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ACRONYMS

°C	Temperature in degrees Celsius
µg	Microgram
ADI	Area of Direct Influence
ADP	Agricultural Development Projects
AERMIC	AMS/EPA Regulatory Model Improvement Committee
AERMOD	AERMIC Dispersion Model
AfDB	African Development Bank
AHA	African Humanitarian Action
AHUs	Air Handling Units
AII	Area of Indirect Influence
Airshed	Airshed Planning Professionals (Pty) Ltd
AITB	Agricultural and Industrial Training Bureau
Al	Aluminium
ALARP	As Low As Reasonably Practicable
AMS	Artisan Mining Sector
ANFO	Ammonium Nitrate Fuel Oil
AoI	Area of Influence
AOO	Area of Occupancy
APELL	Awareness and Preparedness for Emergencies at Local Level
AQSR	Air Quality Sensitive Receptors
ARD	Acid Rock Drainage
ARI	Acute Respiratory Illness
ASG	Atmospheric Studies Group
ASPT	Average Score per Taxon
ASTM	American Society for Testing and Materials
ATSDR	Federal Agency for Toxic Substances and Disease Registry
BDI	Biological Diatom Index
BESU	Bengal Engineering and Science University
BID	Background Information Document
BIF	Banded Iron Formation
BMFR	Bomi Mines Feasibility Report
BMQ	Banded Magnetite Quartzite
BOD	Biochemical Oxygen Demand
BPHS	Basic Package of Health Services
CA	Certificate of Approval
CBL	Central Bank of Liberia
CDR	Crude Death Rate
CEAP	County Environment Action Plans
CEO	County Education Officer
CER	Certified Emissions Reductions
CH4	Methane
CHSWTs	County Health and Social Welfare Team

CITES	Convention on International Trade in Endangered Species
CLO	Community Liason Officer
CO	Carbon Monoxide
CO2	Carbon Dioxide
CO2e	Carbon Dioxide Equivalent
COD	Chemical Oxygen Demand
COP	Conference of Parties
CPRs	Common Property Resources
CR	Critically Endangered
CSR	Corporate Social Responsibility
CZ	Central Zone
dB	Decibels
DD	Data Deficient
DIN	German Deutsches Institut fuer Normung
DPM	Diesel Particulate Matter
DSO	Direct Shipping Ore
DSTV	Digital Satellite Television
DTM	Digital Terrain Model
EC	Electrical Conductivity
ECOWAS	Economic Community of West African States
EEC	Earth Environmental Consultancy Incorporated
EHS	Environmental, Health and Safety
EIA	Environmental Impact Assessment
EIA	Environmental Impact Assessment
EIS	Environmental Impact Statement
EITI	Extractive Industries Transparency Initiative
EM	Environmental Manager
EMP	Environmental Management Plan
EMS	Environmental Management System
EN	Endangered
EOO	Total Extent of Occurrence
EPA	Environmental Protection Agency
EPAA	Environment Protection Agency Act
EPFI	Equator Principles Financial Institutions
EPHS	Essential Package of Health Services
EPML	Environmental Protection and Management Law of Liberia
EPRP	Emergency Preparedness and Response Plan
EPs	Equator Principles
EPSS	Essential Package of Social Services
ERC	Emergency Response Coordinator
ERM	Environmental Resources Management
ERT	Emergency Response Team
ESIA	Environmental Social Impact Assessment
ESMP	Environmental and Social Management Plan

EWD	Eastern Waste Dump
EZ	Eastern Zone
FAO	Food and Agriculture Organization
FDA	Forestry Development Authority
FDA	Food and Drug Administration (United States)
FDI	Foreign Direct Investment
Fe	Iron
FEED	Front End Engineering and Design
FGD	Focussed Group Discussion
FGM	Female Genital Mutilation
FIBLL	First International Bank Liberia
FONSI	Found of No Significant Impact
FoV	Field of Vision
FPIC	Free, Prior, and Informed Consent
FRP	Fibreglass Reinforced Plastic
FSNS	Comprehensive Food Security and Nutrition Survey
GDI	Gender Related Development Index
GDP	Gross Domestic Product
GEF	Global Environmental Facility
GHG	Greenhouse Gas
GIIP	Good International Industry Practice
GLCC	Global Land Cover Characterisation
GMCs	Grievance management Cells
GoL	Government of Liberia
GPS	Geographic Positioning System
GRC	Grievance Redressal Committee
GRM	Grievance Redressal Mechanism
GSM	Gravel, Sand and Mud
GTBL	Guaranty Trust Bank Liberia
GVs	Guideline Values
GWP	Global Warming Potential
HC	Hydro Carbons
HEMM	Heavy Earth Moving Machinery
HF	High Flow
HFCE	Household Final Consumption Expenditure
HFO	Heavy Fuel Oil
HH	Household
HPGR	High Pressure Grinding Roll
HSE	Health Safety and Environment
Hz	Hertz
IA	Impact Assessment
IBAs	Important Bird Areas
ICMM	International Council on Mining and Metals
ICP	Informed Consultation and Participation

IDPs	Internally Displaced Persons
IFC	International Finance Corporation
IFI	International Financial Institution
IH	Instream Habitat
IHI	Index of Habitat Integrity
ILO	International Labor Organization
IPCC	Intergovernmental Panel on Climate Change
IPDP	Indigenous People Development Plan
IRIS	Integrated Risk Information System
ISO	International Standards organization
ITCZ	Inter Tropical Convergence Zone
ITTA	International Tropical Timber Agreement
IUCN	International Union for the Conservation of Nature
IWRMP	Integrated Water Resources Management Plan
kg	Kilogram
km	Kilometer
KOP	Key Observation Point
KPIs	Key Performance Indicators
kWh	Kilowatt Hour
LAC	Liberia Agriculture Company
LBBC	Liberia Beverage and Bottling Company
LBDI	Liberian Bank for Development and Investment
LC	Least Concern
LF	Low Flow
LiDAR	Light Detection and Ranging
LIFE	Liberia Indigenous Forum for the Environment
LIMS	Low Intensity Magnetic Separators
LMC	Liberia Mining Company
Lmo	Monin-Obukhov length
LNP	Liberia National Police
LOM	Life of Mine
Lp	Sound Pressure Level
LPG	Liquid Petroleum Gas
LPP	Local Procurement Plan
LRRRC	Liberia Refugee Repatriation and Resettlement Commission
LSFRP	Liberian-Swedish Feeder Road Project
LTA	Liberia Telecom Authority
LVIA	Landscape and Visual Impact Assessment
LW	Sound Power Level
LWSC	Liberia Water and Sewage Corporation
m	Meter
m^2	Meter Squared
m^3	Meter Cubed
mamsl	Meters above mean sea level

MAP	Mean Annual Precipitation
mbs	Meters below surface
MCH	Maternal and Child Health
MCIMS	Mineral Cadastre Information Management System
MDA	Mineral Development Agreement
MEAs	Multilateral Environmental Agreements
mg	Milligram
ML	Mining Lease
MoA	Ministry of Agriculture
MoF	Ministry of Finance
MoH	Ministry of Health and Social Welfare
MoI	Ministry of Internal Affairs
MoJ	Ministry of Justice
MoLME	Ministry of Land, Mines and Energy
MoPW	Ministry of Public Works
MoT	Ministry of Transport
MRL	Minimum Risk Level
Mt	Million Tonnes
Mtpa	Million tonnes per annum
MW	Mega Watt
NEAP	National Environmental Action Plan
NEAP	National Environmental Action Plan
NEC	National Energy Committee
NECOLIB	National Environmental Commission of Liberia
NEP	National Environmental Policy
NEPC	National Environmental Policy Council
NFPA	National Fire Protection Association
NGO's	Non-Government Organizations
NHSB	National House and Savings Bank
NIOC	National Iron Ore Company
NLTCP	National Leprosy and Tuberculosis Control Program
NO	Nitrogen Monoxide
NO2	Nitrogen Dioxide
NOAEL	No Observed Adverse Effect Level
NoI	Notice of Intent
NOx	Nitrogen Oxides
NPA	National Ports Authority
NPI	Australian National Pollutant Inventory
NSR	Noise Sensitive Receptor
NSSRL	National Security Sector Strategy for the Republic of Liberia
NSSRL-IM	National Security Sector Strategy for the Republic of Liberia - Implementation Matrix
NT	Near Threatened
NTMP	National Transport Master Plan

NWWD	North Western Waste Dump
O3	Ozone
OECD	organization for Economic Co-operation and Development
OPD	Out-Patients Department
PAH	Polycyclic Aromatic Hydrocarbons
PAH	Project-Affected Household
PAP	Project Affected People
PAPs	Project Affected Parties
PBPK	Pharmacokinetic
PDF	Postscript Data File
PFC	Perflourocarbon
PLP	Project Linkage Plan
PM	Particulate Matter
PM10	Thoracic particulate matter with an aerodynamic diameter of less than 10mm
PM2.5	Thoracic particulate matter with an aerodynamic diameter of less than 2.5mm
POPs	Persistent Organic Pollutants
PPE	Personal Protective Equipment
ppm	Parts per Million
PPV	Peak Particle Velocities
PRS	Poverty Reduction Strategy
PS	Performance Standards
RAP	Resettlement Action Plan
RC	Resettlement Conmittee
RCC	Reinforced Cement Concrete
REL	Reference Exposure Level
RfCs	Inhalation Reference Concentrations
RH	Riparian Habitat
ROM	Run of Mine
RPF	Resettlement Policy Framework
RRAP	Resettlement and Rehabilitation Action Plan
RTA	Road Traffic Accidents
S	Storativity
SA DEA	South African Department of Environmental Affairs
SA	South African National Ambient Air Quality Standards
SABS	South African Bureau of Standards
SANS	South African National Standards
SAP	Social Action Plan
SASS5	South African Scoring System 5
SCUK	Save the Children UK
SDF	Social Development Fund
SEP	Stakeholder Engagement Plan
SIA	Social Impact Assessment

SIC	Stones in Current
SIDA	Swedish International Development Cooperation Agency
SMP	Soil Management Plan
SMU	Social Management Unit
SO2	Sulphur Dioxide
SOOC	Stones out of Current
SoW	Scope of Work
SRTM	Shuttle Radar Topography Mission
STDP	Skills and Technology Development Plan
STIs	Sexually Transmitted Infections
STP	Sewage Treatment Plant
SWWD	South Western Waste Dump
T	Transmissivity (m2/d)
TB	Tuberculosis
TC	Tolerable Concentration
TC	Tribal Certificate
TCE	Tata Consulting Engineers
tCO2e	Tonne of Carbon Dioxide Equivalent
TDS	Total Dissolved Solids
TOKTEN	Transfer of Knowledge through Expatriate Nationals
ToR	Terms of Reference
TS	Technical Standards
TSF	Tailings Storage Facilities
TSP	Total Suspended Particulate Matter
TWQR	Target Water Quality Range
UBALL	United Bank for Africa Liberia Ltd
UBN	Unmet Basic Needs
UGF	Upper Guinea Forest
UNCCD	United Nations Convention to Combat Desertification
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
UNMIL	United Nations Mission in Liberia
UNPOL	United Nations Police
URFs	Unit Risk Factors
USBM	United States Bureau of Mines Standard
USGS	United States Geological Survey
UTI	Urinary Tract Infections
VEG	Vegetation
VET	Vocational Education and Training
VOCs	Volatile Organic Compounds
VOD	Velocity of Detonation
WBCSD	World Business Council on Sustainable Development

10. IMPACTS ON SOILS AND LAND CAPABILITY

This Chapter details the Soils and Land Capability Impact Assessment for the proposed Bomi Hills Mine (*Project 1, Phase 1b*).

10. 1 Scope of Assessment

For the impact assessment, all the following phases of the project cycle were considered for potential impacts on soil and land capability. Below is a description of each of the activities that may result in soil impacts:

Construction phase:

- Establishment of access roads;
- Selective clearing of vegetation in areas designated for surface infrastructure;
- Stripping and stockpiling of soil layers;
- Digging of foundations and trenches;
- Preparation of residue disposal areas;
- Storage of materials (steel and equipment) as well as transport of construction personnel;
- Blasting (wherever required);
- General building/construction activities; and
- Wherever top soil is encountered to be stockpiled and utilized for rehabilitation activities.

Operational phase:

- Daily traffic on haul roads;
- Blasting and construction of open pit;
- Operations at tailings storage facility waste rock impoundments; and
- Daily mining activities in different areas of the proposed Bomi Hills Mining Project.

Closure:

- Removal of infrastructure from soil surfaces;
- Removal of topsoil from stockpiles and using it to re-establish vegetation in disturbed areas; and
- Increased traffic on roads to transport waste materials out of the mining areas as well as vehicles for rehabilitation.
- The impacts on soil and land capability anticipated for the project are as follows:
- Soil erosion due to steep slopes and vegetation clearance;

- Topsoil degradation;
- Soil compaction due to regular heavy vehicle transport; and
- Chemical soil pollution as a result of potential spillage of petroleum hydrocarbons and other soil pollutants.

For the Impact Assessment carried out in the following Sections, the following embedded controls have been assumed:

- Minimizing the project footprint to limit surface disturbance;
- Using existing roads to access the site, and
- Limiting linear developments throughout the project development area as much as feasible;
- Using drainage control measures and culverts to control natural runoff and overland flow;
- Stockpiles will be placed in areas far enough from mining activities to prevent contamination.
- If new facilities are required during the operations phase, they will be preferably built in areas that have been previously disturbed so as to avoid disturbing new areas; and
- Topsoil stripping, stockpiling and management will be planned prior to commencement of ground disturbance works.

These impacts are assessed in the following sections.

10. 2 Impact Assessment

16.2.1 Soil Erosion

Potential Impact

Soil erosion is caused by the removal of soil particles from the landscape as a result of water and wind movement. For the proposed project and considering previous mining operations, all soil forms will be prone to erosion where vegetation has been removed. However, the areas where Ferralsols (989 ha) and the combination of Stagnosols and Gleysols (245 ha) has been identified has the least susceptibility to soil erosion. The highest impact of erosion is anticipated for the area where Plinthosols have been identified (6 458 ha), for apart from the obvious soil loss, the exposure of subsurface plinthic horizons will result in irreversible hardening that make soil difficult to remediate. Areas with Technosols are also very susceptible to erosion where vegetation cover has previously not been re-established.

During the construction phase, all soil forms will be susceptible to erosion to some extent because the natural vegetation will be cleared before construction takes place in both the mining and infrastructure areas. During the operational phase, topsoil stockpiles consisting of Plinthosols as well as haul roads

following steep slopes down valleys will still be susceptible to erosion. The walls of tailings storage facilities or areas where soils are temporarily stored for additional construction purposes, will also be susceptible to erosion. Opening new pits for mining purposes in areas with a slope where Plinthosols occur will also result in erosion risk. Soil surfaces with infrastructure such as buildings will not be exposed to erosion any longer.

During the closure phase, soil surfaces will be replanted with indigenous vegetation, and until vegetation cover has established successfully, all surfaces are still susceptible to potential soil erosion.

Potential Consequence

The main potential consequences of soil erosion are the reduction in soil quality and the reduced water-holding capacity of eroded soils. The indirect consequences of soil erosion include disruption of riparian ecosystems and sedimentation leading to reduced water quality.

Significance of Impacts

The impacts of soil erosion are both direct and indirect. The direct impacts are the reduction in soil quality which results from the loss of the nutrient-rich upper layers of the soil and the reduced water-holding capacity of eroded soils. The off-site indirect impacts of soil erosion include the movement of the soil particles to waterways and lakes and dams which leads to disruption of riparian ecosystems and reduced water quality. Soil erosion causes an impact when the resource has been lost from the landscape, until it is suitably reclaimed and rehabilitated. Although there are off-site indirect impacts associated with this, the impact is mainly considered to be local. The impacts may still continue after mining activities have ceased in the case of insufficient vegetation re-establishment. The magnitude of the impact is considered as medium and of a moderate significance (Majority of the surface infrastructure facilities have been planned on the area which was disturbed by earlier mining activities) (Table 1).

Table 1: Impacts on Soil Erosion

Impact	Soil erosion			
Impact Nature	Negative	Positive	Neutral	
	Impact on soils is negative.			
Impact Type	Direct	Indirect	Induced	
	Impact on soils is direct and indirect			
Impact	Temporary	Short-term	Long-term	Permanent

Duration	Impacts are considered permanent, as the impacts will continue post closure with slow recovery rate.				
Impact Extent	Local		Regional	International	
	Impacts on soils are local to the mine site.				
Impact Scale	The scale of the impact is estimated to be restricted to the areas cleared for mining and infrastructure.				
Frequency	Throughout the life time of the mining operations as well as once mining has stopped if left unmitigated.				
Impact Magnitude	Positive	Negligible	Small	Medium	Large
	Impact magnitude is considered medium.				
Receptor	Low		Medium	High	
Sensitivity	The receptor sensitivity is considered as high.				
Impact Significance	Negligible	Minor	Moderate	Major	
	Significance of impact is considered to be **Moderate.**				

Mitigation Measures, Management and Monitoring

Apart from the embedded controls to be included in project design, the following mitigation measures will reduce the significance of soil erosion:

- Stripping of topsoil should not be conducted earlier than required (maintain vegetation cover for as long as possible) in order to prevent the erosion (wind and water) of organic matter, clay and silt.
- Stripped soils should be stockpiled at a slope of not more than 33 percent as a berm upslope (majority) and surrounding the disturbed area.
- Erosion control measures such as intercept drains and toe berms must be constructed where necessary.
- Soil stockpiles must be sampled, ameliorated (if necessary) and re-vegetated as soon after construction as possible. This is in order to limit exposure to rainfall and wind, as well as to slow and trap runoff, thereby reducing soil erosion. Plant species indigenous to the area are preferred, given both their adaptation to the natural site conditions as well as their lower maintenance requirements. This is highly recommended in order to maintain the natural biological soil life associated with the indigenous vegetation.
- Gravel and haul roads must be well drained in order to limit soil erosion.

- The vegetation cover on the soil stockpiles (berms) must be regularly monitored in order to maintain a high basal cover. Such maintenance will limit soil erosion due to both water (runoff) and wind (dust) erosion.

The project site has a distinct wet and dry season. It is recommended that the erosion monitoring programme to be carried out periodically during construction and operations to determine if any seasonal variations do occur. Thereafter, there should be plan for annual monitoring.

Monitoring programme should include a physical observation and reporting of the following:

- ✓ Evidence of erosion or land degradation;
- ✓ Condition of access roads;
- ✓ Condition of cleared areas;
- ✓ Condition of perimeter drains (if installed) and associated settlement ponds (if installed); and
- ✓ Compliance with applicable regulatory and corporate requirements.

Significance of Residual Impacts

With proper mitigation measures and the embedded controls as recommended above, it is anticipated that the significance of this impact can be reduced to minor. Taking the high rainfall area and the extent of the proposed mining operations into consideration it is unlikely that soil erosion will have low significance.

