pit limit in the quarries. Hence the mine will not affect the ground water table.

Total annual Replenishable Recharge has been calculated for the watershed in which the mine is located. The following inputs have been considered **(Table 5.6)** while estimating TARR.

Table 5.6 Inputs for estimation of TARR

Sl. no	Factors	Value	Reference
1	Annual rainfall (mm)	1269.1	Refer Fig.3.2
2	Infiltration coefficient	0.11	Refer clause 3.5
3	Watershed area (sq.km)	171.703	Refer Table 3.8
4	Population in Watershed	107923	Based on population density given at 3.10
5	Per capita Water consumption rate at village (litre)	65	CPHEEO (Central Public Health & Environmental Engineering Organization)
6	Mine discharge water (m^3/d)	0	Refer clause 5.4
7	Water drawl from borewell in the lease (m^3/d)	20	Fig. 2.1

Total annual replenishable recharge and ground water abstractions are estimated and furnished at **Table 5.7**

Table 5.7: Estimation of TARR

Sl. no	TARR and abstractions	Value	References
(i)	Total annual replenishable recharge (Mm^3/y)	23.28	(1) x (2) x (3)
(ii)	Draft excluding mine discharge (Mm^3/y)	1.18	(4) x (5) x365 days
(iii)	Draft due to mine discharge (Mm^3/y)	0	(6)x 365 days
(iv)	Draft due to borewell water drawl from lease (Mm^3/y)	0.0073	(7) x 365 days
(v)	Net ground water availability (Mm^3/y)	22.101	(i) – [(ii)+(iii)+(iv)]
(vi)	Ground water development stage (%)	5.10	100x[(ii)+(iii)+(iv)]/(i)

Note: in reference column sl.no for factors of table 5.6 and 5.7 have been indicated. Proper unit conversion has been effected to arrive at the calculated values.

Table 5.7 shows that water drawl in the region is very less in comparison to the sizeable TARR. There will be no aquifer discharge water due to mining

and meager ground water drawl will not cause any percitible change in TARR.

The core zone, being in a plateau with hill slopes on either sides (east and west) allows substantial quantity of precipitated water to flow down as run offs to the natural gullies. The drainage channels of the relatively plain NE part of the study area join the Machkandana Nadi, which flows towards the north to join the Ardel Nadi which is a tributary of the Baitarani river. The southern part of the study area also has numerous drainage channels which ultimately join the Baitarani river. A number of drainage channels in the core zone shall be diverted due to expansion of quarries and dumps.

Quality of surface water shown in **Tables 3.11.1, 3.11.2, 3.11.3** and **3.11.4** indicates (when compared with IS: 10500) only slightly higher level of iron content in surface water. Also quality of ground water shown in **Tables 3.13.1, 3.131.2, 3.13.3, 3.13.4, 3.13.5** and **3.13.6** indicates (when compared with IS: 10500) slightly higher level of iron content because of presence of iron in the host rocks. Mining and allied activities shall have no impact or bearing on these. During mining substantial quantities of particulates are anticipated to be generated which may result in increase in silt content in adjoining water bodies. In order to prevent siltation storm water will be collected through garland drains and discharged after settling in settling pits.

Small quantity of effluent generated in the workshop and garage, pit head bath etc. shall be recycled after settling solids and passing the water through oil and grease pit.

5.5 IMPACT ON AIR QUALITY

Meteorological monitoring data (chapter 3) shows that in Winter 2005-06, predominant wind direction is NW (10.42 %), followed by NE (7.81 %) and N (6.68 %). Calm conditions prevailed for 42.05 % of the time. During the entire monitoring period in post monsoon and Winter seasons, the predominant wind speeds were in the range of 0.44-2.0 m/s.

In the mechanised open-cast mine, mining operations such as mining excavation, loading and unloading, movement of dumpers on haul roads, drilling and blasting and crushing are expected to generate airborne fugitive dusts. The futuristic plan indicates that the lease will not have any stack. Maximum handling of ore and OB/ waste including HEMM deployment for the entire mine shall commence from 2010-11. Prediction of fugitive dust levels has been carried out (for 24 hr avg.) at this stage with the help of

computerised fugitive dispersion model. Meteorological input parameters generated in Post monsoon,2005 and Winter, 2005-06 were utilised for fugitive dust level prediction through the model.

The Fugitive dispersion model (FDM) is generally based on the well known Gaussian Plume formulation for computing concentrations. The model has been specifically adapted to incorporate an improved gradient–transfer deposition algorithm. Emissions for each source are apportioned by the user into series of particle size classes. A gravitation setting velocity and a deposition velocity are calculated by FDM for each class. This model is designed to work on hourly meteorological data.

The main equation in the FDM model is :

$$C = \frac{Q}{2\pi\,\sigma y.\sigma z.u}\; e\left[\frac{-\,Vg\,(z-h)\,\sqrt{2}\,\beta}{\sigma z} - Vg^2\beta^2\right].\left\{e\left[\frac{-\,(z-h)^2}{2\sigma z^2}\right] + e\left[\frac{(z+h)^2}{2\sigma z^2}\right]\right.$$

$$\left. - 4\sqrt{\pi}\,V_1\beta e\left[\frac{-\,z+h}{2\sigma z^2}\right].\, e\left[\frac{V_1\sqrt{2}\,x}{\sigma z u} + \frac{z+h}{\sqrt{2}\,\sigma y}\right]^2.\, erf\left[\frac{V_1\sigma z}{\sqrt{2}\,.k} + \frac{z+h}{\sqrt{2}\,.\sigma z}\right]\right\}$$

Where

$$\beta = \frac{x}{\sqrt{2}\,.\sigma z.u}\;,\; V_1 = ug - \frac{Vg}{2}\;,\; k = \frac{\sigma z^2.u}{2x}$$

C	concentration (g/m^3)
Q	emission rate (g/s)
σy,σz	standard deviation of concentration in y and z direction (m)
x,y,z	receptor coordinates (m)
Vg	gravitational setting velocity (m/s)
h	plume centre line height (m)
k	eddy diffusivity (m^2/sec)
ug	deposition velocity (m/s)

The following source/ emission inputs have been considered for air pollution prediction modeling:

1. Pollution Sources in multiple combinations of active mining areas and haul roads (as line source) have been considered. Emission from spread top soil surface of reclamation area shall be insignificant because of high moisture content in unconsolidated soil, thus not contributing to fugitive dust level.

2. Fugitive dust level at any particular time is, by a large extent, function of the available active mining area and haul road length under a given set of meteorological conditions.

3. In this particular case, the scenario in 2021 has been considered. During this period maximum ore and overburden shall be handled in main ore quarry.

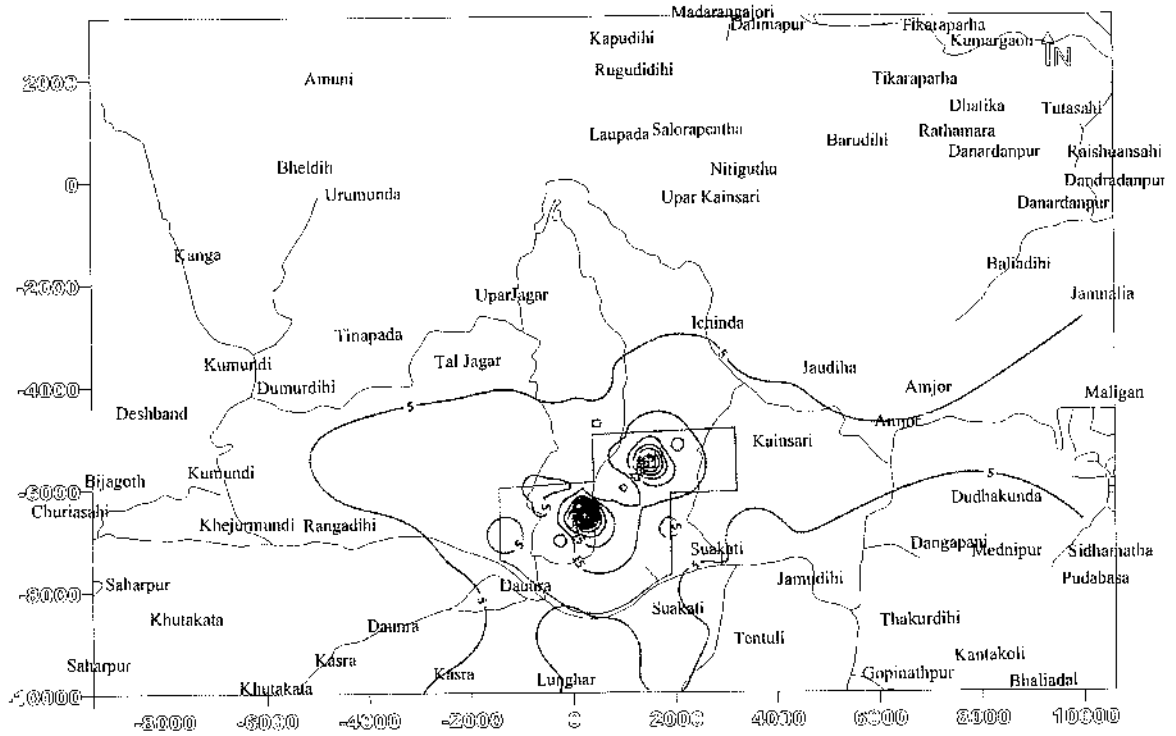
4. Emissions from crushing plant, stack yard and loading arrangement have been considered.