16.2.2 Soil Compaction

Potential Impact

Soil compaction will take place due to unnatural load and increased traffic due to heavy construction vehicles in the area thus changing the soil structure. During the construction phase, soil is susceptible to compaction from heavy construction vehicles when soil is stripped and stockpiled. During the operational phase, soil compaction increases as the weight of the stockpiles results in further compaction as well as constant traffic on the haul roads. During the Closure phase, soil is again compacted as construction vehicles move up and down to remove infrastructure and move topsoil to areas for rehabilitation purposes.

Potential Consequence

Soil compaction generally reduces the amount of water that plants can take up. This is because compaction crushes many of the macropores into micropores, and the bulk density increases. As the clay particles are forced closer together, soil strength may increase beyond about 2000 kPa, the level considered to limit

root penetration. Indirectly, compaction also results in aggravation of run-off erosion as compaction reduces the water infiltration rate which results in an off-site impact.

Significance of Impacts

The impacts of soil compaction are mainly direct and although the impact only has local extent, it is considered to be permanent as soil compaction is very difficult to remediate and will still continue after the mine closure. The impact is of medium magnitude for some areas that have already been compacted by previous mining and infrastructure development activities and the receptors considered only medium sensitive. The impact has moderate significance as soil compaction can be one of the main factors impeding successful mine rehabilitation (Table 2).

Table 2: Impacts on Soil Compaction

Impact	Soil compaction			
Impact Nature	Negative	Positive	Neutral	
	Impact on soils is negative.			
Impact Type	Direct	Indirect	Induced	
Impact Duration	Temporary	Short-term	Long-term	Permanent
	Impacts are considered permanent, as the impacts will continue past closure with only a very slow recovery rate if at all.			
Impact Extent	Local	Regional	International	
	Impacts on soils are local to the mine site.			
Impact Scale	The scale of the impact is estimated to be restricted to the areas used for mining and infrastructure as well as areas where topsoil is stockpiled and additional roads constructed.			
Frequency	This impact will still continue after closure of the mine.			
Impact Magnitude	Positive	Negligible	Small	Medium	Large
	Impact magnitude is considered medium as this is a brownfield site and the soils have already been impacted by compaction in the past.			
Receptor Sensitivity	Low	Medium	High	
	The receptor sensitivity is considered as medium for although compaction will most likely occur, a large area of the site has already been impacted by housing infrastructure.			
Impact Significance	Negligible	Minor	Moderate	Major
	Significance of impact is considered to be **Moderate.**			

Mitigation Measures, Management and Monitoring

Apart from the embedded controls to be included in project design, the following mitigation measure will reduce the significance of soil compaction:

- ✓ Restrict access of vehicles and construction vehicles to haul roads and active project areas. Vehicles should not be permitted to drive on areas of natural or semi-natural vegetation unnecessarily.
- ✓ Once stockpiles have been established they should not be moved around to other areas but directly used for rehabilitation again to avoid creating more compacted areas.

Significance of Residual Impacts

With proper mitigation measures and the embedded controls as recommended above, it is anticipated that the significance of this impact will be moderate.

16.2.3 Loss and Sterilization of Fertile Topsoil Layer

Potential Impact

During the construction phase, topsoil wherever found is stripped and stockpiled for proposed activities including construction of the tailing's storage facilities, main roads and haul roads and open pits. The reason for stripping topsoil is to have soil material available for rehabilitation purposes during closure phases. The most critical and important part of the soil is the uppermost 20 cm as this is the repository for seeds, tubers, bulbs etc. Under natural conditions most grass seed remains viable for only about one (1) year (reproductive seedbank life), with only very few species having seed that can survive for up to 2 - 3 years. Under stockpile conditions it is probable that the seedbank life will be shorter as compared to natural conditions.

Potential Consequence

The stockpiles will remain for more than six (6) months during which the organic carbon content of the soil will decompose in the absence of new carbon sources from dead plant roots and leaf litter. This will result in the soil carbon cycle being disturbed. The disturbance of the soil nutrient cycle will lead to imbalances in the soil microbial population that form an integral part of the soil-plant ecosystem of the area.

Significance of Impacts

The impact on topsoil through stripping and stockpiling is direct but of local extent as it is restricted to the site area. It is considered a long-term impact though it may be restored to a certain extent after closure. The impact is considered to be of medium magnitude as topsoil will be stripped and stockpiled and

become sterilized to a certain extent, especially with the long duration of the life of mine. The impact is considered to have moderate significance (*Table 3*).

Table 3: Impacts on Topsoil Layer

Impact	Loss and sterilization of fertile topsoil layer			
Impact Nature	Negative	Positive	Neutral	
	Impact on soils is negative.			
Impact Type	Direct	Indirect	Induced	
	Impact on soils is direct.			
Impact Duration	Temporary	Short-term	Long-term	Permanent
	Impacts are considered long-term and rehabilitation after closure might restore the soil fertility to a large extent.			
Impact Extent	Local	Regional	International	
	Impacts on soils are local to the mine site.			
Impact Scale	The scale of the impact is estimated to be restricted to the areas used for mining and infrastructure as well as areas where topsoil is stockpiled and additional roads constructed.			
Frequency	This impact will last until proper remediation has been conducted.			
Impact Magnitude	Positive	Negligible	Small	Medium	Large
	Impact magnitude is considered medium as top soils will be stripped to create new open pits.			
Receptor Sensitivity	Low	Medium	High	
	The receptor sensitivity is considered as medium as soil will be displaced and some topsoil will inevitably be lost in the process.			
Impact	Negligible	Minor	Moderate	Major
Significance	Significance of impact is considered to be **Moderate.**			

Mitigation Measures, Management and Monitoring

Apart from the embedded controls to be included in project design, the following mitigation measures will reduce the significance of loss and sterilization of topsoil:

- Soil stockpiles must be sampled, ameliorated (if necessary) and re-vegetated as soon after construction as possible. This is in order to limit exposure to rainfall and wind, as well as to slow and trap runoff, thereby reducing soil erosion. Plant species indigenous to the area are preferred, given both their adaptation to the natural site conditions as well as their lower maintenance requirements. This is highly recommended in order to maintain the natural biological soil life associated with the indigenous vegetation.
- Topsoil should be used after stripping to fill nursery bags that will be used to re-establish indigenous vegetation in a proposed nursery at the mine. This will ensure that beneficial micro-organisms associated with the indigenous plants remain active in the soil and will re-establish populations in the landscape once it is transplanted during rehabilitation.

Significance of Residual Impacts

With proper mitigation measures and the embedded controls as recommended above, it is anticipated that the significance of this impact can feasibly be reduced to minor.

16.2.4 Chemical Soil Pollution

Potential Impact

During the construction phase, chemical soil pollution can result from oil and fuel leakages from construction vehicles. During the operational phase, accidental spillages can result in contaminants entering groundwater resources and soil ecosystems. Spillages from fuel storage units and leakages from construction vehicles can also result in chemical pollution. With the closure phase, soil surfaces are exposed to chemical soil pollution when stored fuel is transported off-site and by leakages from vehicles.

Potential Consequence

The use of vehicles can result in oil and fuel spills on site as well as waste generation by construction and construction workers and the proposed workshop can result in possible chemical soil pollution. Spillages from fuel storage units can result in chemical soil pollution.

These soil contaminants can have significant harmful consequences for ecosystems. The changes in soil chemistry can arise from the presence of many hazardous chemicals even at low concentration in the contaminant species. These changes can manifest in the alteration of metabolism of endemic microorganisms and arthropods resident in a given soil environment. The result can be virtual eradication of some of the primary food chain, which in turn could have major consequences for predator or consumer species. Even if the chemical effect on lower life forms is small, the lower pyramid levels of the food chain may ingest pollutant chemicals, which normally become more concentrated for each consuming rung of the food chain.

Contaminated or polluted soil can also directly affect human health through direct contact with soil or via the infiltration of soil contamination into groundwater aquifers used for human consumption, sometimes in areas apparently far removed from any apparent source of above ground contamination.

Significance of Impacts

Chemical soil pollution will have a negative impact on soil and will directly impact the soil where the pollution occurs. The duration of pollution once it has taken place is long term, depending on the nature and properties of the specific pollutant. It is considered to have high receptor sensitivity and be of major significance as soil chemical pollution may have a negative impact on ecosystem and/or human health (*Table.4*).

Table 4: Impacts on Soil Chemical Pollution

Impact	Chemical soil pollution			
Impact Nature	Negative	Positive	Neutral	
	Impact on soils is negative.			
Impact Type	Direct	Indirect	Induced	
	Impact on soils is direct.			
Impact Duration	Temporary	Short-term	Long-term	Permanent
	Impacts are considered short and long-term, as the impacts will continue past closure with only a very slow recovery rate.			
Impact Extent	Local	Regional	International	
	Impacts on soils are local to the mine site.			
Impact Scale	The scale of the impact is dependent on the type of pollutant but would mainly be restricted to the mine site.			
Frequency	Throughout the life time of the mining operations and during closure phase.			
Impact Magnitude	Positive	Negligible	Small	Medium	Large
	Impact magnitude is considered medium depending on the type of chemical and the volume of spillage.			
Receptor Sensitivity	Low	Medium	High	
	The receptor sensitivity is considered as Medium.			
Impact Significance	Negligible	Minor	Moderate	Major
	Significance of impact is considered to be **Moderate.**			

Mitigation Measures, Management and Monitoring

Apart from the embedded controls to be included in project design, the following mitigation measure will reduce the significance of chemical soil pollution:

- Any chemical spillage should be cleaned up immediately and treated or disposed.
- An intercept drain should possibly be constructed downslope of polluted areas, in order to drain potentially polluted water into a pollution control dam.
- Drains and intercept drains should be maintained to ensure that they continue to redirect clean water away from the polluted areas.
- Conduct proper chemical waste management to avoid spillage of chemicals during all the phases of the project cycle.

Significance of Residual Impacts

With proper mitigation measures as recommended above, it is anticipated that the significance can be mitigated to minor.

11. TERRESTRIAL ECOLOGY

This Chapter presents a summary of the baseline and Impact Assessment of the Terrestrial Ecology Study for the proposed Bomi Hills Mine. The full study can be found in *Annex 7-F*.

11. 1 Scope of Assessment

For the Impact Assessment, the following was undertaken. The baseline data is included in *Chapter 7*.

- Establishing baseline data for each terrestrial ecology discipline (flora, avifauna, herpetofauna, mammalogy and invertebrates);
- Provision of an inventory of observed and predicted flora and fauna species in the Bomi Hills Mine Concession during both a wet season and a dry season survey;
- Evaluation of the importance of the different flora and fauna communities in a local, regional or national context;
- Identification of flora and fauna species of conservation concern[1] in the Bomi Hills Mine Concession and delineation of the habitat types;
- Evaluation of the sensitivity of each delineated habitat type within the Bomi Hills Mine Concession;
- Assessing the impacts on flora and fauna due to the anticipated construction and operational mining activities and if possible, predict changes to species community composition; and
- Identification of any specific areas within the Bomi Hills Mine Concession that may require special protective measures to avoid damage as per the IFC Performance Standards (2012).

11. 2 Receptor Sensitivity

Flora

Habitat loss occurs when areas inhabited by specific flora and fauna species are transformed through human action. Habitat fragmentation occurs when distinct habitat types and systems are isolated through impacts, thereby inhibiting or arresting normal ecological functionality. Although a number of mining activities are expected to lead to habitat loss and fragmentation, the focus of Bomi Hills Mine is centred on the area already transformed through historic mining activity, with some spill over to areas degraded

[1] Referring to Critically endangered, endangered, threatened, near-threatened, Data Deficient, endemic (*senso lato,* including Upper Guinea forest endemics) and nationally protected species

by intensive natural resource use and agriculture. Therefore the floristic receptor is classified as low sensitivity.

Avifauna

Baseline studies have indicated that the concession area and its respective habitat types experienced a long history of forest perturbation and disruption. This statement is supported by the presence of an avifaunal composition dominated by forest-edge species with widespread distribution ranges. The habitat types on the mine concession area that are considered to be of importance are modified (pertaining to tall secondary forest habitat) and support a bird composition comprising of many savannah species with less than 50 percent of the species restricted to the Guinea-Congo forest biome.

However, the proposed mining activities and surface infrastructure are restricted to an area of degraded and transformed habitat. Therefore, the lack of primary forest habitat and the lack of bird species of global conservation concern on these areas render the avifaunal community in the Bomi Hills Mine footprint with low receptor sensitivity.

Herpetofauna

The expected herpetofauna community within the Bomi Hills Mine Concession consists of 102 reptile and 66 amphibian species. The habitats within the mine concession are of a degraded nature due to the intense anthropogenic pressure present here since the initial opening of the Bomi Hills Mine. No pristine habitats exist within the mine concession and evidence of numerous current impacts is obvious and widespread. Based on the review of available literature, twenty-eight (28) red data herpetofauna species (7 reptiles and 21 amphibians) could possibly occur within the Bomi Hills Mine Concession, mostly due to the two rivers that flow through the forested north-eastern section of the concession (Annex 7-F). Virtually no mining activity is planned in the sensitive north-eastern section of the mining concession as it is concentrated in the degraded and disturbed habitats where almost no herpetofauna species of conservation concern are expected. Therefore, the general sensitivity of the herpetofauna receptor is considered to be low.

Mammals

The sensitivity of the receptor will be low due to the fact that most of the mine infrastructure is allocated to non-sensitive areas with low habitat potential. Although a small portion of the eastern arm of the concession will be intruded upon, most of the sensitive areas have been avoided. Predicted mammal

diversity as well as red-data potential is also very low for most of the concession, with the exception of the rivers and the eastern arm of the concession, where the receptor sensitivity is perceived to be higher. As this area has not been earmarked for large scale development, it does not affect the rankings.

11. 3 Impact Assessment

For the Impact Assessment carried out in the following Sections, the following embedded controls have been assumed:

- Minimise the footprint of mining activities through proper planning. Each activity must be well planned to determine the minimum footprint required, which must be demarcated on the ground in advance (to reduce the potential of accidental spill-over into surrounding areas). This area must include vehicle parking areas, turn facilities, material and equipment lay down areas etc;
- Implement proper erosion control measures such as landscaping of cleared areas to reduce slope and replanting with suitable indigenous vegetation to form a vegetation cover that will protect exposed surfaces and attempt to limit the loss of topsoil during high rainfall events while simultaneously reducing sedimentation of streams/rivers.
- In areas where rehabilitation needs to take place, first establish a suitable ground cover of grass to protect the soil surface followed by suitable tree species to provide shade, thereby creating a structured habitat where natural successional development will ultimately result in improved habitat, connectivity and biodiversity.
- Gravel roads with high traffic volumes will require regular wetting (dust-suppression) during the dry season to reduce dust accumulation on vegetation that may result in die-off.
- Implement a mine closure plan in which rehabilitation measures are defined and budgeted for. Re-vegetation trials must be undertaken to determine the most appropriate species for a particular habitat. Species should be selected on a basis of adaptive management. i.e. perform trial runs on several species and select those species most suitable in achieving the desired result of establishing canopy cover and high habitat functionality. A nursery should be established to propagate selected plant species for translocation and rehabilitation. Specific planting plans and schedules for each habitat type must be determined where rehabilitation will be required.

- Generation and implementation of a Biodiversity Protection Policy. This may take the form of an overall memorandum of intent, leading to an actual management plan for the purpose of implementation.
- Design and implementation of embedded bushmeat action plans to prevent all activities of staff and contractors related to the trade in animal protein and live specimens.
- Trenches and pits should be kept open for as short a period as possible. If trenches need to be open for an extended period of time, then at periodic intervals of 50 m the angle of at least one bank should be reduced to no more than 45° to allow fauna to escape. All open trenches should have periodic incorporation of branches from nearby trees into the trenches that will serve as internal escape bridges and allow for the escape of fauna trapped in the trench/pit.
- The drivers operating motor vehicles within Bomi Hills Mine Concession must undergo environmental induction training courses that include instruction on the need to comply with speed limits, to respect all forms of wildlife (including reptiles and amphibians) and, wherever possible, prevent accidental road kills of amphibians and reptiles.
- A strict zero-tolerance approach to the trade in faunal species must be implemented for all staff and contractors working for WCL. This will not only avoid establishment of alien faunal species but also help control the spread of diseases.
- Sensitive areas such as major water bodies will require buffering (150 m where possible) from construction activities and waste disposal to prevent spread of alien invasive plant species in these very sensitive and susceptible habitats.
- Waste, especially domestic waste, should be disposed regularly according to the Liberian/ International Health standards. All areas where domestic waste is temporarily stored should be securely covered to avoid attracting birds and rodents. Trapping for rodents should be intensive and continuous around waste storage sites.
- Storage of chemicals, lubricants and other potentially hazardous liquids should be handled carefully. A dedicated storage facility with spill containment facilities (plastic-lined earth berms) which has restricted access (locked and fenced) must be constructed in a safe location situated as far as possible from sensitive habitat types.

- Regular inspection of structural integrity of berms/dam walls must be conducted to avoid unplanned failure thereof.
- Chemical spill cleanup kits must be stationed at all sites where spills are probable, especially in conjunction with sensitive habitat such as the water abstraction facility. Staff should be trained in the chemical cleanup procedure.

11.3.1 Habitat Loss and Fragmentation

Source of Impact

The mining activities are expected to lead directly to habitat loss and fragmentation. During the construction phase these include pit creation, road creation, clearing of areas for mining infrastructure. Further, during the operational phase habitat loss and fragmentation will occur due to waste rock disposal and the operation of tailings storage facilities. The approximate area of each habitat expected to be lost due to mining infrastructure is shown for each habitat type in *Table* 5. The areas where mining associated impacts such as rock disposal sites and tailings storage facilities encroach on more sensitive habitats are limited: only 2.1 percent of the Short Secondary Forest and 4.1 percent of the river's habitat types will be lost while none of the prevailing Tall Secondary Forest will be lost (*Table* 5).

Table 5: Bomi Hills Mine Concession habitats, their ecological sensitivity and the area of each habitat expected to be lost due to mine infrastructure development

Habitat Type	Ecological Sensitivity	Area (Ha)	Proportion of total	Area lost to infrastructure (Ha)	Proportion of original lost
Tall Secondary Forest	High	1,275.9	11.1%	0.0	0.0%
Short Secondary Forest	High	3,385.9	29.4%	69.9	2.1%
Short Degraded Forest	Moderate	4,286.7	37.2%	640.5	14.9%
Low Degraded Forest/Agriculture	Low	1,431.6	12.4%	122.2	8.5%
Urbanized	Low	250.1	2.2%	29.8	11.9%
Transformed/Mining	Low	481.2	4.2%	417.0	86.7%
Wetland	Moderate	185.0	1.6%	55.8	30.2%
Open Water	Low	77.9	0.7%	63.3	81.2%
River/Stream	High	134.7	1.2%	5.5	4.1%
Grand Total	-	11,508.9	100.0%	1,403.9	12.2%

Due to the increased rainwater runoff (see *Chapter 7*) and associated erosion of cleared areas and waste rock dumps, sedimentation and the potential pollution of rivers, streams and wetland habitat can occur during mine development phases which will result in loss of habitat. While this represents an important

impact from an aquatic ecology perspective, it nevertheless influences terrestrial ecological processes and species. For example, sedimentation of streams may cause them to become murky or opaque which will result in the loss of foraging habitat for many piscivorous[2] bird species. Similarly, rapid changes in stream velocity from uncontrolled runoff can affect breeding of amphibians by washing eggs and tadpoles downstream which will result in the loss of breeding habitat. Pollution or sedimentation of streams will affect plant growth and aquatic organisms negatively and therefore also affect the vertebrate species that feed on aquatic vegetation or prey upon aquatic organisms.