Daily hourly monitored micro-meteorological data was used as input.

Isopleths for fugitive dust (24 hourly values) are shown in **Fig. 5.2**.

Fig 5.2 and **Fig 5.3** shows that pollution contribution is mostly along the W – E axis which is the predominant wind direction. The fugitive dust levels at nearby villages are given in Table 5.8.

Fig. 5.2: Isopleths of fugitive dust emission concentrations (contribution due to Gandhamardan -A mines):



Note: 1. The Lease Area has been marked at the centre

2. The concentrations are in µg/m³.

Fig. 5.3: Isopleths of fugitive dust emission concentrations (combined contribution due to Gandhamardan –A and Gandhamardan-B mines):

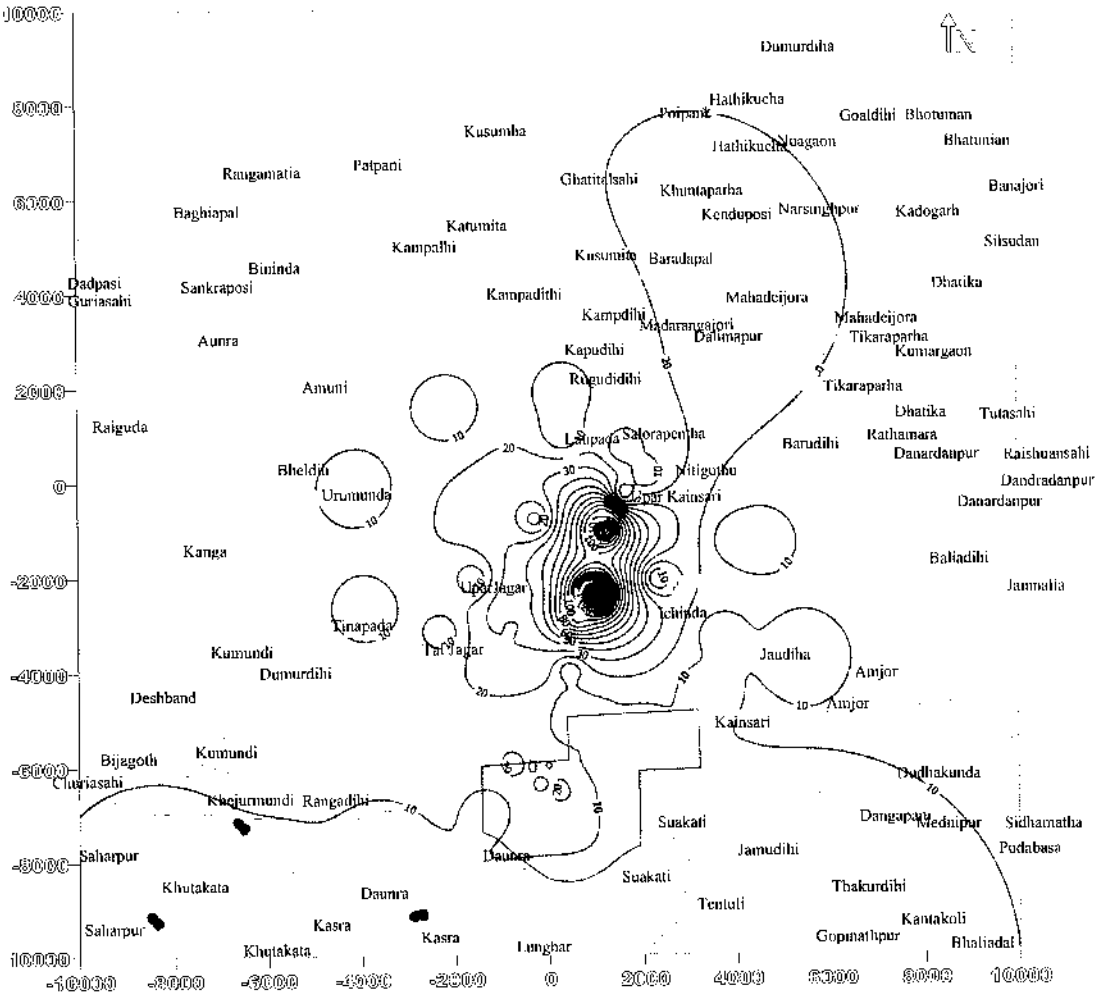


Table 5.8: Fugitive Dust Contribution at nearby villages

Sl. No.	*Location*	Distance & Direction from center of Gandha-mardan-B mine lease	Fugitive Dust (in µg/m^3)	
			Contribution due to Gandhamardan –A mine lease	Combined contribution due to Gandhamardan - A & Gandhamardan-B mines
1	Amjor	5.0 Km ENE	5	8
2	Jaudihi	4.2 Km ESE	5	12
3	Kainnsari	3.0 Km NE	10	24
4	Jamudihi	3.5 Km SE	5	20
5	Suakati-2	1.5 Km SE	5	18
6	Lunghar	3.0 Km S	5	16

7	Daunra	2.0 Km SW	5	16
8	Taljagar	4.0 Km W	5	16
9	Uperjagar	4.5 Km NW	2	24
10	Urumunda	6.5 Km NW	2	2
11	Laupada	6.5 Km N	2	6
12	Upar Kainsari	5.5 Km NNE	5	20
13	Ichinda	4.0 Km NE	5	38
14	Suakati-1	Core zone	5	24

Table 5.8 shows that maximum combined fugitive dust contribution due to the proposed expansion of Gandhamardan A and Gandhamardan-B mines will occur at Ichinda village where the existing SPM level is 192 $\mu g/m^3$. The resultant SPM level at Ichinda (in core zone of adjoining Ghandamardan-B mine lease where crushing plant and loading yard is located) will remain well below the norms for industrial areas (secondary crushing, loading facilities shall be installed at Ichinda village).

In addition to the above, as (i) the fugitive pollution is localized, (ii) there is no stack and (iii) the core zone is on a hill top, physiographically separated by the villages beneath by height, possibility of pollution transport from mining area to the villages below is low. From crusher plant near quarry 9, ore shall be transported by tippers. Transportation of ore shall increase the existing traffic density marginally. Because Iron ore lumps are hard lumpy in nature and trucks carrying fines and blue dust ore shall be covered, dust will not be released during transportation. To assess the impact due to this additional traffic computer model was utilized. The estimated values indicate no significant rise in SO_2 level. NOx emissions from trucks carrying ore from the expanded mine will be widely dispersed and diluted to insignificant levels before reaching any of the receptor villages.

During mining period actual dust level at a distance from source (quarry/ haul road) shall be less than the predicted levels **(Table 5.8)** due to gradual increase of artificial forests on back-filled land (and Avenue Plantation etc.) which shall serve as a screen.

5.6 IMPACT ON NOISE LEVELS

The existing noise level in the core zone, as measured is 56 dB(A) during day time and 41 dB(A) at night. Noise level may increase marginally due to intense mining.

Noise levels in the work zone varies from about 52 to 71 dB (A), except during blasting, which is carried out after the end of working shifts. Personal exposure is less than 90 dB (A) because operators only remain very close to the machines and they sit in closed cabins. Work zone noise level is expected to increase marginally in the open-cast mining area due to increased excavation, blasting, handling and transportation of increased amounts of overburden and ore. Measures suggested in Chapter 6, shall reduce the noise level. Impact of noise level on the nearby villages has been predicted using the computerized noise prediction model. The predicted noise contribution in the nearby villages are given at **Table 5.9.**

Table 5.9: Increase in Noise level at nearby villages due to mine working

Sl No.	Village	Background noise level in dB (A)	Nearest Quarry/ plant	Distance (m) (year)	Noise contribution in dB(A)	Resultant noise level in dB(A)
1.	Kainsari	46	Q-IVD	940 (2006-2011)	9.54	46.0010
2.	Daunra	47	Q-VC1	585 (2006-2011)	13.66	47.0020
3.	Lunghar	49	Q-VC1	2100 (2006-2011)	2.56	49.0001
4.	Suakati	57	Main Ore Body	990 (2016-2023)	9.09	57.0001
5.	OMCL Colony	52	Main Ore Body	640 (2016-2023)	12.88	52.0005

Table 5.9 shows that increase in noise level due to the working at quarries and crushing plant shall be imperceptible.

5.7 BLASTING EFFECTS

Keeping in view the presence of villages (beyond the statutory blasting safety zone) adequate measures shall be followed during blasting (refer Chapter 6). The empirical equations given in this chapter, as derived from trial blasting in nearby mines, has been used for assessment of peak particle velocity (ppv) values at nearby locations.