During the operational phase, habitat loss can also be expected to occur for fauna through indirect means. The anticipated human influx due to the reopening of the mine will have major impact on habitats through natural resource utilization. This is a complex impact which is discussed in detail under the social impact assessment (*Chapter 18*). Die-back of vegetation or decreased nutrient content of vegetation is possible due to heavy coating by dust associated with mining activities during the dry season (road use, blasting etc). Blasting and other activities will displace sensitive fauna and effectively "remove" a portion of the available habitat to them. The sound pressure levels predicted from the blasting (*Chapter 17*) were modelled in relation to the pit boundary to estimate the extent of habitat that will be loss of sensitive fauna due to this disturbance.

Animals are known to have a more sensitive hearing threshold than humans but there is no universal sound pressure threshold applicable to terrestrial fauna (Radle 2007)[3]. Thus when modelling the area of impact for fauna a precautionary threshold of 120 dB was therefore applied below which, is not anticipated to adversely affect the majority of fauna. The sound pressure levels from the maximum number of holes detonated per delay were used as a precautionary measure. Map 11-1 shows both the modelled sound pressure threshold for humans (<125 dB) and that anticipated for fauna (<120 dB). The area of sensitive habitat that may be effectively "lost" to certain fauna from the noise effects of blasting (Map 11-1) is only 58 Ha of which 30 Ha are already lost due to a tailings storage facility which results in only an additional 28 Ha (0.8 percent of total sensitive habitat) of additional sensitive habitat loss (in this case Short Secondary Forest).

Habitat fragmentation will occur whenever the connectivity between portions of habitat has been interrupted. This is an expected side-effect when habitat loss occurs (during the construction and

[2] Fish-eating

[3] Radle, A.L. 2007. The Effects of Noise on Wildlife: A Literature Review. Report Date: 03/02/2007. 16pp. Available May 2012 on: http://wfae.proscenia.net/library/articles/radle_effect_noise_wildlife.pdf

operation phases as mentioned above) but can also occur through additional anticipated mining activities during all phases. For example, the anticipated increase in vehicle traffic on roads, especially the haul roads, will act as a barrier to migration for slow-moving terrestrial fauna, either through direct mortality (see below) or by alteration of animal behavior (e.g. avoidance of road disturbance and decreased inclination to cross the road (Mitchell *et. al* 2008)[4].

The heavily compacted nature of roads will further prevent fossorial[5] fauna from crossing while the smooth surface of tarred roads will prevent snakes and certain lizards from crossing, especially if the road is inclined at the cross section. Large-sized mining infrastructure such as tailings storage facilities will restrict the movement of certain fauna and contribute to the fragmentation of the original habitat.

Potential Consequence

The unavoidable habitat loss is not expected to result in major negative consequences for the ecosystem within the mining concession as the majority of the mining infrastructure is located on areas already modified or transformed through historic mining activities and current human habitation, representing low to medium ecological sensitivity. However, the habitat lost will result in displacement of fauna, a greater shift to a synanthropic[1] species composition and will decrease connectivity (and increase fragmentation) to neighbouring natural areas (such as the sensitive habitat in the eastern portion of the concession), thereby negatively affecting ecological processes (such as gene flow and forest regeneration) between these natural areas.

Loss of sensitive aquatic habitat types through irregular flow velocity, pollution and/or sedimentation may have greater negative consequences for downstream habitats than those within the mining concession, which are already degraded. The potential exists that other sensitive habitats outside of the mining concession (not evaluated) may be negatively influenced by the mine activities. Several of the streams that are to be impacted upon by infrastructure placement (*Chapter 8*) eventually drain into the larger rivers.

Significance of Impact

As a result of the continuous ecological impacts from past mining activities followed by intense anthropogenic disturbances, there are no species of conservation concern that will be directly affected by

[4]Mitchell, J.C., Brown, J. and Bartholomew, B. 2008. Urban Herpetology. Herpetological Conservation. Vol. 3. Society for the Study of Amphibians and Reptiles. Salt Lake City, UT.

[5] Animals living underground e.g. burrowing skinks

the anticipated loss of habitat. All of the species of conservation concern recorded within the concession were located within the sensitive habitat types primarily restricted to the eastern portion of the concession and will therefore not be directly affected by the mining infrastructure and activities.

Populations of some species of conservation concern could be negatively impacted by the expected habitat fragmentation such as the golden cat (*Profelis aurata*) and white-bellied tree pangolin (*Manis tricuspis*) which may suffer decreased migration efficiency due to the discontinuity of habitats (especially from busy roads), but this is unlikely to be a significant change from the current status quo.

For downstream habitats, it is not possible to establish the impact significance accurately without first evaluating the sensitivities of these habitats that may be affected by the potential sedimentation, pollution and flow velocity fluctuations of streams within the mining concession. A precautionary approach is to assume that all aquatic habitats are of a sensitive nature and impacts should be avoided.

The significance of these impacts, not taking downstream impacts into consideration is rated as minor (*Table* 6)

Table 6: Habitat Loss and Fragmentation

Impact	Habitat loss and fragmentation. This excludes habitat loss of downstream aquatic habitat (evaluated separately below)				
Nature	Negative		Positive		Neutral
	Loss of habitat and the fragmentation thereof affect fauna negatively				
Type	Direct		Indirect		Induced
	Both direct (vegetation clearing) and indirect (blasting noise) impacts will occur				
Duration	Temporary	Short-term		Long-term	Permanent
	Impact is envisioned as long-term (life of mine); Habitat reclamation measures and forest regeneration is expected to occur				
Extent	Local		Regional		International
	Only a relatively small area at the local scale will be directly affected by the Project				
Scale	Small-scale				
Frequency	Although major events of habitat loss will occur in a once-off fashion, the habitat fragmentation will be recurrent (continuous throughout lifespan of Project)				
Magnitude	Positive	Negligible	Small	Medium	Large
	The impact will have a long-term duration and will affect an area of local				

	extent. The impact will be of a small-medium magnitude.			
Resource/Receptor Sensitivity/Value Importance	Low	Medium	High	
	Low sensitivity of receptor due to the common species expected because of the already degraded nature of the habitat. The lack of species of conservation importance also reduces the receptor sensitivity			
Significance	Negligible	Minor	Moderate	Major
	This impact is considered to be of minor significance			

The significance of these impacts taking downstream impacts into consideration is rated as moderate to major (*Table7)* .

Table 7: Habitat Loss and Fragmentation (downstream)

Impact	Habitat loss and fragmentation of downstream aquatic habitat due to increased runoff, pollution and sedimentation			
Nature	Negative	Positive	Neutral	
	Loss of habitat and the fragmentation thereof affect fauna negatively			
Type	Direct	Indirect	Induced	
	This impact can occur as a direct consequence of the mining activities			
Duration	Temporary	Short-term	Long-term	Permanent
	Impact is envisioned as long-term (even after life of mine) until pollution and sedimentation processes can no longer occur			
Extent	Local	Regional	International	

Scale	Large-scale				
Frequency	Changes in flow velocity and sedimentation events are expected to occur regularly during the rainy season				
Magnitude	Positive	Negligible	Small	Medium	Large
	The impact will have a long-term duration and will affect habitats in the region. The impact will therefore be of a medium magnitude.				
Resource/Receptor Sensitivity/Value Importance	Low	Medium	High		
	Because the sensitivities of the biotic receptors were not evaluated for downstream habitats the precautionary approach is to assume medium-high sensitivity				
Significance	Negligible	Minor	Moderate	Major	
	This impact will at least be of moderate-major significance				

Embedded Controls, Mitigation Measures and Monitoring

Avoidance Measures

- The sensitive habitats (rivers and drainage lines, semi-natural secondary forest) in the eastern portion of the mine concession should be left undisturbed as much as practicable. No infrastructure development or resource harvesting should occur here other than the required water abstraction facility.
- Protect small patches of natural and regenerated habitat, such as clumps of trees, ponds or wetlands where possible within the mine footprint, to maintain corridors and facilitate the movement of species across the landscape which can utilize these small natural patches as "stepping stones". These areas must be designated as protected and must remain so throughout the operational and decommissioning phases. Staff and contractors must be made aware that these areas are not to be disturbed.
- All plant species for use by the Project should be reviewed and approved by an appointed Environmental Control Officer prior to use on site. Non-native species should not be authorised unless a formal risk assessment has been carried out and approved by the Project, the Government and other relevant stakeholders.
- Where possible buffer by at least 150 m (the minimum required for mammals) around major water bodies to avoid any degradation and disturbance of this sensitive habitat type. Currently, the placement of some mine infrastructure (e.g. tailings storage facility) is undesirable as it is situated within some of the streams. If it is not possible to move this structure then monitoring of runoff velocity, water quality and sedimentation within the stream should take place (see below).

Minimization Measures

- Trees that need to be felled should be utilised by local communities for cutting planks or making charcoal to reduce the demand for such resources from other natural areas.
- The environmental management plan should include maintenance and suitable monitoring of minimisation measures implemented. Suitable follow-up procedures in monitoring successful germination and establishment of vegetation canopy cover must be evaluated and planting palette adjusted to achieve optimum results wherever required. Knowledge gained from one site can be used to devise a more suitable strategy in rehabilitation of subsequent sites disturbed through mining activities.

Rehabilitation Measures

- The rock dumps should be stabilized and re-vegetated. The latter may be achieved by removing and stockpiling the topsoil prior to the creation of the dump. This topsoil will need to be vegetated with indigenous plants and managed during the life of the mine so that it remains viable and doesn't erode during the rainy season. After stabilization, the rock dumps should be covered (at the very least partially) with this topsoil and re-vegetated. This process should be carried out in conjunction with recommendations made in *Chapter 10*.
- Development of a post-closure monitoring programme to assess success and sustainability of rehabilitation and reclamation procedures to be applied. This monitoring programme will aid in continuous adaptation of the rehabilitation process and will demonstrate whether the rehabilitation procedures in place are successful. Three of the critical components that need to be monitored are:
    - Re-vegetation success - it is essential to ensure that the re-vegetated areas are successfully proliferating and not dying or succumbing to alien invasive plant competition;
    - Control of alien and invasive species - it is very important to ensure that continued control of alien and invasive species is taking place after mine closure and this must therefore be monitored closely; and
    - Water quality monitoring - runoff into streams and wetland should be monitored, including potential erosion and gullying, to ensure that rehabilitation procedures have sufficiently controlled any pollution and sedimentation likely to occur in the surrounding streams.
- During the operational phase impacts can be reduced by planting suitable indigenous trees along the roads and open areas not designated for infrastructure. Maintaining such "green belts" of vegetation along roads will promote habitat connectivity and increase success of rehabilitation during mine closure.

Significance of Residual Impacts

Residual impact from habitat loss is expected to be negligible if embedded controls and mitigation measures are applied throughout the lifetime of the mine. Habitat improvement may even be possible in currently degraded areas if suitable indigenous plant species are planted during the operational phase and also used for the rehabilitation during mine closure.

11.3.2 Loss of Biodiversity

Source of Impact

For vegetation, loss of biodiversity will occur whenever habitat loss occurs. The loss of species of conservation concern is not expected as the Red List species *Lophira alata* (VU) and *Terminalia ivorensis* (VU) are only found in the Tall and Short Secondary Forest formations classified as sensitive areas, where impact from mining is not expected.

Since the loss of habitat directly relates to the displacement of its complimentary faunal species composition, it is anticipated that a number of species will become displaced by the construction of infrastructure and the mining operations which will result in a net biodiversity loss for the ecosystem surrounding the main area of operation. Direct action by machinery will cause mortality of slow-moving and inactive fauna (e.g. aestivating[1] amphibians). Mortality of species as a result of development activities (whether mechanical or from pollution) will cause a net loss of biodiversity within the area managed by the Project.

Traffic within the mine concession is expected to have an impact on fauna mortality. All vertebrates are vulnerable to being killed by vehicles on roads. However, mammals and herpetofauna are especially vulnerable as the former are easily blinded by headlights while the latter do not readily flee from relatively fast-moving oncoming traffic. It is also very difficult for vehicle operators to observe and safely avoid driving over small fauna species. Furthermore, negative perceptions of some fauna, especially snakes, result in some people deliberately driving over them on the road. Mine workers/staff may encounter fauna and it is likely that harvesting for protein (bushmeat) or outright killing of snakes due to superstitious beliefs, will contribute to biodiversity loss.

Biodiversity loss may also occur through the interaction of fauna and infrastructure. Any external cabling or wiring spanning large distances could result in avifauna and bat collisions. Power lines in particular pose two categories of hazard to birds: collision and electrocution. The severity of these impacts is strongly dependent on the size and configuration of the power line.

Faunal mortalities may also occur from other infrastructure such as trenches where small species may fall into trenches and not be able to escape.

The potential pollution from the mining operations (including sedimentation of streams and wetlands) may cause the loss of biodiversity though direct mortality due to contamination of habitat, contamination of food/water supplies. Bioaccumulation of pollutants (e.g. heavy metals) may occur over time from continuous low levels of pollution which can ultimately lead to mortalities.

The specific loss of certain flora species due to targeted harvesting (e.g. for timber) is not expected to result from mining activities. However, this situation may arise for flora and is expected to arise for fauna

(e.g. hunting of pangolins for bushmeat) due to the human influx and its associated utilization of natural resources (*Chapter 18*).

Potential Consequence

Direct mortality of fauna will contribute to biodiversity loss and ultimately the loss of ecological processes at the population, community and ecosystem levels. Unavoidable repetitive impact from road traffic will over a period of time, significantly alter fauna population densities and dynamics. This is especially likely to occur adjacent to wetlands/streams where large number of anticipated mortalities will occur. Loss of biodiversity will result in a dysfunctional ecosystem if important species such as pollinators (nectarivorous[1] and frugivorous[2] birds, bats/primates) and carnivores (for pest control) are removed from the faunal community, with the possibility for the proliferation of pests and diseases. Furthermore, loss of biodiversity will ultimately affect local human populations that rely on flora and fauna for food and other valuable ecosystem services.

Significance of Impact

Significance of impact is expected to be low with regards to the loss of floral biodiversity since species lost will most likely be those existing in the previously disturbed areas. The Upper Guinea Endemics such as *Anthocleista nobilis, Mussaenda afzelii, Combretum grandiflorum* and *Tetracera potatoria* present in the concession area are not considered threatened and can be found throughout the Bomi Hills Mine Concession area and most of Liberia.

It is unlikely that any significant number of fauna species of conservation concern will be lost directly due to the mine related infrastructure and activities. Nearly all fauna occurring in the area of the mine footprint are common synanthropic species of low conservation concern. However, even the common amphibians form an important lower tier on the trophic pyramid, on which many vertebrate species rely as a predictable food resource. Therefore, when considering the greater ecosystem functionality, the loss of these species will not be of negligible significance (*Table* 8).

Table 8: Loss of Biodiversity

Impact	Loss of biodiversity			
Nature	Negative	Positive	Neutral	
	Loss of biodiversity is an undesirable and negative impact			
Type	Direct	Indirect	Induced	
	Direct mortality of fauna is expected			
	Temporary	Short-term	Long-term	Permanent

Duration	This impact is likely to be of long-term duration (not permanent) as it is expected that many species could return and recolonize rehabilitated habitat				
Extent	Local	Regional	International		
	Only a small area at the local scale will be directly affected by the Project				
Scale	Medium-scale				
Frequency	Recurrent (road-related mortalities will occur continuously)				
Magnitude	Positive	Negligible	Small	Medium	Large
	Long-term duration of a recurrent negative impact on a medium scale will have a small-medium effect on biodiversity				
Resource/ Receptor Sensitivity/Value/ Importance*	Low	Medium	High		
	The sensitivity of the receptor is low due to the lack of species of conservation concern				
Significance	Negligible	Minor	Moderate	Major	
	This impact is considered to be of minor significance				

Existing Controls, Mitigation Measures and Monitoring

Due to the similar nature of many of the mitigation measures required here as for those specified for the impact of habitat loss and fragmentation (*Section 11.3.1*), only markedly different mitigation measures will be mentioned below.

Avoidance measures

- Pre-construction walkover and botanical surveys must be undertaken prior to clearance of land to identify medium to high value plant species and necessary action taken to avoid areas where they occur or to preserve high value plant species *in situ* where possible.

Minimisation Measures

- Safe translocation of high value tree species (e.g. *Lophira alata* and *Terminalia ivorensis*) to areas of protection if found.
- All vehicles travelling on the roads must do so at the slowest feasible speed to allow fauna species to move off the road as far as possible.

Construct speed humps on sections of roads where fauna populations are especially vulnerable to reduce speed.

- Road related animal mortalities to be monitored by WCL staff operating vehicles on the mine concession roads as far as possible.
- Reduce exterior lighting and implement operational strategies to reduce "spill light". Exterior lightning could attract night-migrating bird taxa and can result in collisions with structures. If

possible, outside lighting should make use of lights with blue or green hues rather than light that contains red wavelengths. In addition, infrastructure should be illuminated by using "down-lighting" instead of "up-lighting" since the lat likely to result in bird collisions with infrastructure (due to blinding and confusion).

Rehabilitation Measures

The majority of rehabilitation measures mentioned above for habitat loss are also applicable here.

- Where possible, retain exceptional large canopy or emergent trees. These trees act as important "fertilizers" since they supply dead wood to saproxylic[1] invertebrate taxa that play a key role in forest decomposition and could facilitate the rehabilitation process. In addition, these trees are important hunting platforms for apex predators as well as breeding stations for hole-nesting bird species. These trees are focal perching sites for seed-dispersing birds, thereby facilitating forest succession;

Significance of Residual Impacts

If the number of anticipated fauna mortalities can be significantly reduced by the implementation of the mitigation measures and rehabilitation measures are successfully applied then the residual impact significance is likely to be negligible.

11.3.3 Spread of Alien Invasive Species

Source of Impact

The use of earth moving equipment and other transport vehicles during mining activities can result in the dispersal of alien and invasive plant material to other localities. Clearance of vegetation for mining activities establishes a suitable environment for alien pioneer species to establish which outcompete slower-growing indigenous species.

Construction camps and their temporary waste disposal facilities, storage facilities and temporary housing facilities are associated with alien invasive rodent species (e.g. house rat *Rattus rattus* and house mouse *Mus musculus*),

aggressive bird species (e.g. pied crows *Corvus albus* and feral rock pigeons *Columba livia*) and other scavenger taxa (including domestic cats and dogs). The house rat (*Rattus rattus*) can become established particularly quickly under such conditions and spread to other regions by being transported within construction equipment and machinery. This is especially likely to occur due to the close proximity of Tubmanburg town where poor sanitation and waste disposal facilities most likely sustain a large rodent population.

Potential Consequence

The current levels of transformation are limited to the mining and urbanized areas, with habitat degradation and agriculture from adjacent areas. All these areas exhibit high species diversity, attributed to high levels of undesirable alien plant species typically associated with disturbance and agriculture. The likelihood of inadvertent dispersal of alien invader species along water courses to other natural areas is high. Uncontrolled spread of invasive and alien plant species serves to effectively "remove" utilizable habitat from native flora and fauna. This is because many invasive plants outcompete native vegetation and are either noxious or grow in such dense stands that foraging within them by native fauna is not possible. Alien invasive plants attract few native invertebrate species which can feed on them and thereby reduce the prey base available for insectivorous[1] native fauna.

Poor waste and sewerage management practices are often associated with alien/invasive fauna species (pigeons, crows, rats and mice). These pests outcompete native fauna, can carry diseases communicable to humans (e.g. histoplasmosis and possibly encephalitis) and other native fauna and they can easily spread to neighbouring communities as they are readily transported great distances within construction equipment/machinery/ore trucks.

Significance of Impact

Significance of this impact will be high for all phases of the mine due to the prevalence of undesirable alien plant species within the concession and the potential regional spread of these plants via the iron ore transportation trucks. It is also unlikely that all of the alien and invasive plants can be removed due to the large number of alien plant stands observed within Tubmanburg. The likelihood that synanthropic mammals will be attracted to mine construction sites and other mining infrastructure is high since rats already exist in Tubmanburg. The potential spread of communicable diseases to humans from these rodents means that this impact is of an overall moderate significance (*Table* 9).

Table 9: Spread of Alien Invasive Species

Nature	Negative	Positive	Neutral	
	Undesirable alien plant species can be dispersed to other localities.			
Type	Direct	Indirect	Induced	
	The presence of alien and invasive plants will directly (loss of biodiversity, loss of habitat) and indirectly (loss of food or prey) impact on fauna			
Duration	Temporary	Short-term	Long-term	Permanent
	It is unlikely that the current alien plant infestation will ever be completely eradicated making this an impact of permanent duration			
	Local	Regional	International	

Extent	Potential exists for the dispersal of undesirable alien and invasive species at the regional scale due to the daily transportation of iron ore to the Freeport of Monrovia				
Scale	Large-scale				
Frequency	The impact is considered a recurrent event				
Magnitude	Positive	Negligible	Small	Medium	Large
	The existence of a stand of alien vegetation or population of rats/mice that can be spread to other regions and propagate at a large scale with a high likelihood of occurrence results in a medium magnitude impact				
Resource/Receptor Sensitivity/Value/ Importance	Low		Medium		High
	While the receptor within the mine footprint has a low sensitivity, the potential exists for spread of alien and invasive species to other areas and/or regions where more sensitive receptors occur such as rare, localized species in sensitive habitats (e.g. rivers)				
Significance	Negligible	Minor	Moderate		Major
	The potential loss of sensitive native species due to spread of alien and invasive species, and the potential spread of diseases at the regional extent results in an impact of moderate significance				

Existing Controls, Mitigation Measures and Monitoring

Avoidance Measures

- Devise and implement an alien plant control policy which must attempt to prevent the spread of alien invasive plant species.
    - Where herbicide treatment is required, herbicides should be selected in line with international standards and must be applied by trained personnel only. Storage and use of herbicides will be as per the manufacturer's instructions. Herbicides must be clearly labelled at all times and application of these herbicides must be planned in consultation with an ecologist/ environmentalist to ensure that the environment is not adversely affected;
    - Prohibiting the transport of live plants, seeds or vegetative material;
    - Wash water runoff must be managed appropriately to avoid spread of alien invasive plants through drainage channels; and
    - Iron-ore storage sites will require frequent monitoring for the presence of alien invader plant species, and eradication measures must be implemented where required;

- Walk-in capture traps should be deployed wherever mining infrastructure is established. Capture traps should be used in order to eliminate only alien species such as *Mus musculus*, *Rattus rattus* and *Rattus norwegicus* and not native rodents which should be released unharmed upon capture (unless they become disproportionately numerous). Rodent-specific poisons can be used inside walk-in capture traps in highly transformed areas where significant assemblages of native rodents are not expected. This will ensure that poison is not spread to the surrounding environment.

All rodent poison controls should be monitored by the Environmental Control Officer in order to prevent poisoning of native small mammals and/or cause accidental mortalities of rodent predators such as raptors, owls, small predators and meso-predators.

Significance of Residual Impacts

By implementing above control measures of alien and invasive plants and by preventing the spread of alien rodents during all phases of the mine development, impacts related to alien invasive species (such as spread of diseases) can be greatly reduced. It is unlikely that the threat of alien and invasive species will ever be eradicated completely and because these species can become established so quickly and proliferate so rapidly the residual significance of this impact cannot be considered as negligible and therefore will be Minor.

11.3.4 Unplanned events - spillage of chemicals and failure of dam walls/berms

Source of Impact

During all phases of the mining development a threat of the spillage of dangerous chemicals (including hydrocarbons) or the failure of berms/dam walls (pollution and massive sedimentation events) exists. Human operating error (accidental) or equipment failure can lead to chemical spills e.g. diesel fuel (hydrocarbon) spills during fuel storage facility recharge from fuel tanker trucks. Poor construction of berms or flooding events from heavy rain could compromise berm/dam wall integrity and eventually fail which will wash the berm/dam wall material into the streams, rivers and wetlands.

Potential Consequence

Pollution, via chemicals or sedimentation, of a particular habitat can effectively "remove" this habitat from utilisation by biota as well as cause direct mortalities, that is why it is considered as an impact of both habitat loss and biodiversity loss. This is of particular concern when sensitive habitat such as wetlands and

rivers are polluted because the pollution is usually spread to a larger area and therefore has a greater effect on the ecosystem. Negative effects on downstream habitats and biota (as mentioned above) outside of the mining concession are likely to occur as well.

Significance of Impact

In the absence of exact information on the location, composition and quantity of chemical spills or massive sedimentation events it is difficult to accurately estimate the significance of the impact. Pollution of any type has a negative effect on ecology and if coupled with sensitive habitats (wetlands, streams and rivers) can result in an impact of major significance. It is prudent to apply the precautionary approach and assume that all aquatic habitat is sensitive and since the location of pollution events cannot be predicted, the significance of this impact should be considered as moderate (*Table 10.*).

Table 10: Unplanned Events

Impact	Unplanned chemical spills and massive sedimentation events				
Nature	Negative		Positive		Neutral
	Reduced habitat availability due to contamination is a negative impact				
Type	Direct		Indirect		Induced
	Habitat loss and biodiversity loss from pollution is a direct impact				
Duration	Temporary	Short-term		Long-term	Permanent
	Impact on habitats should be temporary if cleanup operations are rapidly initiated				
Extent	Local		Regional		International
	There is a potential that streams and rivers can be affected. In such a case, a major spill will influence habitats and species on a regional scale				
Scale	The scale of the impact is likely to be small-medium				
Frequency	Unplanned				
Likelihood	Highly unlikely. Embedded controls and best practice should prevent events from occurring that could lead to this impact				
Magnitude	Positive	Negligible	Small	Medium	Large
	Impact magnitude on the majority of mine footprint habitats should be negligible. However, the impact on streams, rivers and wetlands could be of much greater magnitude				
	Low		Medium		High
Resource/Receptor Sensitivity/Value	While low sensitivity of receptor is expected due to the common species expected in the mine footprint area because of the already degraded nature of the habitat and the lack of species of conservation importance, the				

Importance	presence of the streams, wetlands and rivers introduce the likelihood of more sensitive species being affected and therefore the sensitivity of the receptor must be elevated to Medium.			
Significance	Negligible	Minor	Moderate	Major
	The impacts associated with unplanned pollution are of moderate significance			

Embedded Controls, Mitigation Measures and Monitoring

Avoidance Measures

As mentioned above, major water bodies should be buffered by 150 m (except the water abstraction facility). However, this buffer must be extended to at least 200 m for activities relating to potentially hazardous chemicals and for activities working with large quantities of hydrocarbons. This will significantly contribute to the avoidance of pollution in sensitive habitats.

Rehabilitation Measures

- If extensive spills have occurred, the area must be rehabilitated appropriately. This will require consultation with an ecologist specialized in the rehabilitation of polluted habitats.

Significance of Residual Impacts

Residual impact of the potential for unplanned spills to occur should be minor if all of the precautionary mitigation measures are applied. In the unlikely event that a spill does occur, rapid cleanup procedures and effective rehabilitation should reduce the actual impact to Minor.

12. AQUATIC ECOLOGY AND WATER QUALITY

This Chapter presents an assessment of the surface water ecology for the proposed Bomi Hills Mine.

19.1 Scope of Assessment

As discussed in *Chapter 7*, currently the surrounding areas around Bomi Hills are already impacted by anthropogenic activity due to both previous mining and agriculture. The reconstruction of the Bomi Hills Mine and associated infrastructure is likely to have a number of additional direct and indirect impacts on the aquatic ecology in the surrounding area. Direct impacts include, for example, loss and disturbance of aquatic habitats and species due to the physical footprint of the mine and associated infrastructure; deterioration of water quality and a change in hydrology. Indirect impacts are mainly attributed to human influx to the area for work opportunities and thus impacting the aquatic habitats via anthropogenic activities. Different impacts are associated during the construction and operational phase of the development. Construction impacts are usually direct and either permanent or short term, whereas operational impacts are direct and will affect the surrounding area for an extensive period of time. The direct and indirect impacts associated with aquatic ecology, have been discussed in detail below under the following main headings:

- habitat loss;
- change in water quality;
- change in flow regime; and
- increase in anthropogenic activities.

The impacts are discussed together with the Direct and Indirect Areas of Influence (ADI and AII respectively), the impact ratings, proposed mitigation measures and the residual impact.

Mitigation measures for these impacts mentioned above mainly consist of embedded controls within the design, construction and operational phases of the project. These issues are also discussed in detail in the Surface Water (*Chapter 8*) section of this report.

For the Impact Assessment carried out in the following Sections, the following embedded controls have been assumed:

- Silt ponds to be installed on outlets from tailings storage facilities, to be inspected and cleaned regularly;
- Storm water management;

- Adequate capacity of dirty water management facilities considering high rainfall of the site needs to be assessed and managed; Aquatic Water quality standards to be adhered to for any discharges (DWAF, 1996[6]; CCME, 1999[7]; NRMMC, 2000[8]; Suter & Tsao, 1996[9]);
- Washing of WCL and contractor vehicles only in designated washbays with dirty water handling facilities;
- Setting up of stormwater management measures prior to commencement of construction activities to protect the water resources;
- Concurrent rehabilitation and re-vegetation of disturbed areas during operations to avoid silts from being washed into the natural resources;
- Ensure capacities of all dirty/process water infrastructure with a freeboard of 0.8m is designed and maintained;
- Aquatic bio-monitoring programme (bi-annually and a surface water monitoring programme (monthly) to ensure that potential impacts are identified timely and additional management measures are put in place; and
- Dirty water management around fuel bays, workshops, chemical storage areas and plant areas.

12.1.1 Current Aquatic Impacts

The current aquatic impacts are summarised below:

- The previous mining and current agriculture activities were found to be having direct impact on the water quality with high turbidity and iron levels, especially during peak run off at the downstream site of the mining activities indicating possible runoff from old tailings and or waste dumps.
- The aquatic stream habitats were negatively impacted due to general catchment activities including previous iron ore mining, agricultural activities encroaching on the systems and road crossings that induced modifications to the available aquatic habitats. This is mainly due to siltation caused by runoff from agricultural fields and also some erosion of slopes next to roads within the concession area (*Figure 12.1*).

[6] DEPARTMENT OF WATER AFFAIRS AND FORESTRY (DWAF). 1996. South African water quality guidelines, volume 7: Aquatic Ecosystems.

[7] CCME (Canadian Council of Ministers of the Environment). 1999. Canadian water quality guidelines for the protection of aquatic life. Canadian Council of Ministers of the Environment, Winnipeg.

[8] NRMMC 2000. Australian and New Zealand Guidelines for Fresh and Marine Water Quality, Chapter 3: Aquatic Ecosystems. Natural Resource Management Ministerial Council.

[9] SUTER, G.W. & TSAO, C.L. 1996. Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Aquatic Biota. Department of Energy. Report ES/ER/TM-96/R2.

- Water quality, especially within Tubmanburg town, is impacted due to possible organic pollution from waste causing eutrophication in streams.
- The aquatic biota was also modified from natural assemblages. The macro-invertebrate assemblages were largely modified due to alterations in the habitat due to siltation/ turbidity and poor water quality resulting in an abundance of tolerant families.
- The presence of the exotic fish species, *Cyprinus carpio*, may have detrimental effects on the aquatic community due to their ability to increase turbidity within streams, thus affecting aquatic habitats.
- Harvesting of fish by local villagers' i and streams.

Figure 1: Images showing high turbidity and siltation on banks of the rivers and streams within Project area of influence owing to agricultural and previous mining activities (photo taken at sampling point B2)

19.2 Impact Assessment

12.2.1 Habitat Loss and Resultant Loss in Aquatic Diversity

Potential Impact

The remaining natural aquatic areas, within the Bomi Hills Concession, are limited due to all the previous mining and agriculture in the area, and therefore those remaining in the eastern side of the concession provide important habitat for aquatic species in the area (*Map 12-2*). The highest species diversity and numbers (fish and macro-invertebrates) and the highest habitat integrity were identified in the sites sampled upstream of the past mining activities (B8 and B9). The reconstruction of the Bomi Hills Mine, within the proposed footprint area, will result in site clearance and the resultant loss of the aquatic habitat and diversion of existing streams.

Potential Consequence

The potential consequence resulting from site clearance will result in a loss of aquatic habitat and associated species within the footprint area and subsequent impacts downstream of the mining area in terms of a change in water quality and hydrology (downstream impacts discussed in Sections below). The systems likely to be affected will vary from Modified Habitat to Natural Habitat (IFC, 2012). The systems of main concern are those that classify as Natural Habitat according to the IFC Performance Standard 6, situated in the eastern section of the Concession.

Significance of Impacts

The loss of the aquatic habitats, within the Bomi Hills Concession Area will occur during the Construction Phase and will be permanent in nature. The significance rating, prior to mitigation is considered **major** *(Table 12.11*).

Table 11: Significance of Impacts on Habitat Loss

Impact	Loss of aquatic habitat.				
Impact Nature	Negative		Positive		Neutral
	Impact on aquatic habitat loss is negative.				
Impact Type	Direct		Indirect		Induced
	Impact on habitat loss is direct.				
Impact Duration	Temporary	Short-term	Long-term		Permanent
	The impacts that result in a loss of aquatic habitat within the footprint area will be permanent as well as subsequent impacts on downstream of the mining area.				
Impact Extent	Local		Regional		International
	Impacts on habitat loss will be local to regional.				
Impact Scale	The scale of the impacts from aquatic habitat loss within the mining footprint area will be localized.				
Frequency	Impacts from habitat loss will last throughout the project operation.				
Impact Magnitude	Positive	Negligible	Small	Medium	Large
	Impact magnitude is considered medium.				
Receptor Sensitivity	Low		Medium		High
	The sensitivity of the loss of aquatic habitat is considered medium-high.				
Impact Significance	Negligible	Minor	Moderate		Major
	Significance of impact is considered to be **moderate.**				

Mitigation Measures, Management and Monitoring

The impact significance is predicted to be **moderate** and mitigation measures are thus required. In accordance with Project Proponent's corp sustainability standards, development should not convert or degrade Natural Habitats. Avoidance is therefore the key mitigation measure for these systems. Mining activities should therefore be avoided in the Natural Habitats unless it is absolutely essential and mitigation measures are put in place.

It is recommended that the loss of aquatic habitats should be avoided and if not adequate buffer zones around major/ perennial water bodies to be maintained to minimise impacts on these habitats. Buffers of 200m wide are required for the systems classified as Natural Habitat situated in the eastern section of the Concession.

Significance of Residual Impacts

In terms of the Bomi Hills Mine concession, the residual impact is assessed as **minor** considering that the buffer zones will be implemented.

12.2.2 Change in Water Quality and Associated Impacts on Aquatic Ecology

Source of Impact

Water quality variables, physical (turbidity, suspended solids, temperature, and oxygen) or chemical (trace metals, salt constituents and nutrients), may affect the aquatic ecosystem due to the construction and operation of Bomi Hills Mine and associated infrastructure. Each variable can have either beneficial or detrimental effects on the aquatic organisms. The effect of each variable is influenced by the concentrations of contaminants, the duration of exposure and the tolerance limit of the aquatic organism. When more than one variable is involved, the overall effects are dependent on whether the variables act synergistically or antagonistically.

Potential Consequence

As mentioned in *Chapter 7*, the water quality within the aquatic ecosystems is generally in good condition. Deterioration in water quality will have the potential to progressively alter the constituent species of a biotic community until the point that it is no longer recognizable as the same community (Dallas and Day, 2004[10]). Changes to water quality could result in:

- A shift in the physical position of a community of aquatic organisms;

[10] DALLAS, H.F. & DAY, J.A. 2004. The effect of water quality variables on Aquatic Ecosystems: A Review. WRC Report No. TT 224/04. Water Research Commission. Pretoria, South Africa.

- The introduction or loss of key species;
- Reduction in diversity as a result of increase in the concentration of toxins such as trace metals; and
- Reduced ecosystem functioning.

Contamination takes place as a result of anthropogenic activities of local people using the available streams or water sources for washing, bathing and cleaning vehicles, and surface and ground water pollution from various sources associated with the Mine. An increase in sedimentation is also highly probable during the construction phase where the activities will include the removal of vegetation for the construction of roads and infrastructure and the resultant increase in surface run-off and dust due to blasting, trench excavation and backfilling. In addition, increased activities on the unpaved roads to get machinery and people to the sites (prior to the road being upgraded), during the construction phase, will increase sedimentation. More specific sources for a decline in water quality are discussed below with the impact of these factors on the aquatic ecology highlighted in *Table 12*.

The area of influence includes the rivers, streams and wetlands downstream of mining activities which will be affected by sedimentation or contamination. The expected distance of impact will range from 200 m to 5 km depending on management [(1)] (*Map 12-2*). Contamination sources include:

- Contamination of groundwater from the open pit mining activities and the exposure of the iron ore material;
- Discharge of effluent not treated effectively;
- Seepage from the waste rock dumps and tailings facilities into the surface and groundwater;
- Dust and erosion causing an increase in sedimentation;
- Stormwater run-off from the dirty environment entering the clean water resources; and
- Accidental spills and leaks.