The derived empirical equation for main ore body is:

$$V = 417.8 \{D/(Q^{0.5})\}^{-1.265}$$

Empirical equation for other quarries is:

$$V = 219.6 \{D/(Q^{0.5})\}^{-1.281}$$

Where

V = Peak Particle Velocity in mm/s
D = Distance between location of blast and gauge point
Q = Quantity of explosive per delay

Considering Q= 125 kg per blasting round for main ore body and Q=50 kg per round for Q-IVD and Q-VC1 quarries anticipated vibration values have been calculated (**Table 5.10**) at the nearby villages in expansion phase. The results have been compared with the limiting values prescribed by Central Mining Research Institute (CMRI), Dhanbad, which are as given in Table no 5.11.

Table 5.10: Calculated vibration values in nearby villages in expansion phase

Sl No.	Village	Nearest Quarry	Distance (m) (year)	ppv (mm/s)
1.	Kainsari	Q-IVD	940(2006-2011)	0.4181
2.	Daunra	Q-VC1	585(2006-2011)	0.7675
3.	Lunghar	Q-VC1	2100 (2006-2011)	0.1493
4.	Suakati	Main Ore Body	990 (2016-2023)	1.4381
5.	OMCL Colony	Main Ore Body	640 (2016-2023)	2.4972

Table 5.11: Permissible Peak Particle Velocity (ppv) at the foundation level of structures in mining areas in mm/sec.

Type of Structure	Dominant excitation frequency, Hz		
	<8 Hz	8-25 Hz	>25 Hz
A. Buildings/structures not belonging to owner			
▪ Domestic houses /structures (Kuchha brick and cement)	5	10	15
▪ Industrial buildings (RCC and framed structures)	10	20	25
▪ Objects of historical importance and sensitive structures.	2	5	10
B. Building belonging to owner with limited span of life			
▪ Domestic houses/structures (Kuchha brick and cement)	10	15	25
▪ Industrial buildings (RCC and framed structures)	15	25	50

Comparison of the estimated ground vibrations show that with the planned charge per blast round, the vibrations are within limits for existing structures.

5.8 BIOLOGICAL ENVIRONMENT

As already indicated most of the mining lease (84.03%) lies within forest land. At present only a small fraction of the forest land (10.46%) has been utilized (Refer **Table 5.2**). The iron ore reserve is mostly in forestland of the Mine lease. The expansion project envisages utilises an additional 216.3617 ha (Refer **Table 5.3**) of forest land. The forest vegetation in the core zone has density of about 1400 trees / ha. Apparently the tree density seems to be moderate but the trees are closely spaced with stunted growth and ranging in height from 2 to 6m and in girth from 20cm to 40cm. The species wise and girth class wise number of trees to be cut due to the proposed activity is given in **Table 5.12**. Class I species are good timber value species like Sal, Piasal, Gamahar, Kurum, etc., Class II species are inferior in timber quality than Class I, like Asun, Kendu, etc. and Class II species are inferior type timber used for fuel wood purpose like Sidha, Kusum, Char, Bhalia, Bahara, Sonari, Bel, Kurchi, etc. From **Table 5.12** it can be seen that more number of trees are in diameter class 10 to 29 cm and 30 - 60 cm. Cutting of most of these trees is essential for mining activities. However the loss will be more than compensated by compensatory afforestation and also green belt/cover development planned in and around the mine which will rather increase the green cover and vegetation diversity. Out of the total forest in the mine lease area only 216.3617 ha will be cut and the number of trees to be cut is given in **Table 5.12.**

Table 5.12: Abstract list of trees to be cut in forest areas in the Core Zone in 30 Sample Plots of 1 ha each.

Type of Tree Species	No. of Trees in Diameter Class						Total
	30–59	60–89	90–119	120 - 149	150 - 179	>180	
Spl. Class	3	3	1	0	1	0	8
Class I Species	1763	416	21	6	0	1	2207
Class II Species	997	248	25	6	4	4	1284
Class III Species	2688	963	91	26	23	14	3805
Total	5451	1630	138	38	28	19	7304
Average tree to be cut per ha.	181.7	54.3333	4.6	1.2667	0.9333	0.6333	243.4667
Total trees to be cut in 216.3617 ha. of forest land	27553	8239	698	192	142	96	36919

As regards to impact on wildlife is concerned, there are a few other mines in the area. Moreover there is heavy traffic around the clock on NH – 6, which passes

through the buffer zone area. The forests support faunal species which have become habituated to prevailing conditions. Similarly, in the core zone the fauna in the vicinity of the mine is restricted to few common small species. There are existing open-cast quarries, where blasting operations are regular which may have scared away the fauna from the mine lease area. But after the mine is closed, the plantations developed on the abandoned mine area will attract back at least some of the animals displaced / scared away by the project.

So far as impact of noise generated due to the proposed expansion activity is concerned, it can be said that noise contribution shall not be more than 13 dB(A) resulting in insignificant rise in background noise level. Thus it is expected that the animals in the study area will not get impacted due the noise from the proposed mining activity.

As per the ORSAC report the Keonjhar district falls under zone - 2 (as per their classification) of elephant but the proposed mining site does not fall under migratory path / corridor of elephants.

5.9 SOIL AND AGRICULTURE

5.9.1 Soil

The top soil in the area is scanty. Whatever top soil is available soil will be excavated during the development of the mine pits. Most of this soil is rocky in nature and will get mixed with the overburden. Although minimum storage time shall be attempted to avoid nutrient loss, but loss of some nutrients due to temporary storage and even after direct placement of soil to the reclaimed areas of the external waste dump, cannot be ruled out.

Top soil shall be subjected to water borne erosion from reclamation areas when in unconsolidated state. As described later (in chapter 6), a combination of diversion ditches and garland drain etc. shall be constructed to minimize soil loss. Construction of three ditches makes the effective slope length $1/4^{th}$. A large amount of this loss shall be arrested in catch pits/ reservoir, which shall be collected and put back to the reclamation areas.

5.9.2 Agriculture

As indicated in chapter 3, the proposed mining lease area includes 11.55 ha agricultural land. The agricultural land will not come under mining extraction. However, the agriculture in the core zone is not very productive due to low soil fertility and absence of lift irrigation at hill top.

5.10 SOCIO ECONOMICS

Analysis of various aspects of the study amply reveals that the proposed project is going to create considerable impact on the socio-economic conditions of the people in the study area. On the basis of the present study the following major conclusions may be drawn:

- The proposed project is not going to cause any damage to the existing rural agrarian economy of the study area, in stead it may help agriculture by way of providing supplementary income which may result in increase investment in agriculture and consequently, agricultural production.

- The project is expected to foster the existing trend of shift in the pattern of demand of the local people from food to non-food items as a result of the modernizing influences.

- The project has strong positive employment and income effects, both direct as well as indirect.

- The project is going to create positive impact on consumption behaviour by way of raising average consumption level of the people of the study area and income through multiplier effect.

- The project is likely to speed up the growing view on importance of education among the people of the study area.

Peoples' perception regarding the project is a very important factor because it is the people on whom the major part of the impact will fall. To this end, an opinion poll was conducted as a part of field survey. The results of this poll are furnished in **Table 5.13.** It is observed that about 87% of the respondents are optimistic about the project because of the employment opportunity, specifically, the temporary jobs for the local people in construction activity of the expansion project. 68 % of them are hopeful about improvement of the roads. So far disadvantages are concerned, 65% of the respondents are worried about water pollution. According to them damage of health and agriculture due to dust is a big problem. Some of them have also reported that forest may be damaged due to mining activities.

Table 5.13: Peoples' perception regarding the project

Sl.No.	Perception	No of respondents	
A	ADVANTAGES		
1.	Employment opportunity	27	(87.1)
2.	Improvement of roads	21	(67.7)
3.	Improvement of the area	9	(29.0)
B.	DISADVANTAGES		
1.	Water pollution	20	(64.5)
2.	Damage to forest	18	(58.1)

Figures in ( ) indicate % in total number of respondents

Environment Management Plan

6.0 ENVIRONMENTAL MANAGEMENT PLAN

To maintain ecological balance and to check harmful effects due to mining and allied activities at Gandhamardan-A mine, environmental control measures have been integrated into the process of mine planning.

Many of the areas of environmental management planning require multidisciplinary approach. Therefore the measures envisaged in the report are to be regarded as guidelines and depending upon the continuing advice to be taken from experts of relevant fields like forestry, soil chemistry, ground water etc. the suggested schemes are to be detailed and if necessary to be modified from time to time to meet statutory requirements. The changes warranted as per site specific conditions are to be accounted for, during actual implementation. Further, in the light of experience likely to be gained during the initial years of operation, proposed schemes may require periodic modification/ updating. In this chapter all technical, biological and socio-economic control measures have been envisaged and these pertain to:

- Solid Waste Management
- Air Pollution Control
- Water Management and Water Pollution Control
- Noise Control
- Control of vibration, noise and fly rock throw due to blasting
- Biological reclamation measures
- Land use planning and mine closure
- Occupational safety and health
- Socio-economic measures

6.2 SOLID WASTE MANAGEMENT

The principal solid waste produced in the open cast mine is overburden. At present overburden is dumped in four numbers of small external overburden dumps which were created unscientifically alongside the quarries in past. In the expansion phase dumping will be carried out mainly in two external dumps. In addition, substantial quantity of overburden shall be backfilled in progressively abandoned quarries on north-eastern side. In the first five years of expansion phase quarry 9, quarry VD, Hill top quarry and small quarries on north eastern part shall be in operation. Waste from quarry 9 shall be backfilled in exhausted quarry VB and small abandoned quarry near OMCL colony. Waste from Quarry VD and Hill top quarry shall be backfilled into exhausted quarry VB and part of Quarry VD shall be backfilled into small abandoned quarry at central part. Waste from north eastern small quarries shall be dumped in

north eastern external dump. During 2011-2016 stage also waste from Quarry 9, quarry VD and Hill top quarry shall be utilized for backfilling abandoned quarry VB, western side external dump, Small abandoned quarry at central part and exhausted north eastern quarries. During 2016 – 2023 stage waste from Quarry 9, quarry VD and Hill top quarry shall be utilized for backfilling abandoned quarry VB, western side external dump and exhausted north eastern quarries. Following the above arrangement, during the projected life of the mine waste shall be backfilled in 21.57 ha exhausted quarry and 26.63 ha external dump area.

Table 6.1: Overburden disposal linkage

Expansion phase	External dump		Internal dump			
	Western dump	North eastern dump	Western side (abandoned quarry VB)	Abandoned NE quarries	Small abandoned quarry near OMCL colony	Small abandoned quarry at central part
Till 2011	-	3	1,2,4	-	1	2
2011-2016	1,2	-	1,2,4	1,4		2
2016-2023	1,2			1,2,4		

Note: 1= Quarry 9; 2= Quarry V D; 3 = North eastern small quarries; 4 = Hill top Quarry

Internal dumps (backfilled areas) shall match with adjoining ground profile. Dump height in all the external dumps will be maximum 10m. The dumps shall have the following protection measures:

- The individual dump lifts will have maximum slope of 37° and the overall slope of the dump shall not exceed 28°.
- The external dumps will have stretches of retaining wall at suitable locations. The retaining walls will be of boulder in mud construction. The walls will be of maximum 1 m height and the top surface will be of 0.5 m flat. Retaining walls will have weep holes to drain out water.
- The back-filled areas shall be leveled to match with adjoining ground level.
- The completed dumps and the back-filled areas shall be gradually afforested to increase the stability.

The waste consists of laterite, brecciated chert, banded iron formations and shale. These are non-toxic in nature and no chemical contamination is expected. However, substantial sediment loads are expected through running storm water from dumps and unafforestated backfilled areas. In order to manage the sediments at the toe of

dumps, few metres away beyond the retaining walls, garland drains will be constructed to receive water coming out of the weep holes and surrounding areas.

Waste management in five yearly stages has been shown in **Drawing Nos. MEC/Q696/11/S2/(6)10.1,MEC/Q696/11/S2/(6)10.2** and **MEC/Q696/11/ S2/(6) 10. 3** for 2011, 2016 and 2023 stages respectively.

6.2 AIR POLLUTION CONTROL

Fugitive dust is generated in open cast mine due to drilling, blasting, handling of overburden and ore and operation of dumpers/trucks on haul roads. In addition, fugitive dusts shall also be generated in the surface crushing plant at hilltop near quarry 9.

To control dust from drilling operations wet drilling will be practiced. Also drill speeds will be regulated as per manufacturer's guidelines.

Spread of dust from blasting will be somewhat checked by use of suitable explosives e.g. ANFO. Overcharging of blast holes will be avoided.

Haul roads are the major source of fugitive dusts. To reduce dust from haul roads the following measures will be taken:

- The main haul road will be made a metalled road.
- The unmetalled haul roads shall be adequately compacted before being put into use. Periodically water will be sprinkled on these roads in amounts just sufficient to wet the surface. Water will also be sprinkled on stacks of ore.
- As practiced now, overloading of transport equipment shall be prevented in order to stop spillage.
- Trucks carrying fines and blue dust will be covered with tarpaulin sheets to prevent fugitive dust generation.
- The roads will be properly maintained and pot-holes filled in regularly to reduce generation of fugitive dusts and emissions from vehicles.

Once a overburden dump has reached its designed size, it will be covered with a layer of top-soil and water will be sprayed on the soil. Grass will be immediately planted on the dump to reduce fugitive dusts. Subsequently green belt will be developed on the dump.

Dust extraction system shall be installed in the crusher plant whereas dust suppression arrangement in the haul roads shall be practiced to minimize the chances of fugitive particulate emission and exhaust fumes in transportation roads.

Gaseous pollutants in the exhaust fumes generated by the other machinery shall be minimized by ensuring vigorous maintenance adhering to stringent overhaul schedules. The repair workshop and maintenance garage, which shall be equipped with all necessary facilities, will ensure upkeep and maintenance of engines.

In the maintenance garage, waste lubricants and grease etc. will be placed in separate containers and shall be auctioned off from time to time.

6.3 WATER MANAGEMENT AND WATER POLLUTION CONTROL

Drainage in the core zone has been planned to be regulated in a manner so that impact on surface water bodies is minimized and yet the drainage pattern of the area is not affected.

A number of drainage channels in the core zone shall be diverted due to expansion of quarries and dumps. The drainage channels of NE part of the study area join the Machkandana Nadi, which flows towards the north to join the Ardel Nadi which is a tributary of the Baitarani river. The southern part of the study area also has numerous drainage channels which ultimately join the Baitarani river. The storm water run-offs carry substantial amounts of solids from mining core zone.

Water management (including storm water drainage) scheme (by a network of garland drains/ diversion ditches and catch-pits) has been planned. The salient features of the scheme are as follows:

- The overall drainage planning has been done in a manner which follows the existing pre mining drainage routing to the extent possible, maintaining the overall slope in the direction of pre-mining flow direction so the run off distribution is not affected.

- Garland drains shall be constructed as much as possible on all sides of quarries and external dumps (depending on contours). The garland drains shall be routed through catch pits and settling tanks to settle out suspended solids in the storm water. The clarified water will be discharged to natural water courses. Retaining walls will be built all-around the external dumps which will have weep holes for passage of storm water to join garland drains.

- Small grasses and bushes in drains hold back solid particles from draining away

- Small stone barriers across the drain will check water current and arrest solids

- Stone pitching will be made at suitable places to regulate water flow.

- Some of the drains which will serve for a long time shall be made pucca

- Settling pits and drains shall be cleaned periodically.

- HEMMs will be washed in a designated area and the effluents will be routed through drains to a settling pit, which has an oil & grease trap. The clarified effluents will be used for irrigating the green belt.

- Effluents from the canteen and rest areas will be diverted through drains for green belt development. Sanitary sewage generated in office area etc will be treated in septic tanks and soak pit.

Water management has been shown in the stage wise reclamation drawings **MEC/Q696/11/S2/(6)10.1, MEC/Q696/11/S2/(6)10.2** and **MEC/Q696/11 /S2/(6) 10.3** for 2011, 2016 and 2023 stages respectively.

6.4 NOISE CONTROL

Noise level shall be maintained below 90 dB (A) in work zone (for 8 hours exposure) Noise levels are expected to increase at work zone with commencement of mining and allied activities (in comparison to existing state). The following measures will be taken to reduce noise levels.

- Diesel powered machinery, which are major source of noise in open cast mines, will be properly maintained as per maintenance schedule to prevent undesirable noise. Attention shall be paid towards rigorous maintenance of the silencers of diesel engines

- Static diesel engines shall be housed as far as possible (not made of sheet metals) or surrounded by baffles. If possible they will be placed on vibration isolators.

- Blasting will be carried out once only and in day time.

- Drill machine operators and dumper drivers have been issued earplugs and earmuffs. Duty hours of operators of noisy machinery will be regulated to keep their noise exposure levels within limits.

- In the Crushing and Screening Plant, the screen will be mounted on multiple helical spring units to isolate vibration transmission to supporting structure thus eliminating structure born vibration and noise.

- The Crusher will have independent block foundation isolated from other supporting structure. Crusher internal elements will be covered by casing to reduce transmission of impact noise. The crusher will be housed to contain noise.

- Green belt will be developed around office building, crushing and screening plant and mine to reduce noise exposure level.

6.5 CONTROL OF VIBRATION, NOISE AND FLY ROCK GENERATION DUE TO BLASTING

So far as the impact of noise and vibrations due to blasting operations on nearby villagers are concerned it can be said that the predicted ppv values (**Table 5.5**) are very much within the permissible standards. However, the following measures shall be followed:

- Blasting will be carried out only during day-time. Blasting shall not be carried out in stormy and rainy weather and during lightning.

- The distribution ratio of booster to column charge may be 1:3

- Maximum permissible charge per delay would depend on the distance of structure to be protected from the blasting

- Detonation cords should be used for connections and for initiation of detonation in holes.

- Detonation cord relays should be used for providing delay timings between rows (25 ms to 50 ms) and within rows or between holes (15, 17 or 25 ms duration). Use of electric delay detonators should be avoided because of the possibility of overlapping of delay timings.