Table 12: The effect of some major physical attributes and chemical constituents of water in aquatic ecosystems (Dallas & Day, 2004)

WQ Constituent	Sources	Major Effects
Physical Factors		
Temperature	Reduction in flows as a result of abstraction will influence water levels and therefore temperature	Temperature determines metabolic rate of aquatic organisms, availability of nutrients and toxins, oxygen saturation levels in water bodies and provides cues for breeding, migration etc. for macro-invertebrates and fish. Changes in temperature may lead to changes in the abundance, diversity and composition of aquatic communities. Organism with a narrow range of temperature will disappear from heated waters and heat-tolerant species will increase in number and replace original species.
Turbidity and suspended solids	The construction of the Mine and associated infrastructure, removal of vegetation, runoff from roads etc is expected to induce high levels of turbidity and SS	Turbidity determines degree of penetration of light, hence impacts on the vision of fish and photosynthesis of plants Suspended solids reduce penetration of light, smother and clog surfaces (e.g. gills) and adsorb nutrients, toxins, etc.
Chemical Factors		
pH	Effluent discharge	With a decrease in pH, the aquatic organisms need to increase the rate of osmotic and ionic regulations which cause physiological stress on organisms. This will lead to slow growth and reduced fecundity. A reduce pH will affect macro-invertebrate species and therefore reducing availability. The gill functioning of fish will also be affected.
Conductivity, TDS, individual ions	Change in flow regime in downstream water resources	Affect osmotic, ionic and water balance in aquatic organisms which might lead to a decrease in sensitive species, but an increase in more tolerant species. Juvenile stages are often more sensitive, which can cause a reduction in aquatic populations.
Dissolved oxygen	Modification in flow rate and quantity	Required for aerobic respiration Reduce oxygen concentration with is critical for the survival and functioning of aquatic biota.
Organic enrichment	Influx of workers and utilisation of water resources	Increase nutrient levels which change species composition, increase densities of taxa tolerant to enrichment and decrease of sensitive taxa
Nutrient enrichment	Influx of workers and utilisation of water resources	Not toxic but can cause eutrophication and thus affect community structure of macro-invertebrates and fish
Biocides	Influx of people to the greater area & associated increase in agricultural activities	Usually target specific groups (e.g. molluscs, insects, plants) and thus alter community structure

Metals	unwanted leakages, runoff, exposed iron ore	Many elements are essential at low concentrations Some metals are mutagenic, teratogenic and carcinogenic to biota Some metals are metabolic inhibitors in fish
Hydrocarbons	Unwanted leakages, runoff	Hydrocarbons are organic compounds that may be present within the gas drilling processes of this project. They can cause major toxic effects on the receiving environment at relatively low concentrations (Phillips and Rainbow, 1993). Due to its lipophilic nature, they concentrate in the sediment and bioaccumulate in high concentrations in aquatic organisms. The aquatic organisms are particularly susceptible to such exposure as hydrocarbons are generally difficult to metabolise.

Significance of Impacts

The impact significance of a deterioration of water quality on the aquatic ecosystems is assessed as **moderate** prior to mitigation during the construction and operational phases (*Table 12.3)*.

Table 13: Significance of Impacts on Water Quality

Impact	Impacts on water quality				
Impact Nature	Negative		Positive		Neutral
	Impact on water quality is negative.				
Impact Type	Direct		Indirect		Induced
	Impact on water quality is direct.				
Impact Duration	Temporary	Short-term	Long-term		Permanent
	Impacts from water impairment within the Mine footprint will last throughout the life time of the Mine operation, whilst land clearance, excavation, construction works, domestic, industrial waste water will cause short-term impacts.				
Impact Extent	Local		Regional		International
	Impacts on hydrology are local-regional.				
Impact Scale	The area affected will be the direct vicinity of the mine operations as well as areas downstream of impacts.				
Frequency	Impacts on water quality around the mine footprint will last throughout the project operation, whereas impact due to construction works will be temporary.				
Impact Magnitude	Positive	Negligible	Small	Medium	Large
	Impact magnitude is considered medium.				
Receptor Sensitivity	Low		Medium		High
	The sensitivity of streams and rivers to be impacted is considered medium.				
Impact Significance	Negligible	Minor	Moderate		Major
	Significance of impact is considered to be **moderate.**				

Mitigation Measures, Management and Monitoring

Key mitigation measures to avoid, minimize and reduce a negative change in water quality during construction and operation of the Mine include the following:

- Tailings facilities, waste rock dumps and soil stockpiles should be located away from watercourses, and shaped to reduce erosion. Where possible diversions and storm water channels should be placed around dumps and piles to divert water flow away from the dumps and stockpiles.

- Storm water channels and cut-off trenches to be placed around the tailings facilities, waste rock dumps and soil stockpiles so that rain water is diverted away from the possible sources of contamination. The disposal facilities and stockpile facilities need to be designed with the necessary drainage, trench systems and pollution control dams to ensure that all dirty water is contained. Sediment traps are to be created at the end of the storm water channels for the settling of silt and to prevent the eroded, contaminated soils from entering the receiving environment. The silt gathered in the settling pits is to be cleaned before every rainy season. After mine closure the settling pits are to be cleaned before every rainy season for the first two years, after which it is assumed that the slopes would have stabilized and erosion reduced.

The material used for joining of underground drainage and sewer pipes shall be such as to make the joints water tight for preventing ingress of sub-soil water by infiltration and escape of inside waters to the surrounding areas.

Recommended monitoring programmes for water quality include:

- Water quality should be monitored on a monthly basis at the identified sampling sites around the Mine. If necessary, additional points should be included to ensure that water monitoring takes place up and downstream of any potential point of contamination. Regular water quality monitoring will give an indication of the normal monthly, seasonal and annual variations. These water quality results should be compared against baseline data and Target Water Quality Guidelines (TWQR), annually incorporated and interpreted in order to determine trends and identify possible sources of long-term chronic contamination. Monitoring should include:
    - pH;
    - Dissolved oxygen;
    - Conductivity;
    - Suspended solids;
    - Metals;
    - Nutrients;
    - Organic enrichment; and
    - Turbidity.

If significant changes occur in water quality, the cause must be investigated and rectified immediately.

Significance of Residual Impact

The residual impact is assessed as **minor** should erosion and contamination measures be successfully implemented.

12.2.3 Change in Hydrology and Associated Impacts on Aquatic Ecology

Source of Impact

The hydrology within the affected systems will be impacted by a number of factors, including but not limited to the following:

- Water abstraction from the river systems and also the old mine pits for use in the mining operations;
- Discharge of water from disused mine pit into the surrounding rivers and streams;
- Hardening of surfaces;
- Stormwater run-off;
- Diversion of rivers and streams; and
- Removal of natural vegetation.
- Potential Consequence

The potential consequence of the above impacts on hydrology and the subsequent impact on the aquatic ecology are discussed in more detail below.

- Aspects increasing the quantity of water and flow rate of the downstream systems include:
    - Areas where associated infrastructure constructed will be cleared of vegetation and surfaced, paved or built during the construction phase. Infiltration of rain water into the soil will be substantially reduced as a result in these areas, which may potentially reduce the natural recharge of the water into the receiving environment. The hardened surfaces will result in stormwater run-off that needs to be managed.
    - in addition to the stormwater runoff, the streams and rivers that are likely to be affected e within the project footprint will need to be diverted.
    - the water accumulated in the old mine pit will be used for construction, beneficiation of ore and other activities. However, some volumes may be discharged into a nearby watercourse, if required.

- Sumps will be located within the mine pit to ensure that all mine working faces are water free during the operational phase of mining. The water from these sumps will be used for mining activities.

- The water from the diversions, stormwater runoff and disused mine pit will need to be discharged at some point into the receiving environment resulting in a change in the flooding regime (quantity and flow rate) of the receiving systems. This change in hydrology will occur during both the construction and operational phases of the mine. The area downstream of the discharge point will be altered due to a change in flow regime. The impact is likely to occur with decreasing intensity downstream. The impacts of this on the aquatic ecology has been summarised below:
    - Overall biological communities are largely dependent on the velocity-depth ratios. The increased water quantity will result in changing habitat conditions from slow to faster flowing river conditions with a concurrent reduction in in-stream vegetation. The reduction in in-stream vegetation and increase in flow will affect the macro-invertebrates and fish that prefer the current biotopes. The higher flow rates will lead to increased erosion; scouring and sedimentation which in return affect these species negatively. In addition, rapid changes between flow rates will influence the biological community negatively. If the conditions change constantly, the macro-invertebrates and fish species will not have a chance to adapt to these conditions in order to breed and establish their communities.
    - In terms of the macro-invertebrates present, most of the families will be impacted at most of the sampling sites with any alterations in flow.
    - The fish species present have preferences to a variety of habitat conditions with the most sensitive species sampled preferring both fast-shallow and slow-shallow habitats (FishBase, 2012).

Aspects decreasing the quantity of water and flow rate of the downstream systems include:

- Abstraction of water for use during the construction and operational phases, water will be sourced from disused mine pit, borehole pumps and the Mahe River; and
- The de-watering cone of drawdown from the proposed mine may result in a drop in groundwater levels. The link between the surface and groundwater of these aquatic systems has not yet been confirmed, so it has been assumed that a link may/ may not exist.

The impact on the aquatic ecology due to a decrease in flow rate and quantity of water includes:

- A change in channel shape and patterns of sedimentation, resulting in a change in the available aquatic habitats; and
- A deterioration of water quality due to a decrease in the dilution factor.

Significance of Impacts

The impact significance in the change in hydrology on the aquatic ecosystems is assessed as **moderate** prior to mitigation during the construction and operational phases. The increased flow of water will have an adverse effect on the water quality and available habitats (*Table 12.4*)

Table 14: Significance of Impacts on change in hydrology and associated aquatic ecology

Impact	Impacts on change in hydrology				
Impact Nature	Negative	Positive	Neutral		
	Impact on hydrology is negative.				
Impact Type	Direct	Indirect	Induced		
	Impact on hydrology is direct.				
Impact Duration	Temporary	Short-term	Long-term	Permanent	
	Impacts on hydrology of the streams within the mine footprint will last throughout the life time of the mine operation, however, changes to the morphology of the receiving streams and rivers will be permanent.				
Impact Extent	Local	Regional	International		
	The impact is likely to occur with decreasing intensity downstream.				
Impact Scale	The area downstream of the discharge point will be altered due to a change in flow regime.				
Frequency	Impacts from the change in hydrology will occur during both the construction and operational phases of the mine.				
Impact Magnitude	Positive	Negligible	Small	Medium	Large
	Impact magnitude is considered medium.				
Receptor Sensitivity	Low	Medium	High		
	A change in channel shape and patterns of sedimentation, resulting in a change in the available aquatic habitats.				
Impact Significance	Negligible	Minor	Moderate	Major	
	Significance of impact is considered to be **moderate.**				

Mitigation Measures

Key mitigation measures that would help to avoid, minimize/reduce changes in hydrology during construction and operations include the following:

- Optimum abstraction of water from the Mahe River or associated tributaries. All water supply to be sourced from disused mine pit or the man-made lake.
- The rate of discharge from the storm water, river diversions and disused mine pit should take base flow rate into consideration and be adjusted accordingly. Discharge should be limited to high flow periods or slow release of water during the low flow season to minimize the impact of increased flow in the system.
- Maintenance and construction crews should include routine checks to ensure drains and culverts are clear and clean during the wet season.
- Vegetation clearance in the project footprint must be limited to the smallest extent possible.
- Water quality to be discharged need to be monitored on a regular basis. Should a significant decrease in water quality be detected additional measures should be implemented to purify water before it is released into the environment.

Significance of Residual Impact

The impact significance is reduced to **minor** during the construction and operational phases if mitigation measures are implemented.

12.2.4 Human Influx

Impact Description

As noted in *Chapter 7.6*, the baseline conditions in the area are already impacted by anthropogenic influences caused by the local communities in the area e.g. cultivation of alien plants and washing of clothes, organic enrichment (possibly from faecal matter), water abstraction and increased fishing in streams and rivers. The anthropogenic influences are currently having a moderate effect on the systems. Both direct and indirect economic opportunities presented by the Project are expected to result in an influx of people hoping to improve their livelihood.

With the influx of people to the area, existing anthropogenic impacts are likely to increase or new impacts arise, putting pressure on the aquatic systems. These are likely to include:

- ✓ Increased disturbance to aquatic habitats outside of the Bomi Hills Project Site due to increased demand for natural resources such as fuel wood and wooden poles for building materials. In addition influx may result in the displacement of natural riparian habitats for agricultural production.
- ✓ Overfishing - a secondary impact caused by influx of people will lead to a decline in the indigenous fish population, particularly those species that are larger fleshy species adequate for eating such as *Labeo coubie* and *Heterobranchus isopterus*. By-catches of smaller species, such as *Hemichromis fasciatus*, are also expected to be impacted on.
- ✓ Increased solid waste (litter) in the aquatic ecosystems - submerged debris can cause instream habitat destruction, smothering of bottom-dwelling species, physical damage (through entanglement and ingestion) and death to aquatic species.
- ✓ Water quality deterioration, through nutrient and organic enrichment.
- ✓ Erosion from increased footpaths accessing these systems, subsistence farming within the riparian zone and other human activities such as artisanal sand mining in rivers, causing increased sedimentation in the rivers and streams.
- ✓ Increased pressure on the surface water resource due to the need for the resource for drinking, washing, bathing etc.

These impacts are considered to be indirect secondary impacts and are likely to occur outside Bomi Hills Mine, starting at the construction phase when influx to the area is likely to begin, and occurring at all phases of the development lasting beyond the duration of the Projects life span. The AII is difficult to define and will be limited by terrain accessibility (although access roads being constructed for the mines will result in an increase in the accessibility of the areas) but can be expected to occur within a zone of 5 km within and around the project components.

Significance of Impacts

The impacts will be permanent and likely to occur on a **local** to **regional** scale. The number of people migrating to the area is not known but the intensity of the impact on aquatic systems outside the Bomi Hills concession is expected to be **major- moderate** and focussed on the systems nearest to Tubmanburg and the Bomi Hills Mine. The magnitude may be **medium**. This coupled with the **definite** likelihood of anthropogenic influences on the aquatic habitats occurring will result in an impact of **moderate** significance (*Table 12.5*).

Table 15: Significance of Impacts of Human Influx on Aquatic Ecology

Impact	Impacts of Human Influx			
Impact Nature	Negative	Positive	Neutral	
	Impact on aquatic biodiversity is negative.			
Impact Type	Direct	Indirect	Induced	
	The impacts are secondary and are likely to occur outside Bomi Hills Project area.			
Impact Duration	Temporary	Short-term	Long-term	Permanent
	Loss in aquatic habitats and species will be severely affected			
Impact Extent	Local	Regional	International	
	Impacts on aquatic ecology due to human influx are local to regional.			
Impact Scale	The number of people migrating to the area is not known but the intensity of the impact on aquatic systems outside Bomi Hills Project area is expected to be focused on the systems nearest to Tubmanburg and the Bomi Hills Project area.			
Frequency	Impacts will be continuous starting from the construction phase when influx to the area is likely to begin, and occurring at all phases of the development lasting beyond the duration of the Projects lifespan.			
Impact Magnitude	Positive	Negligible	Small	Medium	Large
	Impact magnitude is considered medium.			
Receptor Sensitivity	Low	Medium	High	
	Some habitats may be more sensitive to the impact, but overall the aquatic community retains the ability to cope with changes			
Impact Significance	Negligible	Minor	Moderate	Major
	Significance of impact is considered to be **moderate.**			

Mitigation Measures, Management and Monitoring

Although the impacts described above will be felt outside the Project the indirect and secondary impacts will occur as a result of the presence of the Project. Key mitigations measures to avoid, minimize / reduce the impacts of human influx during the project lifespan include the following:

- A Social Development Plan for the surrounding area will be required to manage community expectations. This needs to be implemented with cooperation from the local and regional government authorities.
- Support should be provided to the authorities responsible for natural resource management.

- Workers and their families should be educated as to the environmental impacts that may result from their activities through:
    - Awareness campaigns;
    - Involvement in cleanup operations; and
    - Training in pollution prevention, such as proper disposal and waste reduction (recycling and reuse) of litter.
- Discourage mine staff and contractors on fishing within the vicinity of the mine operations should be implemented to avoid increased pressure of fish communities.

The effectiveness of implementation of the above mitigation is difficult to predict. It is likely that the intensity and magnitude of the impact is reduced during the various phases of the Project, however, due to the uncertainties a conservative approach has been applied in assessing the intensity and magnitude of this impact as **moderate**.

Significance of Residual Impact

The residual impact is assessed as **minor** should measures to reduce the impact of human influx be successfully implemented.

19.3 Summary

The activities associated with Bomi Hills mine will have impacts on local and regional resources in the various stages of the Project. As discussed previously, the current and surrounding areas are already impacted by anthropogenic activity due to both previous mining and agriculture. The reconstruction of the Bomi Hills Mine and associated infrastructure is likely to have a number of additional direct and indirect impacts on the aquatic ecology in the surrounding area.

Direct impacts include, for example, loss and disturbance of aquatic habitats and species due to the physical footprint of the mine and associated infrastructure; further deterioration of water quality and a change in hydrology. Indirect impacts are mainly attributed to human influx to the area for work opportunities and thus impacting the aquatic habitats via anthropogenic activities.

Different impacts are associated with the construction and operational phase of the development. Construction impacts are usually direct and either permanent or short term, whereas operational impacts are direct and will affect the surrounding area for an extensive period of time. The direct and indirect impacts, associated with aquatic ecology, are summarised as:

- habitat loss;
- change in water quality;
- change in flow regime; and
- Increase in anthropogenic activities.

The impacts are considered to be avoidable should the mitigation measures, as provided in the previous sections, be implemented.

LANDSCAPE AND VISUAL IMPACT ASSESSMENT

This chapter presents the results of the assessment of impacts of the Bomi Mine on baseline landscape and visual resources. Landscape and visual impacts occur when new elements are introduced into a landscape or existing elements are altered or removed leading to a change in the way stakeholders, perceive or experience landscapes resources. In each case the impact may be perceived as either adverse or beneficial, depending on the nature and degree of change and the attitudes of people to the existing and new landscape. Impacts can be assessed by reference to changes in the landscape as seen from a key observation point (KOP) from which individuals or groups of people can see a project.

Scope of Assessment

Impacts can occur during construction, operation and closure. Sources of impacts associated with the construction phase include:

- road construction;
- clearing of vegetation;
- movement of large construction vehicles; and
- construction of the mine and plant infrastructure.

Sources of impacts during the operational phase include:

- changes to the profile of the Bomi Mine, as seen from one KOP;
- movement of large mining vehicles and machinery; and
- presence of mine infrastructure (buildings and facilities).

Sources of impact during the closure phase include:

- removal of redundant infrastructure; and
- changes to the land use as a result of land rehabilitation.

The remainder of this chapter is organized as follows:

- *Section 13.1* describes the methodology and approach used in the assessment; and
- *Section 13.2* discusses the impacts of the mine proposals; summary of impacts and significance; mitigation measures and a summary of findings of the assessment and residual impacts.

Prediction and Evaluation of Impacts

The assessment has followed the general approach of characterizing the baseline, predicting the magnitude of impacts, evaluating significance, developing mitigation measures and assessing residual impact as stipulated in *Chapter 4*.

Approach to Landscape and Visual Impact Assessment (LVIA)

The general approach is described in *Figure 13.1*.