- Maximum total period of blast should preferably be less than 600 ms to minimize cut offs.

- Suggested number of rows in a blast should not be more than four to reduce fly rock and ground vibrations.

- Length of blast will depend on the total number of holes which can be blasted in a round while observing the above guidelines/ restrictions. However, it should be as large as design would permit. Attempts should be made to have one large blast with less frequency than to have several small blasts.

- Initiation sequence : Diagonal or extended V pattern

- Drill cuttings may be used as stemming material.

6.6 BIOLOGICAL MANAGEMENT MEASURS

6.6.1 GREEN BELT DEVELOPMENT

Green belt / cover, is an important sink for air pollutants, it also absorbs noise. Enhancing green cover not only mitigates pollutants but also improves the ecological conditions / aesthetics and reduces the adversities of extreme weather conditions. Trees also have major long-term impacts on soil quality and the ground water table. By using suitable plant species, green belts can be developed in strategic zones to provide protection from emitted pollutants and noise.

Plant species suitable for green belts should not only be able to flourish in the area but must also have rapid growth rate, evergreen habit, large crown volume and small / pendulous leaves with smooth surfaces. All these traits

are difficult to get in a single species. Therefore a combination of these is sought while selecting trees for green belt / vegetation cover. The green belt should be planted close to the source or to the area to be protected to optimize the attenuation within physical limitations.

The green belt / cover will serve the following purposes:

- Compensate the damage to vegetation due to setting up and operation of the mine
- Prevent the spread of fugitive dust generated due to mining and allied activities
- Attenuate noise generated by the mine.
- Reduce soil erosion
- Help stabilize the slope of external over-burden dumps
- Increases green cover and improve aesthetics.
- Attract animals to re-colonise the area when the mine is abandoned.

In the proposed mining project, in addition to compensatory afforestation, green belt will also be developed in the following areas:

- Along mine lease boundary (if there is existing forest already there, the same will be conserved on the direction of thee State Forest Department).
- Plantation for improvement of forests in vacant areas
- Around office buildings, garage, stores etc.
- Along the side of major roads
- On external overburden dumps
- On backfill areas and on mining upper benches / slope (where overburden backfill material is not available for back filling) of mine pits after closure of the mine pit.

The species for plantation have been selected on the basis of soil quality, place of plantation, chances of survival, commercial value (timber value, ornamental value, etc.), etc. It is to be noted that only indigenous species will be planted. Exotic species like Eucalyptus and Australian Acacia will not be planted. The species for green belt / vegetation cover development will be selected in consultation with State Forest Department and State Soil Conservation Department. Mixed plantations will be done keeping optimum spacing between the saplings. The species suitable for planting in the area as recommended by Central Pollution Control Board in their publication "Guidelines for Developing Greenbelts" (PROBES/75/1999-2000) has been followed.

In order to supply seedlings for the proposed green belt and green cover development a small nursery will be developed with the help of the state forest department. In this nursery, saplings will be developed from seeds or seedlings collected from nearby forest areas / other nurseries.

Plantation along mine lease boundary

The width of the belt around the proposed mining operations will be of suitable width (minimum 7.5 m) all around the ML boundary (in areas where the existing forest trees are not there). In places where existing forest abuts the mine lease area, the same will be protected / maintained and the balance width will be planted. Around external waste dumps site an area of about 26.63 ha will be under green belt with a suitable width as per the availability of space. A total of about 5.06 lakhs trees will be planted. Since most of the project area lies on the plateau with hillocks and slopes, saplings will be planted in pits at about 2.5 m intervals along contours so that the tree density is about 1600 trees per ha. The pits will be filled with a mixture of good quality soil and organic manure (cow dung, agricultural waste, kitchen waste) and insecticide. Since, tests have shown that availability of phosphorus, a limiting nutrient, is low, phosphoric fertilizers will also be added. The saplings will be planted just after the commencement of the monsoons to ensure maximum survival. The species selected for plantation must be locally growing varieties with fast growth rate and ability to flourish even in poor quality soils.

The row of plants facing mine should be smaller species and those facing outside should be taller species. The species suggested for plantation is:

Small Species:	**Tall Species**
Yellow Kaneer (*Thevieta peruviana*)	Sal (*Shorea robusta)*
Pink Kaner (*Nerium sp.*)	Siris (*Albizzia lebbeck*)
Bougainvellea (*Bougainvillea sp.*)	Neem (*Azadirachta indica*)
Barkoli (*Zizyphus sp.*)	Druping Ashok (*Polyalthia longifoila*)
Gulmohar (*Delonix regia*)	Aam (*Mangifera indica*)
Duranta (*Duranta sp.*)	Jodi (*Ficus religiosa*)
Kamayani (*Murriya exocitica*)	Palash (*Butea sp*)
Babool (*Acacia arabica*)	Cassia (*Cassia siamea*)
Sharifa (*Annona squamosa*)	Karanja (*Pongamia pinnata*)
Sonnari (*Cassia fistula*)	Subabool (*Leucaena leucocephala*)
	Baheda (*Terminalia bellirica)*
	Harra (*Terminalia chebula*)

In case of Sal, because of the very short viability of seeds and low survival rate of seedlings, seeds will be sown in rows and subsequently extra / unhealthy seedlings will be thinned out.

Plantation for forest improvement in selected areas within lease

In the proposed plant, green belt will be developed in vacant areas. Species suggested for such areas are:

Siris (*Albizzia lebbeck*)	Panasa (*Artocarpus heterophyllus*)
Dimiri (*Ficus racemosa)*	Palas (*Butea spp.*)
Gulmohar (*Delonix regia)*	Lowa (*Ficus glomerata*)
Tentuli (*Tamarindus indica)*	Mahula (*Madhuca longifolia*)
Neem (*Azadirachta indica*)	Jamun (*Syzygium cuminii*)
Aam (*Mangifera indica*)	Baheda (*Terminalia bellirica*)
Jodi (*Ficus religiosa*)	Harra (*Terminalia chebula*)
Bara (*Ficus bengalisis)*	Sal (*Shorea robusta)*
Cassia (*Cassia siamea)*	Peltophorum *(Peltophorum feruginium)*
Karanja (*Pongamia pinnata*)	Sita Phal (Anona squamosa)

Mixed plantation will be done to take care of different heights and rates of growth

Plantation around office buildings, stores, garage etc. and along roads

Plantation will be carried out around various shops, stores and other buildings, along the side of connecting roads. Species suggested for plantation are as follows which are mostly ornamental plants:

Cassia (*Cassia javanica*)	Jarul (*Lagerstroemia flos-reginae*)
Cassia (*Cassia siamea*)	Sisso (*Dalbergia sissoo*)
Sonnari (*Cassia fistula*)	Jodi (*Ficus religiosa*)
Arjuna (*Terminalia arjuna*)	Aam (*Mangifera indica*)
Gulmohar (*Delonix regia*)	Siris *(Albizzia lebbeck)*
Karanja (*Pongamia pinnata*)	Tentuli *(Tamarindus indica)*
Neem (*Azadirachta indica*)	Druping Ashok *(Polyalthia longifoila)*
Bara (*Ficus bengalensis*)	Peltophorum (*Peltophorum feruginium*)

Plantation on dumps

Plantation on the overburden dumps cannot start till dumping activities cease at least in a dump and the site is prepared for plantation. Once dumping is complete in a

dump, a path will be cleared to the designated area so that the basic inputs (water, manure, and seedlings) can be carried up to the site. Next, a layer of topsoil shall be spread over the area and roughly leveled. Grass seeds / seedlings will be planted on the soil layer to stabilise the soil.

Plants selected for plantation in and around the waste dumps should have pollution hardy nature, fast growth rate, glabrous/ pendulous leaves, and large crown volume to surface area of fluttering leaves. The species selected will be from among the following:

Jodi (*Ficus religiosa*)
Gulmohar *(Delonix regia)*
Siris (*Albizzia lebbeck*)
Ata *(Annona squamosa)*
Babool *(Acacia nilotica),*
Neem (*Azadirachta indica*)
Karanja (Pongamia pinnata)
Acacia *(Acacia leucophloea)*
Barkuli *(Zizyphus mauritiana)*
Druping Ashok (*Polyalthia longifolia)*
Subabool (*Leucaena leucocephala)*

Plantation on top of dumps

Trenches of 45 cm X 45 cm will be dug on the flat top of the dumps and the excavated material will be used to form a bund on the dip side of the trenches to retain maximum water in the trenches during rains. Suitable benches will be made on the waste dumps and a size of 60cm X 60cm pits will be dug on the benches at 2-3 m intervals. The pits will be filled with a mixture of topsoil, organic manure and phosphoric fertilisers. Saplings will be planted in these pits once monsoon has commenced to ensure maximum survival of the saplings. Initially hardy pioneers species, *Acacia auriculiformis* and *Prosopis juliflora* will be planted to help build up the soil. Subsequently these will be replaced by species such as *Acacia nilotica, Acacia catechu, Acacia leucophloea, Azadirachta indica, Annona squamosa, Lucaena leucocephala, Zizyphus mauritiana* etc.