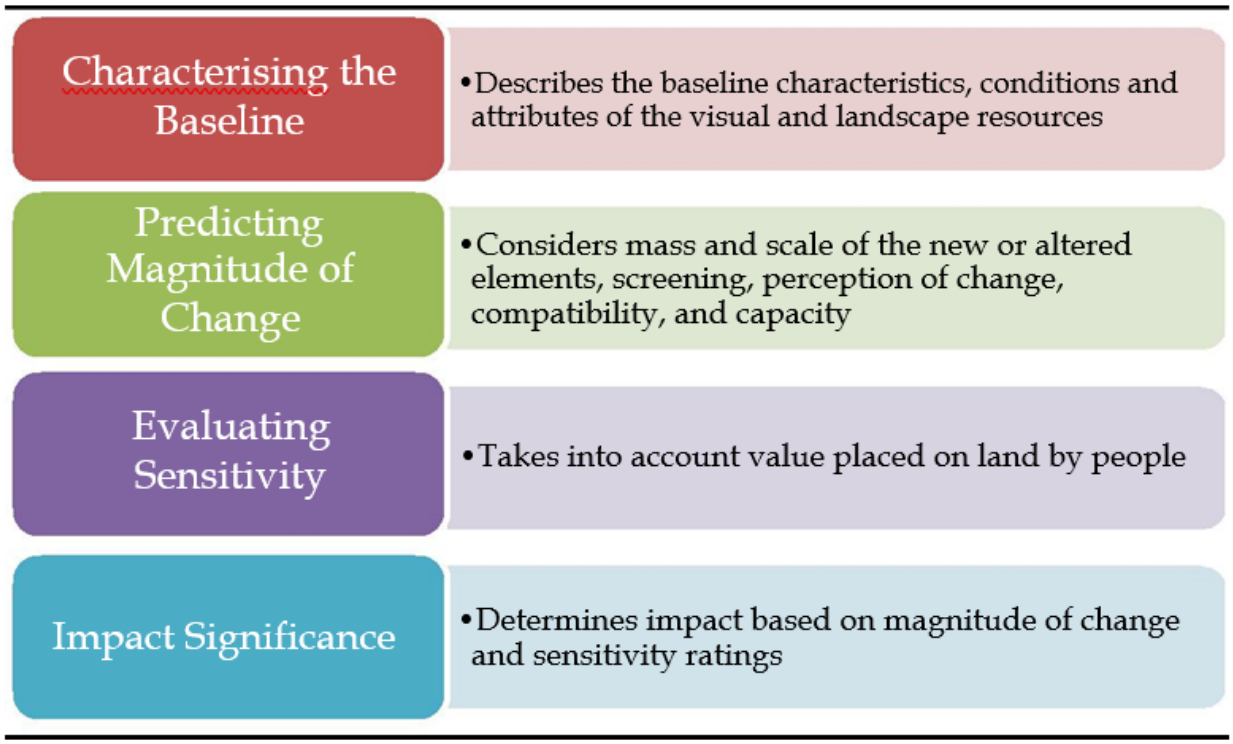


Figure 2: Approach to LVIA

Characterizing the Baseline

The baseline characteristics, conditions and attributes of the visual and landscape resources are described in *Chapter 7.*

The Bomi Hills Mine is located at the transition between the coastal plain and rolling hills geomorphological landscapes. The landscape is tropical rain forest with topography gradually rising from the coast to an elevation of about 60 m at the base of Bomi Hills. Before mining, the Bomi Hill crest attained an elevation of 222 metres above mean sea level. The area is generally flat with gently rolling hills. Previous mining led to the creation of the disused mine pit which was filled with water and was also known as Bomi

Lake. The landscape resources have been extensively modified by human activity, primarily by previous mining activity.

Three key observation points (KOPs) were identified located at Telecommunication Tower Point overlooking the Project area of influence. The sensitivity of the receptors at the KOPs is considered to be low (see *Table 13.3* for detailed evaluation of sensitivity).

Predicting Magnitude of Change

The magnitude of change in a landscape or view depends on a number of factors:

- the mass and scale of the new or altered elements in the view;
- the likelihood that the new elements will be screened by intervening features such as vegetation, hills, buildings;
- the perception of change, that is, how far away they are from the project, if the project can be seen in the foreground, middle ground and background, or seen above or below;
- compatibility of the project components with the existing landscape character, taking into account whether the landscape is natural, modified or built, the characteristics of the landscape and the importance of each to its value, how well the project components fit with these characteristics with regard to size, form, colour, material; and
- the capacity or ability of the foreground, middle ground and background of the landscape to accommodate or assimilate the change.

Evaluation of Impact Significance

The significance of impact was then evaluated taking into account the sensitivity of the KOP and the magnitude of change in the landscape from the KOP, as set out in Table 13.2.

Table 16: Evaluation of Impact Significance

Value of Resource/ Sensitivity of Sensitive Visual Receptor		Magnitude of Change			
		Negligible	**Small**	**Medium**	**Large**
		Within the normal range of day to day variation	Perceptible difference from baseline conditions	Clearly evident change from baseline conditions	Change which is sufficient to be dominant in comparison to baseline conditions
Negligible	No specific value or importance attached to the resource. Receptor is not sensitive to the type of change	**Not Significant**	**Not Significant**	**Not Significant**	**Not Significant**
Low	Resource is locally valued / important. Receptor is slightly sensitive to the type of change.	**Not Significant**	**Not Significant**	**Minor**	**Moderate**
Medium	Resource of regional/ national importance. Receptor shows moderate sensitivity to the type of change and/or resource is locally valued / important and receptor is moderate to highly sensitive to the type of change	**Not Significant**	**Minor**	**Moderate**	**Major**
High	Resource of national/international importance. Receptor shows high sensitivity to the change.	**Not Significant**	**Moderate**	**Major**	**Critical**

Table 13.3 assesses the sensitivity of each KOP.

Table 17: Evaluation of KOP Sensitivity

KOP	Factors given Weighting in Assessment of Sensitivity	Sensitivity to Change
KOP1	• Bomi Mine comprises a prominent part of the foreground and is visually dominant. • No potential for blocking by structures in the immediate foreground. Resource is not locally valued as local population does not utilize viewpoint; however, some international populations utilize it. Local receptor is slightly sensitive to the type of change, but regional receptor may be moderate to highly sensitive to the type of change.	
KOP2	• Landscape is visible in the middle ground. Resource is not locally valued as local population does not utilize viewpoint; however, some international populations utilize it. Local receptor is slightly sensitive to the type of change, but regional receptor may be moderate to highly sensitive to the type of change.	
KOP3	• Bomi Hill and Bomi Lake are visually dominant on the immediate near middle ground. Resource is not locally valued as local population does not utilize viewpoint; however, some international populations utilize it. Local receptor is slightly sensitive to the type of change, but regional receptor may be moderate to highly sensitive to the type of change.	

13.2 Impact Assessment

The assessment presented below considers this baseline position and predicts the magnitude of change and the significance of the impacts that will occur as a result of the construction and operation of the mine, prior to mitigation being implemented.

13.2.1 *Impact on Landscape and Visual Resources*

Construction and Operational Impacts

A large construction program will be required to build the infrastructure before mining can commence. The construction phase also covers the period required to clear vegetation, remove topsoil and overburden to expose the ore. Construction of the mine is expected to take place over approximately 13

months with the first stages of construction work starting in September 2013 and due for completion in August 2014.

The key construction and operation activities and facilities are outline in Chapter 2).

The change in the landscape as viewed from the KOP viewpoints is illustrated in photomontages presented in *Annex 7-H*. These show sequences over the lifetime of the mine at each KOP viewpoint (baseline, end of mining –year 19, and 15 years after closure) and are used to assist the assessment of the impact of the mine project.

Closure Impacts

During and after mine closure, the mine pits and waste emplacements will remain unsuitable for future beneficial use, but much of the remaining land that had been used for mining infrastructure will be rehabilitated. Local people will be engaged to understand their land use needs and to agree the rehabilitation for useable areas of land. During the development of the Land and Rehabilitation Plan, key stakeholders, including government agencies and representatives of impacted communities, will be consulted and their comments incorporated into plans where feasible.

Significance of Impacts

In summary, the main findings of the landscape and visual impact assessment showed that there is likely to be a negative, moderate impact on sensitive visual receptors from Telecommunication Tower Point according to KOP1 and KOP3 at 19 years after mining. From 15 years after closure the impact is likely to become positive as the mine pit again fills with water. Although the magnitude of change is high, sensitivity is low as relatively few people travel to Telecommunication Tower Point.

Table 18: Summary of Significance of Impact KOP1

Impact	Visual Impact at KOP1 After 19 Years of Mining (worst case scenario)			
Impact Nature	Negative	Positive	Neutral	
	Impact is negative in nature			
Impact Type	Direct	Indirect	Induced	
	Impact is direct in nature			
Impact Duration	Temporary	Short-term	Long-term	Permanent
	Long term for duration of project			

Impact Extent	Local		Regional		International
	Bomi County				
Impact Scale	30 Kilometres out from Telecommunication Tower Point/UNMIL point				
Frequency	Throughout duration of mining				
Impact Magnitude	Positive	Negligible	Small	Medium	Large
	Magnitude of impact is large				
Receptor Sensitivity	Low		Medium		High
	Low sensitivity as not many people travel to top of Telecommunication Tower Point/UNMIL point				
Impact Significance	Negligible	Minor	Moderate		Major
	Impact significance is moderate				

Table 19: Summary of Significance of Impact KOP1 (post closure)

Impact	Visual Impact at KOP1 15 Years After Closure				
Impact Nature	Negative		Positive		Neutral
	Impact is positive in nature as the pit lake fills with water.				
Impact Type	Direct		Indirect		Induced
	Impact is direct in nature				
Impact Duration	Temporary	Short-term	Long-term		Permanent
	Duration is a permanent change				
Impact Extent	Local		Regional		International
	Bomi County				
Impact Scale	30 Kilometres out from Telecommunication Tower Point/UNMIL point				
Frequency	Throughout duration of mining				
Impact Magnitude	Positive	Negligible	Small	Medium	Large
	The magnitude of change is large				

Receptor Sensitivity	Low		Medium		High
	Low sensitivity as not many people travel to top of Telecommunication Tower Point/UNMIL point				
Impact Significance	Negligible	Minor	Moderate		Major
	Impact significance is moderate				

There will not be a significant impact on sensitive visual receptors facing south or southeast from Telecommunication Tower Point KOP2. Sensitivity is low as not many people travel there for the view and it does not have cultural significance nor is it valued highly by the local population (Table 20). As only some mining infrastructure will be visible after 19 years of mining the magnitude of change is small and will therefore have a negligible impact; and 15 years after closure this infrastructure will be demolished. Thus, residual impact on the visual landscape will be negligible (Table 21).

Table 20: Summary of Significance of Impact KOP2

Impact	Visual Impact at KOP2 After 19 Years of Mining				
Impact Nature	Negative		Positive		Neutral
	Impact is negative in nature				
Impact Type	Direct		Indirect		Induced
	Impact is direct in nature				
Impact Duration	Temporary	Short-term	Long-term		Permanent
	Duration is a permanent change				
Impact Extent	Local		Regional		International
	Bomi County				
Impact Scale	30 Kilometres out from Telecommunication Tower Point/UNMIL point				
Frequency	Throughout duration of mining				
Impact	Positive	Negligible	Small	Medium	Large

Magnitude	The magnitude of change is small as only a few small buildings will be visible in the middle ground.			
	Low	Medium	High	
Receptor Sensitivity	Low sensitivity as not many people travel to top of Telecommunication Tower Point/UNMIL point			
	Negligible	Minor	Moderate	Major
Impact Significance	Impact significance is minor			

Table 21: Summary of Significance of Impact KOP2 (post closure)

Impact	Visual Impact at KOP2 15 Years After Closure				
	Negative	Positive	Neutral		
Impact Nature	Impact is positive in nature as the mine infrastructure will be demolished and the view will restore to close to baseline.				
	Direct	Indirect	Induced		
Impact Type	Impact is direct in nature				
	Temporary	Short-term	Long-term	Permanent	
Impact Duration	Duration is a permanent change				
	Local	Regional	International		
Impact Extent	Bomi County				
Impact Scale	30 Kilometres out from Telecommunication Tower Point/UNMIL point				
Frequency	Throughout duration of mining				
	Positive	Negligible	Small	Medium	Large
Impact Magnitude	The magnitude of change is small as the mining infrastructure will be demolished.				
	Low	Medium	High		
Receptor Sensitivity	Low sensitivity as not many people travel to top of Telecommunication Tower Point/UNMIL point				
	Negligible	Minor	Moderate	Major	
Impact Significance	Impact significance is minor				

Table 22: Summary of Significance of Impact KOP3

Impact	Visual Impact at KOP3 After 19 Years				
Impact Nature	Negative		Positive		Neutral
	Impact is negative in nature				
Impact Type	Direct		Indirect		Induced
	Impact is direct in nature				
Impact Duration	Temporary	Short-term		Long-term	Permanent
	Long term for the duration of project				
Impact Extent	Local		Regional		International
	Bomi County				
Impact Scale	30 Kilometres out from Telecommunication Tower Point/UNMIL point				
Frequency	Throughout duration of mining				
Impact Magnitude	Positive	Negligible	Small	Medium	Large
	The magnitude of change is large				
Receptor Sensitivity	Low		Medium		High
	Low sensitivity as not many people travel to top of Telecommunication Tower Point/UNMIL point				
Impact Significance	Negligible	Minor		Moderate	Major
	Impact significance is moderate				

Table 23: Summary of Significance of Impact KOP3 (post closure)

Impact	Visual Impact at KOP3 15 Years After Closure				
Impact Nature	Negative	**Positive**	Neutral		
	Impact is positive in nature as the pit starts to fill with water.				
Impact Type	**Direct**	Indirect	Induced		
	Impact is direct in nature				
Impact Duration	Temporary	Short-term	Long-term	**Permanent**	
	Duration is a permanent change				
Impact Extent	**Local**	Regional	International		
	Bomi County				
Impact Scale	30 Kilometres out from Telecommunication Tower Point/UNMIL point				
Frequency	Once				
Impact Magnitude	Positive	Negligible	Small	Medium	**Large**
	The magnitude of change is large				
Receptor Sensitivity	**Low**	Medium	High		
	Low sensitivity as not many people travel to top of Telecommunication Tower Point/UNMIL point				
Impact Significance	Negligible	Minor	**Moderate**		Major
	Impact significance is moderate				

Mitigation Measures and Residual Impacts

A range of embedded controls within the Bomi Hills Mine project design have been taken into account in the impact assessment. These measures will help minimize the landscape and visual impacts of the construction and operation activities and where appropriate will be encompassed in the Land Rehabilitation Plan. These measures will be designed to:

- keep the area of vegetation required to be cleared during construction to the minimum area necessary;

- ensure construction work areas are maintained in a clean and tidy condition by good housekeeping;
- prevent encroachment into areas outside designated work areas to avoid damage to landscape resources;
- keep the lighting of construction and operational sites to the minimum necessary for safety and security, and minimize light spill outside of the immediate work area, and particularly into the night sky, including keeping lighting downward facing where ever possible;
- ensure where lighting is required, low level bollard lighting is used on roads and conveyors where possible;
- rehabilitate areas used only temporarily during construction as soon as possible after completion of the works;
- fencing, earthworks and screen planting (trees and shrubs) will be used to reduce visual intrusion on nearby settlements; and
- ensure waste emplacements will be designed as a safe and stable landform and take into account the surrounding landscape.

During the operational phase of the Project, the Land Rehabilitation Plan will continue to apply to ensure that:

- temporary work areas are successfully rehabilitated;
- landscape planting continues to provide screening where required; and
- working areas and operational facilities are kept tidy and clear of clutter.

It is assumed that embedded controls will be used for the color of finishes for buildings and structures, will be of visually appealing colors. Light and primary colors will be avoided where possible and in addition to these physical measures, stakeholders will be engaged to understand their concerns and aspirations for the landscape, so that these can be responded to in a fair and equitable way. During development of the Land Rehabilitation Plan key stakeholders, including government agencies and representatives of impacted communities, will be consulted and their comments incorporated into planning where feasible. It will also involve consulting on specific measures to minimize impacts on visual amenity such as landscape planting and earthworks appropriate to the character of the local landscape, and supporting planning of village development to enable communities to benefit from the Project.

Where significant adverse impacts cannot be avoided or reduced to a level acceptable to the affected communities, the scope for further landscape and visual resource mitigation measures beyond those listed

above is limited. The Project will continue to give careful attention to the fit of the mined landform with the surrounding landscape and consult with stakeholders to ensure their opinions are taken into account, wherever feasible. A strong positive visual association will emerge in the local communities, between the benefits of these programs (for example in economic development, health, education, agriculture, and promotion of cultural events) and the visible operation of the mining, including in some cases the significant adverse landscape and visual impacts.

Residual Impacts

The following table summarizes the significance of landscape and visual impacts before and after mitigation and identifies key mitigation measures.

Table 24: Summary of Impacts

Description of Impact	Evaluation Prior to Mitigation	Key Mitigation	Residual Impact
KOP1: 0-19 Years Mining will be visible and dominate the foreground and middle ground. A waste rock dump will be visible in the middle ground.	Moderate	None	Negative Moderate
KOP1: 19 Years to 15 After Closure The mined pit will gradually fill after closure to the same level as the baseline water line. Waste rock dump will be visible in the middle ground	Moderate	None (Embedded controls only - The waste rock dump will be rehabilitated and blend in to the middle ground. Lake will fill naturally.)	Positive Moderate
KOP2: 0-19 Years	Minor/Not Significant	None (embedded building colour controls only)	Minor/Not Significant
KOP2: 19 Years to 15 After Closure	Minor/Not Significant	None (Embedded controls only – The mining infrastructure will be demolished and land	Minor/Not Significant

		rehabilitated))	
KOP3: 0-19 Years	Moderate	None	Negative Moderate
KOP3: 19 Years to 15 After Closure	Moderate	None (Lake will fill naturally)	Positive Moderate

As seen in Table 24, there will be positive moderate changes from KOP1 and KOP3 given existing embedded controls. After the lake fills naturally to the existing baseline water level, at post-closure the residual impact will be moderate but positive. At KOP3, there will be only minor/not-significant residual impacts post-closure the mining infrastructure will be demolished and the land rehabilitated.

14. AIR QUALITY

This Chapter presents a summary of the baseline and Impact Assessment of the Air Quality Study for the proposed Bomi Hills Mine.

19.4 Assessment Methodology

Impact assessment methodology is outlined in *Annex A14.* The specific steps followed are outlined in the next sections:

18.2.1 Description of the site and atmospheric environment

Physical environmental parameters like terrain, land cover and meteorology influence the dispersion of pollutants in the atmosphere.

Readily available terrain and land cover data was obtained from the Atmospheric Studies Group (ASG) via the United States Geological Survey (USGS) web site at (ASG, 2011[11]). Shuttle Radar Topography Mission (SRTM) (90 m, 3 arcsec) data and Global Land Cover Characterization (GLCC) data for Africa were also used.

An understanding of the atmospheric dispersion potential of the area is essential for assessment of air quality impact. In the absence of measured hourly sequential surface meteorological data (that is required for atmospheric dispersion modelling), on-site modelled MM5[12] meteorological data was referred to. MM5 data for the period January to December 2011 on a 12 km horizontal resolution for a 150 km by 150 km area was prepared for the analysis.