Plantation on dump slopes

Plantation on slope of the dumps will commence as soon as the first bench is ready. The terraces on the slopes will be sloped inward. 60cm X 60cm pits will be dug at 1.5m intervals and filled with a mixture of topsoil and organic manure. There will be open masonry drains on the terraces. These will receive water from the higher terraces and convey it to the next lower terrace. Before the commencement of the monsoon the slopes and terraces will be covered with a layer of soil (held with suitable mechanical soil binder) and sprinkled with water. Just before the

commencement of the monsoon seeds of grasses and small shrubs will be sprinkled on the soil covering of the dump slopes or seedlings of such plants will be planted on the slopes.

Plantation on backfill areas and mining benches / slope (where back filling is not possible) of mine pits

Plantation on the mining benches cannot commence till all the mining activities from the pit ceases. Once the abandoned pit is backfilled and leveled, a layer of topsoil will be spread over the area. Grass seeds / seedlings will be planted on the soil layer to stabilise the soil.

Plants selected for plantation on the mining benches shall be draught hardy in nature, with fast growth rate and with glabrous/ pendulous leaves, and with large crown volume to surface area of fluttering leaves. The species selected will be from among the following:

Neem (*Azadirachta indica*)
Karanja (Pongamia pinnata)
Babool (Acacia nilotica),
Acacia *(Acacia leucophloea)*
Ata *(Annona squamosa)*
Bar`kuli *(Zizyphus mauritiana)*
Subabool (*Leucaena leucocephala)*
Jodi (*Ficus religiosa*)
Druping Ashok (*Polyalthia longifolia)*
Gulmohar *(Delonix regia)*
Siris (*Albizzia lebbeck*)

Trenches of 60cm X 60cm will be dug on the flat top of the back filled mine pits and on mining benches (where back filling is not possible) and the excavated material will be used to form bund on the dip side of the pits to retain maximum water. Contour trenches at 2-3 m intervals will be dug on the backfilled mine pits / mining benches for soil and moisture conservation. The pits will be filled with a mixture of topsoil, organic manure and phosphoric fertilizers and insecticides. Saplings will be planted in these pits once monsoon has commenced to ensure maximum survival of the saplings.

Plantation on upper mining benches will commence as soon as the first bench is ready. There will be open masonry drains sloping along the mining benches. These will receive water from the higher benches and convey it to the next lower bench.

Before the commencement of the monsoon the side slopes of mining benches will be covered with a layer of soil by means of suitable mechanical binders like nylon ropes and sprinkled with water. Just before the commencement of the monsoon seeds of

grasses and small shrubs will be sprinkled on the soil covering of the bench side-slopes.

Phase wise plantation for improvement of forest land

Stretches of open land in the lease area which will not be covered by any activity will be selected for improvement of forest density in such areas. Plantation there will commence from the initial years of the expansion phase and plantation will be expanded in such areas in progressive stages.

The trees will be watered using the effluent from the sewage treatment plant and treated discharges from mine pit. They will be manured using sludge from the sewage treatment plant. In addition kitchen waste from the town-ship and mine canteen can be used as manure either after composting or by directly burring the manure at the base of the plants.

Phase wise requirement of saplings are indicated in **Table 6.2**

Table 6.2: Phase wise requirement of saplings

Expansion Phase	Available land (ha)	Requirement of saplings (nos.)
Existing	18.73	29968
Existing -2011	80.62	128992
2011-2016	94.23	150768
2023-Post Mining	130.72	197230
Total	**324.30**	**506958**

Saplings will be planted at the rate of 700 trees/ ha for forest land improvement and at the rate of 1600 trees /ha on internal and external dumps etc.

Post Plantation Care

Immediately after planting the seedlings, watering will be done. Further watering will depend on the rainfall. In the dry seasons watering will be regularly done especially during March to June. Watering in one year planted saplings will be more frequent (thrice a week). Manuring will be done using organic manure (animal dung, agricultural waste, kitchen waste, etc.). Younger saplings will be surrounded with tree guards. Diseased and dead plants will be uprooted and destroyed and replaced by fresh saplings. Growth / health and survival rate of saplings will be regularly monitored and remedial actions will be undertaken as required.

6.6.2 MANAGEMENT MEASURES FOR REDUCING IMPACTS ON FAUNAL SPECIES

So far as impact of noise generated due to the proposed expansion is concerned, it can be said that the noise level contribution out side the mine lease area shall be imperceptible. Further, adequate thickness of green belt along the mine-lease boundary (minimum 7.5 m) will further reduce the noise level outside of the project boundary. Thus the animals in the study area will not get impacted due the noise from the proposed project activity.

So far as the impact of noise and vibrations due to blasting operations on wild-life is concerned, it can be said that the predicted ppv values are very much within the permissible standards. In addition, measures suggested under 6.5 shall help to reduce some noise and vibrations generated due to blasting operations. The blasting operations will be restricted to day time only and even before 17.00hrs, so as to cause minimum disturbance to animals when they are out for their requirements during late evening and night.

The strong light in the project premises during night may cause some disturbance to the fauna in the near by forests. It is proposed that all the light posts erected along the mine lease boundary will face inwards and down wards (with reflectors facing the mine and downwards), so that the light do not spreads out side the ML area.

6.7 LAND USE PLANNING AND MINE CLOSURE

Forestry shall be the post mining use of land. Justifications of deciding forestry as the post mining land use are as follows:

- About 84% of the leasehold consists of forestland.
- The artificial forests developed on abandoned quarry areas, overburden dumps, internal dumps and other areas in the lease shall match well with the existing forests on hill slopes in the buffer zone resulting in an uniform land use.
- Restoration of forest cover shall attract back at least some of the impacted fauna on cessation of mining.

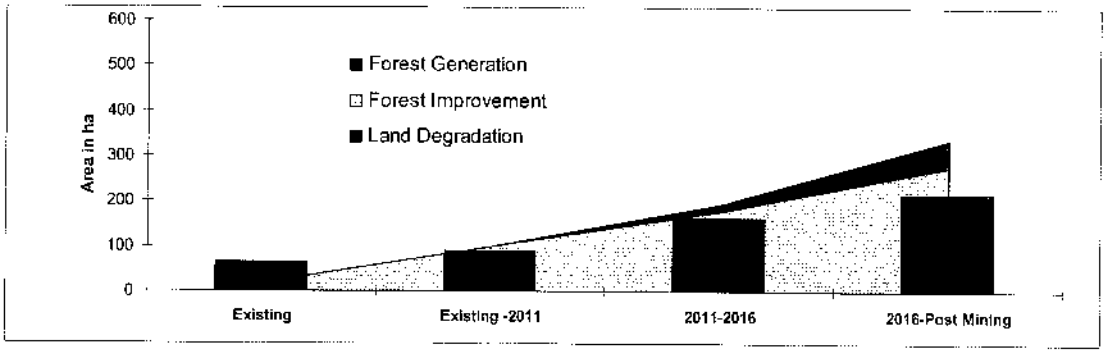
Progressive forest land area degradation vis-à-vis biological reclamation planned has been shown in the Table (**Table 6.3**) below:

Table 6.3: Stage-wise forest land degradation vis-à-vis Biological reclamation

Expansion phase	Land degradation	Afforestation			
		Generation			Improvement
		Internal Dump	External dump	Selected Patches(N.F.)	Selected Patches (F)
Existing	64.72	0.00	0.00	0.00	18.73
Existing -2011	91.04	0.00	0.00	0.00	99.35
2011-2016	163.48	16.04	0.00	0.00	177.54
2026-Post Mining	216.36	21.57	26.63	13.24	262.86

Stage wise forest land degradation vis-à-vis area coverage under biological reclamation is shown also in **Fig. 6.1. Table 6.3** and **Fig 6.1** shows that rate of biological reclamation is faster than land degradation in all the stages till 2023. By 2023 all the available areas will be afforestated. During 2016 –2023 and in post mining phase emphasis will be given for afforestation on account of closure phase.

Fig. 6.1: Stage wise forest land degradation vis-à-vis afforestation



The abandoned mine pits on eastern side shall be backfilled and afforestated. The combined main ore quarry shall not be backfilled because (i) mining in the quarries shall continue till end of mine life and (ii) very less quantity of overburden is generated in iron ore mining. However as explained under 6.6 the quarry benches shall be afforestated.

Some of the civil construction shall remain after cessation of active mining. These infrastructure facilities shall benefit the site as the roads will form a much better communication link with the outside compared to the existing unpaved roads and the office buildings etc. may be used by the State government or Central government agencies or can be developed as a school/primary health centre etc in the region. The areas of temporary use viz. stack yard, areas for site services etc. shall be afforestated during closure. The unfilled main ore quarry (although afforestated on

benches) shall be fenced. Electrical installations shall be dismantled following proper procedure.

Progressive reclamation planning is shown in **Drawing Nos. MEC/Q696 /11 /S2/(6)10.1, MEC/Q696/11/S2/(6)10.2** & **MEC/Q696/11/S2/(6)10.3** for 2011, 2016 and 2023 stages respectively.

Post mining land use plan is shown in **Drawing No. MEC/Q696/11/S2/(6) 11.1.**

6.8 OCCUPATIONAL SAFETY AND HEALTH

Occupational safety and health is very closely related to productivity and good employer-employee relationship. The factors of occupational health in OMCL's Gandhamardan A project are mainly dust, siltation etc. Safety of employees during operation and maintenance etc. shall be as per mines rules and regulations. To avoid any adverse effects on the health of workers due to various pollutants, sufficient measures have already been addressed in this chapter. The following measures relating to safety and health shall also be practised:

- Provision of rest shelters for mine workers with amenities like drinking water etc.
- All safety measures like use of safety appliances, safety awards, posters, slogans related to safety etc.
- Training of employees for use of safety appliances and first aid.
- Regular maintenance and testing of all equipment as per manufacturers' guidelines.
- Periodical Medical Examination (PME) of all workers by a medical specialist so that any adverse effect may be detected in its early stage.
- First Aid organisation in mines including training and retraining of First Aiders.
- Close surveillance of the factors in working environment and work practices, which may affect environment and worker's health. Monitoring

of the values of various factors which may lead to occupational health hazards.

- Working of mine as per approved mining and environmental plans.

6.9 SOCIO-ECONOMIC MEASURES

OMCL shall take up the following general measures for the socio economic upliftment of the nearby villagers. Some of the following measures already being practiced by OMCL.

- Mining and mineral handling involve transportation activity for day to day operation. Substantial amount of revenue is generated by transportation activities along with employment e.g. labour, helper etc. Project authorities give preference to local people while engaging contractors for material transportation or at least for loading and unloading.

- In case of direct manpower required for mining and mineral handling operations, local people are employed as much as possible especially in the categories of unskilled and semi skilled labours subject to rules and procedures in vogue in OMCL.

- A section of local youth shall be trained in phases so that they can take up some jobs (mining contractorship, building contractorship, supply of mining materials and also small scale rural business developments) of their own (self employment) or in mines (on contract basis) or elsewhere.

- OMCL shall provide training from time to time for improved agro techniques, first aid and safety, adult literacy programme etc. to the villagers.

- OMCL supports schools in nearby villages and provide constant encouragement for sports and cultural activities in local villages.

- OMCL shall provide social infrastructure (tube-wells for drinking water, road-side shelters etc.) in villages around the project.

- OMCL sponsors free periodic health camps in nearby villages.

EMP Implementation and Monitoring

7.0 EMP IMPLEMENTATION AND MONITORING

A large part of the sampling and measurement activities will be concerned with long term monitoring aimed at providing an early warning of any undesirable changes or trends in the natural environment that could be associated with mining and allied activities. This is essential to determine whether the changes are a response to a cycle of climatic conditions or are due to the mining and allied activities.

In particular, a monitoring strategy is required to ensure that all environmental resources, which may be subjected to contamination, are kept under review. Monitoring of the individual elements of the environment is necessary.

A separate department "Environmental Management Cell (EMC)" has been formed at OMCL for Gandhamardan-B project to look after the inspection/ monitoring requirements. The same department takes care of the environmental monitoring, inspection and reclamation activities for Gandhamatdan-A project also. The officers of the department meet frequently to assess the progress and analyse the data collected during the preceding fortnight/ month. The following items are considered under the monitoring schedule.

7.1 ACTIVITIES TO BE MONITORED / INSPECTED BY EMC

Slope failure

Regular examination will be carried out to look for slope failure on open cast mine faces, ore and overburden benches etc. Any abnormal condition, if observed will be brought to the notice of concerned department. Survey team will also monitor mine face with precision level instruments.

Land erosion

Regular observation for checking land erosion will be made in backfilled area/ hill slopes.

Drainage

The effectiveness of drainage system depends upon proper cleaning of all drains and sumps. Any blockage due to silting or accumulation of loose

materials will be checked on a regular basis. Stone pitching, brick mounds etc, on drains shall also be monitored.

Blasting Effects

Regular testing and inspection of blasting operations in work zone will be carried out with respect to noise, fly rock throw, vibration, dust and fume generation. These tests will also be conducted whenever new patterns of blasting are adopted as per mine working.

Revegetation and Green Belt Development

Schedule planned for green belt development will be checked after every year and any alteration required will be implemented. Post plantation status will be regularly checked in every season. Phase wise development in the areas of plantation including rate of growth, survival rate etc., will be recorded systematically. The format given in **Table 7.1** will be filled every year for revising the schedule for the following year.

Table 7.1: Format to Record / Monitor Plantation Measures

1. Area (s) under plantation / vegetation.
2. Post plantation work involved
3. Period of plantation
4. Type of plantation
   a / Tree Species
   b/ Grass
5. Type of plant saplings/ seedlings/ grass species/ shrub species/ planted
6. Distance between plant species/ between row of plant
7. Type and amount of fertilizer (organic) used.
8. Interval of watering
9. Method and period of post plantation care
10. Survival rate of plant species
11. Response of species to
    a/ time of seedling (season)
    b/ interval of watering
    c/ type and quantity of fertilizer (Organic) based
12. Density of afforested area
    a/ Pre-mining condition

b/ Post mining condition

Water Quality Monitoring

Facilities for monitoring surface run-off water and ground infiltration will be provided.

Ground water, treated and untreated mine discharge water and also surface water bodies and wells will be monitored once in every month. Samples will be fully analysed for the parameters specified by Orissa Pollution Control Board (OPCB).

Emissions and Air Quality

Dust prevention and control actions are being taken at surface work zone. To monitor the effectiveness of dust control at surface, the background levels of airborne dust with conditions downwind are compared and this is backed up with an adequate meteorological measurement.

Three high volume samplers, complete with particle size partitioning and independent power generators are deployed periodically to provide sufficient data. The equipment deployed is capable of collection of sulfur dioxide and nitrogen oxides samples.

The method of deployment is in down wind condition at the mine site and in nearby villages where there is chance of dust nuisance. Air quality analysis is carried out once in every month all round the year as directed by OPCB. Monitoring is carried out for particulate matter, Sulphur-dioxide, Nitrogen - oxides and Carbo-monoxide.

Meteorological Station

It is proposed to set up a meteorological station at Gandhamardan-B mine. The following parameters will be recorded regularly:

- Wind speed and direction (on a suitable tower – 10 m above ground)
- Rainfall
- Temperature and humidity
- Evaporation

Occupational Health

Facilities for checking, levels of dust in the workplace will be provided.

Each group of mine workers will be monitored at regular intervals. The analysis will be conducted by a specialist.

Socio-economic development

The environmental department will be in regular touch with surrounding villages to monitor the implementation of various developmental schemes made by the mine authorities. They will also consider any immediate requirement, which can be taken care of.

7.2 DUTIES OF EMC

In order to carry out the above monitoring / inspection in a systematic manner EMC will practise the following:

- EMC will chalk out a site-based strategy to control pollution. The strategy should include formulation of code of actions for controlling air, water, noise, soil pollution, managing blasting effects, phase wise afforestation scheme and actions to be taken in respect of socio economic development. Frequency of monitoring/ sampling and inspection of various parameters / factors will also be planned.

- EMC will oversee that environmental control measures are implemented as per approved action plan.

- Plan conservation programmes in respect of water and energy.

- Identify and record the constraints in respect of environmental planning and implementation.

- Systematically document all the field monitoring and laboratory analysis results.

- Analyse the monitoring results and inspection findings. The results can be compared with various standards/ Norms. EMC will prepare periodic progress reports, which will include the analysis and inspection results. Environmental audit results and actions taken should also be systematically documented.

- Plan the management responsibilities defined for various environmental matters. This should be displayed in the notice board in the office of EMC.

- Interact and liaison with H. Q. officials and also with State/ Central Government departments.

Important records to be maintained by EMC are given in **Table 7.2.**

Table 7.2 : Important Records Maintained by EMC

Sl. No.	Particulars
1.	Field monitoring results for air, water, meteorology
2.	Inspection records of slope failure, land erosion, drainage, socioeconomic development
3.	Format to record /monitor plantation measures
4.	Nursery records
5.	Environmental and related standards/norms
6.	Records pertaining to statutory consents, approvals
7.	Code of actions for pollution control in defined areas
8.	Periodic Medical examination (PME) records
9.	Records pertaining to laboratory equipment maintenance and calibration
10.	Complain register (environmental poilution)
11.	Records on water and electricity consumption
12.	Periodic progress records
13.	Environmental audit records
14.	Records of annual budgetary requirement and allocation for pollution control

7.3 LABORATORY FACILITIES AND EQUIPMENT

In order to conduct the work programme as envisaged, an environmental laboratory shall be set up. Equipment to be procured for the laboratory is given in **Table 7.3.**

Monitoring activities, which cannot be carried out using in-house resources, are carried out through external agencies.

7.4 UPDATING OF EMP

The action plan of EMP shall be updated every year with respect to the results achieved and proposed activities for next year. Any new regulations

considered by OPCB / CPCB will be taken care of. Budget sanctions will be made while updating EMP.