18.2.2 Establish baseline ambient air quality

During the initial ESIA, a three (3) month baseline air quality monitoring was carried out from December 2012 for the purpose of establishing the existing ambient air quality at Bomi Hills. This is standard practice as described in the methodology in *Annex A14*. The baseline air quality monitoring campaign included sampling of dustfall, PM10 and SO2/NO2.

18.2.3 Development of an Emissions Inventory

The establishment of a comprehensive emission inventory formed the basis for the assessment of the air quality impacts from the proposed operations emissions on the receiving environment.

[11] ASG. (2011, January 20). Air Quality Modelling Data Sets: The Atmospheric Studies Group at TRC. Retrieved September 11, 2012, from The Atmospheric Studies Group at TRC: http://www.src.com

[12] MM5 is an acronym for the Fifth-Generation NCAR/Penn State Mesoscale Model

All technical information on Bomi Hills Mine applied in the emissions inventory was taken from the *Feasibility Report on Development of Iron Ore Mines with Associated Facilities at Bomi Hills.* Where information gaps exist, assumptions were made. These are clearly indicated in the detailed emissions inventory of *Annex 14-A*.

In the quantification of fugitive dust, vehicle exhaust and power plant emissions, emission factors were used to associate the quantity of a pollutant to the activity associated with the release of that pollutant. Emissions were calculated using a comprehensive set of emission factors and equations, published by the US EPA and Australian National Pollutant Inventory (NPI).

18.2.4 Atmospheric Dispersion Modelling

In the calculation of ambient air pollutant concentrations and dustfall rates, US EPA AERMOD atmospheric dispersion modelling suite was used. AERMOD is a Gaussian plume model best used for near-field applications where the steady-state meteorology assumption is most likely to apply. AERMOD is a model developed with the support of the AMS/EPA Regulatory Model Improvement Committee (AERMIC), whose objective has been to include state-of the-art science in regulatory models[13]. AERMOD is a dispersion modelling system with three components, namely: AERMOD (AERMIC Dispersion Model), AERMAP (AERMOD terrain pre-processor), and AERMET (AERMOD meteorological pre-processor).

18.2.5 Management and Mitigation Measures

The findings of the above components revealed recommendations of air quality management measures, including mitigation and monitoring.

14.2 Receptor Sensitivity

Several communities, considered air quality sensitive receptors (AQSR) lie within a few kilometers3 from the proposed mining operations and are likely to be affected by air quality impacts associated with the mine. The locations of potential AQSR are shown in *Map 7-29.*

Ambient air quality guidelines are set to protect the health of an entire population. The sensitivity of the population is therefore taken into account when impacts at AQSR are assessed.

[13] Hanna, S. R., Egan, B. A., Purdum, J., & Wagler, J. (1999). Evaluation of ISC3, AERMOD, and ADMS Dispersion Models with Observations from Five Field Sites

14.3 Impact Assessment

Potential sources of atmospheric pollutants and air quality impacts that may arise during the construction and operational phases of Bomi Hills Mine have been identified and are presented in the following sections. For all the identified sources, atmospheric pollutants and air quality impacts have been evaluated and the impact significance has been determined considering the factors of the nature and magnitude of impacts and sensitivity of identified AQSR.

Embedded controls that were included in the assessment are:

- Tarpaulin covered product transport trucks;
- Water spraying on the haul roads,
- Dust control measures in the beneficiation plants, and
- Natural fugitive dust mitigation due to rainfall.

It should be noted that unplanned events were scoped out of this assessment.

14.3.1 Construction Phase - Impact on Health as a Result of Increased Ambient Air Pollutants

Source of Impacts

Atmospheric emissions and air quality impacts may occur during the construction phase of the project. The most significant sources of fugitive particulate matter (PM10 and PM2.5) include bulk earthworks, windblown dust from exposed surfaces, stockpiles and the construction of infrastructure such as the plant, administrative buildings, storage facilities and roads.

Particulate matter and gases from combustion of fuels in generators and by mobile equipment will also be emitted. Combustion emissions include PM_{10} and $PM_{2.5}$, CO, NOx, SO_2, PAH and VOCs such as formaldehyde.

Potential Consequence

Fugitive dust emissions from construction activities depend on the type of activity i.e. land clearing, building construction etc., the extent of the area being worked, the nature of materials used/affected by construction activities and the duration. A very high level of detail, including a construction schedule, is required for the accurate quantification of construction phase impacts. Because of the variable nature of dust generating construction activities, construction phase impacts on AQSRs are *qualitatively* described and assessed.

All the pollutants listed above have the potential to cause health impacts if inhaled at concentrations in exceedance of ambient air quality criteria.

Significance of Impacts

During the construction phase, the potential for impacts on human health as a result of PM10 emissions and associated ambient concentrations is considered the most significant. The impact significance is provided in *Table 25*.

Increased ambient PM10 concentrations as a result of construction phase activities are a *negative* impact that *directly* affects AQSR. Increased PM10 ambient concentrations will continue for a limited period and will cease at the end of the construction phase. The impact is therefore considered to be *short term*.

Exceedance of the most stringent air quality criteria i.e. the annual average WHO Guideline Value will in all likelihood extend across the operational project boundary affecting the closest AQSRs (*see Map 14-1*) assuming no mitigation measures are incorporated into the project. The extent of the impact would be considered to be *local*.

Communities to the north-east and north-northeast of the pit will be most affected by increased PM_{10} concentrations and the impact magnitude would be *medium.*

Receptor sensitivity is considered *medium*. It should be noted that ambient air quality criteria used in this assessment makes provision for the sensitivity of the population.

From the above impact magnitude and receptor sensitivity, the unmitigated impact significance is considered **moderate.** The next section discusses mitigation measures which will reduce this significance of impact.

Table 25 Construction phase –Potential health impact significance

Impact	Potential health impacts as a result of construction phase activities with specific reference to the potential impact of increased ambient PM10 concentrations.			
Impact Nature	Negative	Positive	Neutral	
	Impact on air quality is negative.			
Impact Type	Direct	Indirect	Induced	
	Impact on air quality is direct.			
Impact	Temporary	Short-term	Long-term	Permanent
	Impacts will continue for a limited period and cease at the end of the			

Duration	construction phase.				
Impact Extent	Local	Regional	International		
	Impacts on air quality are local to Bomi Hills mine and surrounding areas.				
Impact Scale	The scale of the impact is estimated to be restricted to the site and surrounding areas.				
Frequency	Till the completion of the construction phase.				
Impact	Positive	Negligible	Small	Medium	Large

Magnitude	The impact may affect some of the AQSR in the study area.			
Receptor Sensitivity	Low	Medium	High	
	The receptor sensitivity is considered as medium.			
Impact Significance	Negligible	Minor	Moderate	Major
	Significance of impact is considered to be **Moderate.**			

Mitigation Measures, Management and Monitoring

To reduce ambient PM10 concentrations at AQSR to levels that comply with WHO air quality criteria, the following mitigation measures will be deployed at sources of PM10 emissions during the construction phase:

- Damping of bulk earthworks areas;
- Dust suppression with water in combination with chemical suppressants if required to reduce dust generated by trucks traveling on haul roads;
- Water mist sprays or dampening at handling and conveyor transfer points wherever practicable; and
- Generators and diesel mobile equipment are maintained to reduce exhaust emissions.

To measure compliance with ambient air quality criteria during the construction phase the following mitigation measures will be deployed:

- Ambient PM10 monitoring:
  - **Location:** At one location downwind of Bomi Hills mine that is, along the northern boundary of the project between the mine and the closest AQSRs, either Todemai or Borbor.
  - **Procedure:** In accordance with the procedure used for baseline PM10 sampling (BS EN 12341) or other internationally recognized procedures.
  - **Duration:** During the entire duration of construction phase at three-**to-six-day** intervals.

Significance of Residual Impacts

With the abovementioned mitigation in place, the PM10 impact area is expected to decrease materially. Residual impacts will reduce to **minor.** For details regarding the effectiveness of proposed mitigation measures and its effect on emissions, refer to *Annex 14-A*, the detailed emissions inventory.

14.3.2 Construction Phase - Nuisance Impact as a Result of Increased Dustfall

Source of Impacts

As PM_{10} is a fraction of TSP, construction phase related sources of atmospheric PM_{10} emission will result in atmospheric TSP emissions. Whereas PM_{10} is conspired for its potential impact on health, TSP is considered for potential nuisance dust impacts.

Consequence of Impact

As for TSP construction phase nuisance dust fall impacts on AQSRs are *qualitatively* described and assessed.

Significance of Impacts

The significance of nuisance dust impacts is provided in *Table 26*.

Increased dustfall as a result of construction activities is a *negative* impact that *directly* affects AQSR. Increased dustfall will continue for limited period and will cease at the end of the construction phase. The impact is therefore considered to as *short term*. The extent of the impact will be *localized* and limited to immediate surroundings of construction areas.

Communities to the north-east and north-northeast of the pit will be most affected by increased dustfall. The impact affects a portion of the population in the study area and the impact magnitude therefore considered *medium.*

Since dustfall is assessed from a *nuisance* perspective receptor sensitivity is considered *low*.

Considering the impact magnitude and receptor sensitivity, the impact significance is considered **minor.**

Table 26: Construction phase –Potential nuisance dust impact significance

Impact	Potential nuisance dust impact as a result of construction phase		
Impact Nature	Negative	Positive	Neutral
	Impact on air quality is negative.		
Impact Type	Direct	Indirect	Induced

Impact Duration	Impact on air quality is direct.			
	Temporary	Short-term	Long-term	Permanent
	Impacts will continue for the duration of construction activities.			
Impact Extent	Local	Regional	International	
	Impacts on air quality are local to Bomi Hills mine and surrounding areas.			
Impact Scale	The scale of the impact is estimated to be restricted to the site and surrounding areas.			
Frequency	till the completion of the construction activities.			
Impact Magnitude	Positive	Negligible	Small	Medium	Large
	The impact may affect some of the AQSR in the study area.			
Receptor Sensitivity	Low	Medium	High	
	The receptor sensitivity is considered as low.			
Impact Significance	Negligible	Minor	Moderate	Major
	Significance of impact is considered to be **Minor.**			

Mitigation Measures, Management and Monitoring

Mitigation measures recommended for the mitigation of PM10 emissions during the construction phase will similarly reduce TSP emissions and associated dustfall impacts. These include:

- Damping of bulk earthworks areas;
- Dust suppression with water in combination with chemical suppressants if required to reduce dust generated by trucks traveling on haul roads;
- Water mist sprays or dampening at handling and conveyor transfer points wherever practicable; and
- Generators and diesel mobile equipment are maintained to reduce exhaust emissions.

To measure compliance with dustfall criteria during the construction phase the following is recommended:

- Dustfall sampling:
    - **Location:** At four locations (north, east, south and west) on the project boundary.
    - **Procedure:** In accordance with the procedure used for baseline dustfall sampling (ASTM D1739-98).
    - **Duration:** During the entire duration of construction phase at 30 day intervals as specified in ASTM D1739-98.

Significance of Residual Impacts

With the abovementioned mitigation in place, the nuisance dustfall impact area is expected to decrease materially. For details regarding the effectiveness of proposed mitigation measures and its effect on emissions, refer to *Annex 14-A*, the detailed emissions inventory.

Based on the methodology followed in the assessment of impact significance, residual impacts will reduce to **negligible.**

14.3.3 Operational Phase - Impact on Health as a Result of Increased Ambient Air Pollutants

Source of Impacts

Atmospheric emissions and air quality impacts may occur during the operational phases of the mining cycle. The most significant sources of particulate matter (PM_{10} and $PM_{2.5}$) include drilling, blasting, bulk earthworks, windblown dust from exposed surfaces such as tailings facilities, stockpiles, waste dumps and hauls roads.

Particulate matter and gases from combustion of fuels at the Power Plant and by mobile equipment are also considered. Combustion emissions include PM_{10} and $PM_{2.5}$, CO, NOx, SO_2, PAH and VOCs such as All the pollutants listed above have the potential to cause health impacts if inhaled at concentrations in exceedance of ambient air quality criteria.

Potential Consequence

In order to determine the *potential consequence on AQSRs* it was necessary to quantify atmospheric emissions and predict ambient pollutant concentrations occurring as a result of such emissions.

A summary of estimated annual emission rates (determined from project information and by applying US EPA and Australian NPI emission factors) of pollutants with the potential to have an impact on human health is provided in Table 27 (Estimated Annual Emission Rates of Pollutants with the Potential to have an Impact on Health). The contribution of the various sources of atmospheric emission to total emissions is visually presented in *Figure 3.* The detailed emissions inventory for the operational phase of the mine is provided in *Annex 14-A*.

Table 27: Operational Phase –Estimated annual emission rates of pollutants with the potential to have an impact on health

Pollutant	Annual Emission Rate in tonnes/annum (t/a)
PM_{10}	1 788
$PM_{2.5}$	261
CO	2 173
Formaldehyde	31.3
NO_x	5 601
PAH	0.063
SO_2	3 127
VOC	324

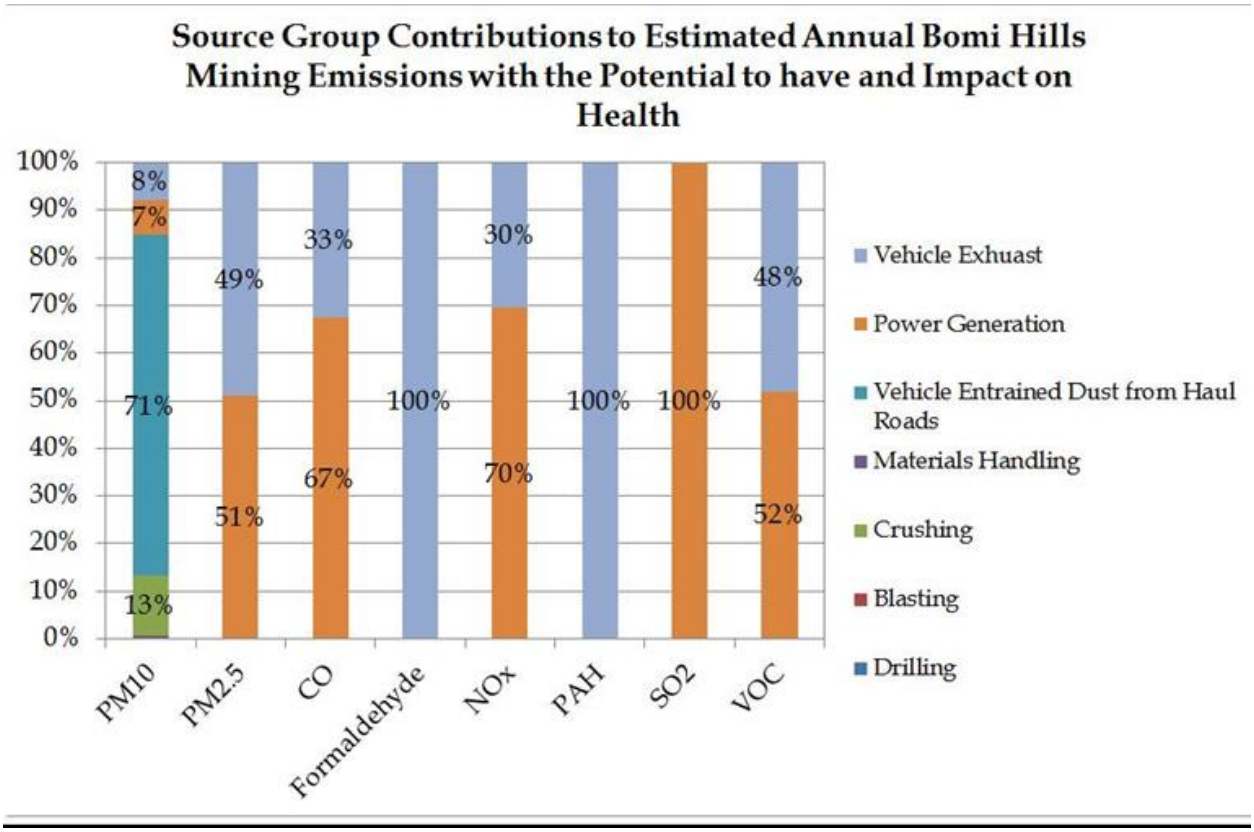


Figure 3: 1 Operational Phase –Source group contributions to estimated emissions with the potential to have an impact on health

The emissions inventory established for the operational phase was used to populate AERMOD, the atmospheric dispersion model used in the assessment. AERMOD was applied to simulate ambient air pollutant concentrations over the study area at a grid resolution of 200 m and at AQSR.

Predicted ambient air quality concentrations at AQSR were compared to air quality criteria and exceedances flagged as a potential health impact. Of the pollutants considered for potential health impacts, PM10 impacts were found to be most significant, with exceedances of air quality criteria at AQSR. A more detailed description of the atmospheric dispersion model is provided in *Annex 14-B.*

Predicted annual average and 99th percentile 24-hour average PM10 concentrations as a result of Bomi Hills mining operations are presented in *Map 14-1* and *Map 14-2* respectively.

Significance of Impacts

During the operational phase, the potential for impacts on human health as a result of PM10 emissions and associated ambient concentrations is most significant. The impact significance is provided in Table 28.

Increased ambient PM10 concentrations as a result of Bomi Hills mining activities are a *negative* impact that *directly* affects AQSR. Increased PM10 ambient concentrations will continue for the life of the project but will cease at the end of the project life. The impact is therefore considered to be *long term*.

Exceedance of the most stringent air quality criteria i.e. the annual average WHO Guideline Value extends up to 4.5 km from mining activities. The extent of the impact is therefore considered to be *local*.

Communities to the north-east and north-northeast of the pit will be most affected by increased PM10 concentrations. The annual average WHO Interim Targets and the Guideline Value for PM10 are likely to be exceeded at several of the AQSR communities. The impact therefore affects a portion of the population in the study area. The impact magnitude is considered *medium.*

Receptor sensitivity is considered *medium*. It should be noted that ambient air quality criteria used in this assessment makes provision for the sensitivity of the population.

From the above impact magnitude and receptor sensitivity, the impact significance is considered **moderate.**

Table 28: Operational phase –Potential health impact significance

Impact	Potential health impacts as a result of operational phase mining activities with specific reference to the potential impact of increased ambient PM_{10} concentration.		
Impact Nature	Negative	Positive	Neutral
	Impact on air quality is negative.		
Impact Type	Direct	Indirect	Induced
	Impact on air quality is direct.		