Table7.3: Equipment for Environmental laboratory of Gandhamardan project (both for Gandhamardan A & B projects)

Sl. No.	Particulars	Number
1.	High volume sampler (complete with particle size partitioning)	03
2.	Hygrometer	01
3.	Air Drying Oven	01
4.	Balance (Analytical – Electrical)	01
5.	Muffle Furnace	01
6.	Rain Gauge Apparatus	01
7.	pH Meter (Portable Type)	03
8.	Spectro-photometer (non-Scanning Type)	01
9.	Atomic Absorption Spectrophotometer	01
10.	BOD Incubator	01
11.	Meteorological Kit (Manual Type)	01
12.	Hot Plate	01
13.	Turbidity Meter	01
14.	D.O. Meter	01
15.	Conductivity Meter	01
16.	Glass Ware	Lot
17.	Distilled Water Apparatus	01

Organisation, Manpower and Training

8.0 ORGANISATION, MANPOWER AND TRAINING

8.1 ORGANISATIONAL SET UP

Environmental monitoring and reporting will be designed to provide a close watch on the surrounding natural environment and provide early warnings of any adverse changes that may be related to some dimension of the mining and allied operations.

As discussed earlier, A separate department "Environmental Management Cell (EMC)" has been formed at OMCL for Gandhamardan-B project to look after the inspection/ monitoring requirements. The same department takes care of the environmental monitoring, inspection and reclamation activities for Gandhamardan-A project also. Important functions being performed by EMC have been discussed under chapter 7. Since it is difficult to carry out the entire monitoring programme using in-house facilities, services of external agencies are engaged periodically to carry out the necessary monitoring work. Casual labourers etc. are employed for plantation, drain cleaning etc as and when required.

The officers of the department meet frequently to assess the progress and analyze the data collected during the preceding fortnight/ month. The following items are considered under the monitoring schedule.

8.2 MANPOWER

To cater to need of environmental management in the expansion phase, the present EMC at Gandhamardan-B project (which will cater to Gandhamardan-A project also) will be expanded to have total ten persons. The EMC is headed by Senior Manager, Quality & Control. Services of retired forest officials may be taken for effective implementation of plantation schemes. For development and maintenance of jobs like drainage, clearing settling pits etc. assistance from the project's civil engineering department will be taken. Total manpower requirement for EMC is shown in **Table 8.1.**

Table 8.1: Manpower requirement at EMC

Description	Nos
Senior Manager, Quality & Control,	1
Environmental Engineer	1
Horticultural supervisor	1
Chemist	1
Laboratory assisstant	2
Field assisstant	2
Labourers	2

8.3 TRAINING FACILITIES

EMC will arrange environmental related training facilities. Specialised courses at various research/ educational institutes will be organised. Training will cover the following fields:

- Awareness regarding Pollution Control and Environmental protection
- Operation and maintenance of pollution control equipment.
- Afforestation / plantation and post care of plants.
- Field monitoring, maintenance and calibration of pollution monitoring instruments.
- Chemical analysis of various environmental parameters at laboratory.
- Repair of pollution monitoring instruments.
- Knowledge of norms, regulations and procedures.
- Occupational health and safety.
- Risk assessment and disaster Management plan

Risk Assessment &
Disaster Management Plan

9.0 DISASTER MANAGEMENT PLAN

For the Gandhamardan-A mine risk assessment has been carried out and based on the same; disaster management plan has been prepared which is as follows:

During the operation of the proposed open-cast mine, following risks have been identified.

1. Failure of Slope in the pit
2. Failure of Slope of External dump
3. Fly rock fragments from Blasting operations
4. Surface fire (Electrical and Oil).
5. Possible danger due to storage of explosives

9.1 FAILURE OF SLOPE IN THE PIT

In order to allay dangers due to open cast slope failure slope stability estimations have been made for the existing quarries after determining various physical parameters of the ground mass like uniaxial compressive strength, triaxial compressive strength, cohesion, angle of friction, specific gravity of the rock, water pressure etc. Besides, all the discontinuities have been plotted in stereo plots, which indicate that there is no chance of any planer failure, or wedge failure. Even then, factor of safety has been determined against overall slope failure as well as against individual bench slope by circular failure, planer failure, wedge failure. Besides determining factor of safety the slopes are monitored at regular intervals to check for any possible failure. The well-developed drainage system over the lease area ensures that storm water does not accumulate in the lease area and therefore hydrostatic pressure remains at a low level.

For future workings also similar measurements and inspection shall be carried out. The mine has been designed based on the above considerations with sufficient safety margins to eliminate any chances of slope failure in the pit.

9.2 FAILURE OF SLOPE OF EXTERNAL DUMP

The slopes of external dumps shall be planned at an overall angle of less than 28 with individual lifts at less than 378. As the dumps attain final position, the slopes will be terraced and proper vegetation will be laid which will cause binding of the soil preventing any slope failure. Retaining walls will be built all-around the external dumps which will have weep holes for passage of storm water to join garland drains.

9.3 FLY ROCK FRAGMENTS AND VIBRATIONS DUE TO BLASTING

Trial blasting results of Gandhamardan mines have been used to arrive at the field empirical equations based on which the charge per delay has been regulated to protect the nearby structures. All precautions related to control of fly rock will be taken during the blasting operations (described in chapter 6 of EIA report). Safety zone of 500m as per statutes is being maintained. The nearest habitation is too far to be affected by fly rock.

9.4 SURFACE FIRE

Spillage of HSD and resultant fire constitutes a potential risk. The quantity of the maximum oil, which can spill, is not much and can be easily controlled. Sufficient nos. of portable fire extinguishers has been provided at strategic locations to take care of any eventuality.

There are risks of fire at the electrical substation and transformers. Dry and foam type portable fire extinguishers are available at the electrical substation and control room. In case of any electrical fire, the personnel on duty shall shut down the electrical fire and inform the shift-in-charge. Personnel trained in dealing with electrical fires will be summoned. The fire area will be cordoned off till the fire is fully extinguished and remain so until all wreckage and debris is cleared away. After effecting necessary repairs the power will be restored. The clearance for restoration of power shall be given only by the shift-in-charge.

As soon as any fire is reported the shift-in-charge shall assume the function of disaster controller. In case of serious fire and depending on the gravity of the situation, the Mines Manager may be summoned to assume charge. Personnel trained in dealing with fires will be summoned. Meanwhile the hospital will be informed to handle casualties. The fire area will be cordoned off till the fire is fully extinguished and remain so until all wreckage and debris is cleared away.

9.5 DANGER DUE TO STORAGE OF EXPLOSIVES

An explosive magazine exists in the mine. Adequate safety zone has been provided as per statutory requirements while locating the magazine The magazine has been constructed as per plan approved by Dept. of Explosives. The following have been considered in the design of the magazine.

- All dry vegetation within a 15 m radius cleared.
- Lightning arrestor installed on the magazine roof.
- A safety zone around the magazine created.
- In summer, the temperature inside the magazine is monitored to guard against spontaneous fire.
- The manufacturing dates of all explosives stored in the magazine are carefully recorded so that no explosive whose shelf life has expired is kept in stock.

In case of any fire, whosoever notices the fire will sound the alarm and inform the shift-in-charge. The shift-in-charge will inform security personnel and arrange to evacuate all personnel, except those who are required for fire fighting, from the area. The fire brigade shall be summoned to deal with the emergency. Concerned district officials will be informed. Nearby hospitals will be informed to standby to handle casualties.

Since the mines are at plateau, at much higher elevation than nearby perennial water bodies, chances of inundation of mine does not exist.

Cost of Environmental Control Measures

10.0 COST OF ENVIRONMENTAL CONTROL MEASURES

In the previous chapters a number of site specific issues have been identified which require due consideration as part of development planning and environmental project costing. The measures suggested are detailed under environmental management plan.

The order of costs are presented under various headings in Table 10.1. The updated capital cost and recurring cost (per annum) for the environmental facilities for the mining project works out to Rs. 25 lakhs (Rupees Twenty five lakhs) and Rs. 36 lakhs / yr (Rupees Thirty Six lakhs per year) respectively, based on price prevailing during first quarter of 2006. The capital cost excludes the cost of Pollution monitoring and Green belt, which has been accounted under Gandhamardan-B project.

Table 10.1: Cost of environmental protection measures*

	Recurring cost (Lakhs Rs./yr)	Capital cost (Lakhs Rs.)
Pollution control	5	15[a]
Pollution monitoring	3	b
Occupational safety	5	10[c]
Green belt	18	d
Socio-economic welfare measures in nearby villages	5[e]	-
TOTAL	**36**	**25**

*As indicated in the Mine Plan report cost of Mine closure and abandonment is Rs. 83.96 lakhs, which is not included under environmental cost.

Note : a = Surface drainage including garland drains, settlement pits, retaining wall etc. Dust extraction system at crusher house, dust suppression system at Screens etc have been accounted under Gandhamardan-B project. Other costs have been included in Mine Closure Cost.

b = Environmental monitoring laboratory with equipment specified in chapter 7 is accounted under Gandhamardan-B project.

c = Procurement of safety appliances

d = Cost of Nursery building has been accounted under Gandhamardan –B project

e = This amount is contributed to a Local Area Development Fund administered by the District Collector