Impact Duration	Temporary	Short-term	Long-term	Permanent
	Impacts will continue for the life of the project, but cease when the project stops operating.			
Impact Extent	Local	Regional	International	
	Impacts on air quality are local to Bomi Hills mine and surrounding AQSR, specifically Todemai, Borbor, the proposed township Area and the WCL Camp.			
Impact Scale	The scale of the impact is estimated to be restricted to the site and surrounding areas.			
Frequency	Throughout the life time of project.			
Impact Magnitude	Positive	Negligible	Small	Medium	Large
	The impact will affect some of the AQSR in the study area.			
Receptor Sensitivity	Low	Medium	High	
	The receptor sensitivity is considered as medium.			
Impact Significance	Negligible	Minor	Moderate	Major
	Significance of impact is considered to be **Moderate.**			

Mitigation Measures, Management and Monitoring

To reduce ambient PM10 concentrations at AQSR to levels that comply with WHO air quality criteria, the following mitigation measures must be considered at sources of PM10 emissions:

- Wet drilling/Water mist sprays at drill rigs to suppress dust;
- Crushers;
    - Water mist sprays to suppress dust; or
    - Enclosure with dust extraction.
- Dust suppression with water in combination with chemical suppressants if required to reduce dust generated by trucks traveling on haul roads;
- Water mist sprays or dampening at handling and conveyor transfer points where practicable;
- Suppliers of the power generation plant must guarantee that IFC emission limits will be met; and
- The power generation plant and diesel mobile equipment must be well maintained and serviced at regular intervals to reduce exhaust emissions.

To measure compliance with ambient PM10 air quality criteria during the operational phase the following is recommended:

- Ambient PM10 monitoring:

- **Location:** At one location downwind of Bomi Hills mining operations that is, along the northern boundary of the project between the mine and the closest AQSRs, either Todemai or Borbor.
- **Procedure:** In accordance with the procedure used for baseline PM10 sampling (BS EN 12341) or other internationally recognized procedures.
- **Duration:** 3 months in a year during dry season campaigns at three-to-six-day intervals.

Significance of Residual Impacts

With the above-mentioned mitigation in place, the PM10 impact area is predicted to decrease materially (*Map 14-3* and *Map 14-4*). For details regarding the effectiveness of proposed mitigation measures and its effect on emissions, refer to *Annex 14-A*.

Based on the methodology followed in the assessment of impact significance, residual impacts, however, remains at **moderate**.

Operational Phase - Nuisance Impact as a Result of Increased Dustfall

Source of Impacts

As PM10 is a fraction of TSP, the same sources of atmospheric PM10 emission result in atmospheric TSP emissions i.e. drilling, blasting, bulk earthworks, windblown dust from exposed surfaces such as tailings facilities, stockpiles and waste dumps and hauls roads. Whereas PM10 is considered for its potential impact on health, TSP is considered for potential nuisance dust impacts.

Potential Consequence

In order to determine the potential consequence of dustfall on AQSRs it was necessary to quantify atmospheric TSP emissions and predict dustfall rates occurring as a result of such emissions. A summary of estimated annual TSP emission rates (determined similarly to PM10 emissions). *The* contribution of the various sources of atmospheric emission to the total TSP emission rate is visually presented in *Figure 4*.

Estimated Annual Unmitigated TSP Emission Rate with the Potential to Cause Nuisance Dust Impacts

Pollutant	**Annual Emission Rate in tonnes/annum (t/a)**
TSP	5 241

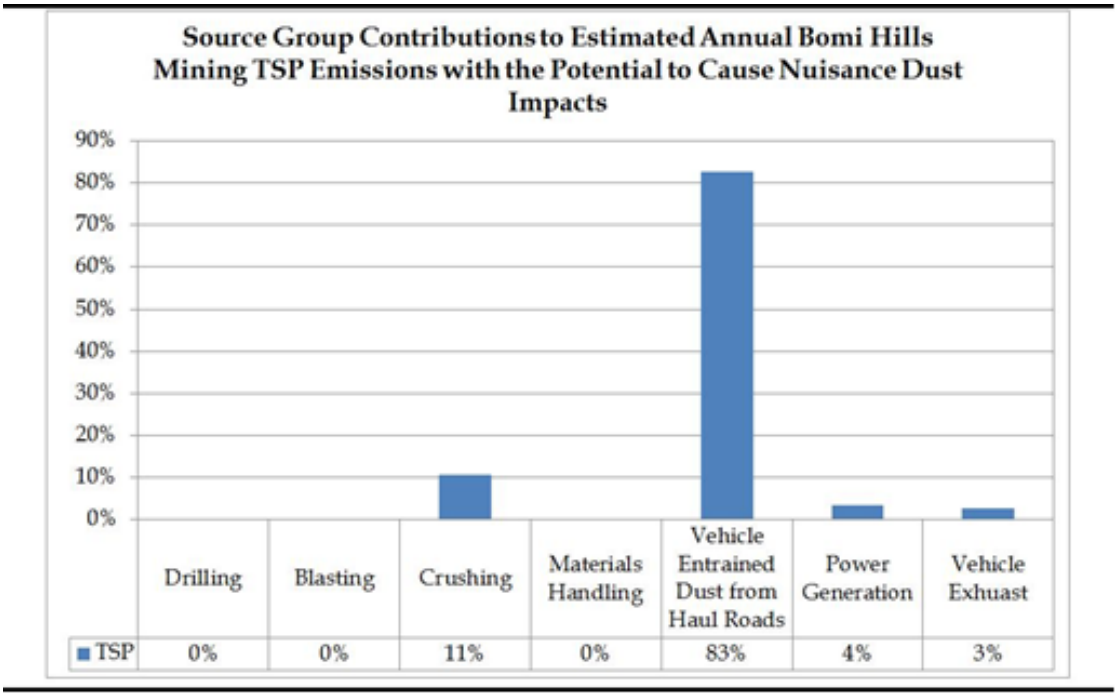


Figure 4: Operational Phase –Source group contributions to estimated emissions with the potential to have nuisance dust impact

Significance of Impacts

The significance of nuisance dust impacts is provided in *Table 29*.

Increased dustfall as a result of Bomi Hills mining activities is a *negative* impact that *directly* affects AQSR. Increased dustfall will continue for the life of the project but will cease at the end of the project life. The impact is therefore considered to be *long term.*

Exceedance of the South African draft dustfall guideline for residential areas extends up to 2 km north of mining activities. The extent of the impact is therefore considered to be *local*.

Communities to the north-east and north-northeast of the pit will be most affected by increased dustfall. The impact affects a portion of the population in the study area and the impact magnitude therefore considered *medium.*

Since dustfall is assessed from a *nuisance* perspective receptor sensitivity is considered *low*.

From the above impact magnitude and receptor sensitivity, the impact significance is considered **minor**.

Table 29: Operational phase –Potential nuisance dust impact significance

Impact	Potential nuisance dust impact as a result of operational phase mining activities.			
Impact Nature	Negative	Positive	Neutral	
	Impact on air quality is negative.			
Impact Type	Direct	Indirect	Induced	
	Impact on air quality is direct.			
Impact Duration	Temporary	Short-term	Long-term	Permanent
	Impacts will continue for the life of the project, but cease when the project stops operating.			
Impact Extent	Local	Regional	International	
	Impacts on air quality are local to Bomi Hills mine and surrounding areas.			
Impact Scale	The scale of the impact is estimated to be restricted to the site and surrounding areas.			
Frequency	Throughout the life time of project.			
Impact Magnitude	Positive	Negligible	Small	Medium	Large
	The impact will affect some of the AQSR in the study area.			
Receptor Sensitivity	Low	Medium	High	
	The receptor sensitivity is considered as low.			
Impact Significance	Negligible	Minor	Moderate	Major
	Significance of impact is considered to be **Minor.**			

Mitigation Measures, Management and Monitoring

Mitigation measures recommended for the mitigation of PM10 emissions will similarly reduce TSP emissions and associated dustfall impacts. These include:

- Wet drilling/Water mist sprays at drill rigs to supress dust;
- Crushers;
    - Water mist sprays to supress dust; or
    - Enclosure with dust extraction.
- Dust suppression with water in combination with chemical suppressants if required to reduce dust generated by trucks traveling on haul roads;
- Water mist sprays or dampening at handling and conveyor transfer points where practicable;

To measure compliance with dustfall criteria the following is recommended:

- Dustfall sampling:
    - **Location:** At four locations (north, east, south and west) on the project boundary among them one being at the primary crusher and adjacent any one of the haul roads.
    - **Procedure:** In accordance with the procedure used for baseline dustfall sampling (ASTM D1739-98).
    - **Duration:** During the entire life of mine at 30 day intervals as specified in ASTM D1739-98.

Significance of Residual Impacts

With the abovementioned mitigation in place, the nuisance dustfall impact area is predicted to decrease materially (*Map 14-6*). For details regarding the effectiveness of proposed mitigation measures and its effect on emissions, refer to *Annex 14-A*.

Based on the methodology followed in the assessment of impact significance, residual impacts however remain **minor**.

Summary

From an air quality perspective, the potential for human health impacts associated with particulate matter emissions from Bomi Hills Mine and associated ground level concentrations, specifically PM10, are considered most significant.

The significance of the impact of construction phase activities on human health as a result of increased PM10 emissions and ambient concentrations is considered as *minor*. Efficient air quality management and mitigation measures will result in *negligible* residual impacts.

The significance of the impact of operational phase activities on human health as a result of increased PM10 emissions and ambient concentrations is considered as *moderate*. Although efficient air quality management and mitigation measures will materially decrease in impact area, residual impacts remain *moderate*. It is therefore, essential that management measures be implemented diligently.

15 CLIMATE CHANGE

Climate change, and the associated political and social response, is already presenting material risks and opportunities to business and industrial sectors. These risks and opportunities have grown in prominence over the last decade and are expected to increase significantly in scale and coverage in near future. *Annex 15-A* provides more detail about the climate change challenge at a global scale.

Governments in most countries are proposing and implementing legislation to mitigate greenhouse gas emissions such as carbon taxes, emission limits etc., and the cost of business interruption following extreme weather events is increasing the need for implementation of adaptation measures. In this context, forward thinking business and governments are beginning to identify their exposure to climate change issues, understand the financial implications and develop mitigation strategies and adaptation response plans in order to 'climate ready' their operations going forward.

Vedanta's Sustainability Framework contains 8 policies (including an Energy and Carbon Policy), which are supported by 34 Management and Technical Standards. The Technical Standard on Environmental Management outlines the requirements in order to avoid or minimize adverse impacts on the environment and human health from Vedanta operations. The requirements are to be followed by all Vedanta subsidiary companies and operations. All programs are to meet the requirements of the IFC Performance Standards and IFC EHS and Mining Sector Guidelines.

Impact Assessment

The estimated operational carbon footprint for the WCL Bomi Hills Mine is shown in Table 30.

Table 30: WCL estimated operational carbon footprint

Emission Source	Annual Emissions (tCO_2e)	LOM Total Emissions (tCO_2e)	Percentage of Total Emissions
Mobile Combustion	81 252	1 454 415	23.33%
Stationary Combustion	264 427	4 733 241	75.93%
Non-Combustion	1 739	31 120	0.50%
Explosives	831	14 866	0.24%
Total CO_2e Emissions	348 248.17	6 233 642	100.00%

Benchmark against international Iron Ore facilities

Liberia, as compared to other countries who have signed onto the United Nations Framework Convention on Climate Change (UNFCCC), has published a national GHG emissions inventory to the UNFCCC. The

recent publicly available data on Liberia's national GHG emissions is published by the European Commission[14] and is for the year 2024 (Table 31) and Liberia accounts for 0.01% of global emission.

Table 31: GHG Emissions of Liberia

Year	1990	2000	2005	2015	2020	2022	2023	2023%
Country	**Mton CO2eq**	**Mton CO2eq**	**Mton CO2eq**	**Mton CO2eq**	**Mton CO2eq**	**Mton CO2eq**	**Mton CO2eq**	**% World Tot**
Liberia	1.71	2.09	2.6	3.87	4.36	4.56	4.53	0.01

Benchmarking emissions intensity of the WCL project against other Iron Ore projects provides a measure of its performance against the industry average. The production capacity of WCL is expected to be 10 Mtpa of iron ore per year of full operation (i.e. for 2015 - 2031). With an estimated carbon footprint of 348 248 tCO_2e at full production, the carbon intensity at the WCL Project is equivalent to 0.09 tCO_2e/tonne iron ore. This is the third lowest when compared with the intensity of other iron projects under operation around the world as illustrated in *Figure 5 (All calculations are based on Scope 1 & 2 emissions obtained from publicly available sources)*.

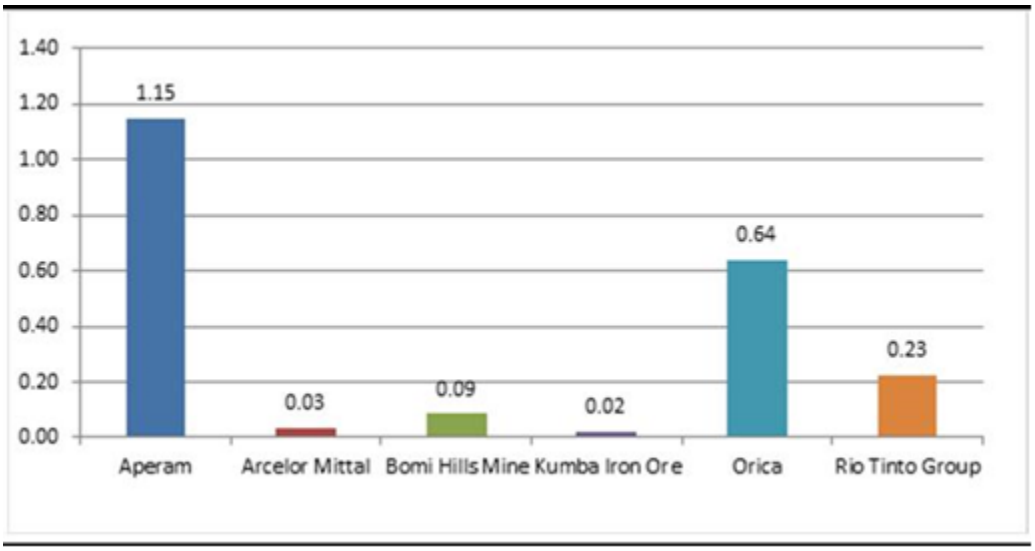


Figure 5: Emissions Intensity of WCL and other Iron Ore Projects (tCO2e/tonne)

Recommendations for Potential Emission Reduction Actions

Given its global nature, mitigation of the impact of climate change takes the form of reducing the concentration of greenhouse gases in the atmosphere. The WCL Project has an opportunity to reduce their

[14] EDGAR - Emissions Database for Global Atmospheric Research, 2024

GHG emissions by ensuring that the final design includes the most energy efficient and low emissions options available.

This section identifies a number of operational areas where best practice options can be considered by the WCL Project in order to improve energy efficiency and/or emissions intensity of its activities in Liberia and thereby reduce Scope 1, 2 and 3 emissions. These operational areas include:

- Stationary combustion, i.e. energy production;
- Energy Efficiency and Renewable Energy;
- Transport;
- Waste management;
- Business travel; and
- Reduced Deforestation and/or Offsets.

Given the early stage in the design of the project, it was not possible to accurately estimate the abatement potential of each option. These activities will, however, contribute towards the sustainability of the project, reducing the greenhouse gas emissions, and reducing costs (e.g. fuel use for energy generation).

Mitigation Initiatives and Technologies

Stationary Combustion –Alternative sources of energy

A significant source of CO2e emissions that contributes to the carbon footprint is intensive use of generators for power generation. Power generation through HFO is a carbon intensive activity. Alternative sources of energy produced from renewable energy sources, or a mix thereof, should be considered:

(1) **Gas:** More facilities in the mining industry are using gas as a source of fuel. This is because Natural Gas and Liquid Petroleum Gas (LPG) have lower carbon content than HFO. Transmission links between Cote d'Ivoire, Liberia, Sierra Leone significant and Guin offshore exploration blocks which could lead to local gas being procured.

(2) **Biofuels:** The country is endowed with considerable biomass resources. Biofuels includes both biodiesel and ethanol fuels which will greatly reduce the CO2e emissions. Biodiesel-diesel fuel mixes can be used in most diesel generators in a mix that includes up to 20 percent biodiesel without having to modify the engines (NREL 2009)[15]. This opportunity will require further

[15][15]National Renewable Energy Laboratory (NREL), 2009, Available from: http://www.nrel.gov/vehiclesandfuels/pdfs/43672.pdf

investigation into the specific impact(s) and the feasibility to the specific operation. The importance of performing a detailed assessment on biofuels cannot be underestimated as biofuels can potentially have a greater negative impact on the environment than alternative energy sources when taking the full life cycle into consideration.

(3) **Hydropower:** Liberia has an economic hydro-electric potential of around 1 000 MW through six major rivers, which drain over 60 percent of the country's intensive water drainage. This pattern indicates considerable potential for hydro-electric power in Liberia.

(4) **Solar photovoltaic:** As part of the energy system, solar photovoltaics can take some of the pressure off of the carbon intensive power generation. Solar power can be applied to offices, accommodation and other buildings.

Energy Efficiency and Renewable Energy

The majority of emissions linked to offices and accommodation are associated with energy use; by building well insulated buildings which utilise renewable energy and efficient cooling systems, the carbon footprint associated with these activities will be reduced as will the cost of fuel and energy. There are a number of initiatives which can be implemented when constructing the camps and offices which will help reduce energy consumption and GHG emissions. Whilst the majority of these initiatives may not significantly reduce the overall carbon footprint, they would improve the efficiency of the buildings. Initiatives include:

- **Solar power -** significant reductions in fuel costs and energy use from offices, accommodation and other buildings can be expected if hot water is heated by solar water heaters and photovoltaic panels that can supplement fossil fuel generated energy.
- **Insulation** –well insulated walls and ceilings will reduce temperature extremes within the buildings leading to more comfortable living/ working conditions and reduced air conditioning requirements.
- **Lighting** –use of natural light where possible and compact fluorescent or LED lighting throughout the site will reduce energy consumption;
- Buildings (particularly offices) should be fitted with sensors, timers and **control systems** which allow lights and equipment to switch off or go onto stand by when not in use (e.g. overnight).

- **Metering and Submetering -** Installation of meters and sub meters for internal energy use monitoring and management. This will allow the identification of energy consumption and energy reduction opportunities which will in turn result in emission and monetary savings. For an administration building this may include: chillers, air handling units (AHUs), lighting and parking areas.
- **Training and awareness** for behaviour change could result in decreased consumption (e.g. switching off lights/geysers).

Transport

Diesel trucks and mining vehicles are expected to emit a high level of CO2e emissions during the operations phase. There are several efforts that could be made to minimize the emissions:

- **Optimisation of transport logistics** (e.g. equipment, products and people) and the use of energy efficient vehicles and machinery will reduce fuel consumption and therefore GHG emissions.
- **Institute fuel efficient driving rules** such as to avoid idling, drive at reduced speeds, avoid excessive breaking. This should be enforced through driving training and health and safety awareness.
- **Fuel Additives and Catalysts for Fuel Savings -** many diesel fuel additives are able to significantly reduce hydro carbons (HC), carbon monoxide (CO), oxides of nitrogen (NOx) and particulate matter (PM). This reduction is due to an increase in complete combustion. Oxides of nitrogen can be reduced by 10-45 percent, and PM can be decreased by 30-70 percent.

In the near future there is potential for biofuels to be readily available (Booyens 2012 [(1)]). For vehicles, biofuel mixing should be considered to reduce CO2e emissions. Many vehicle systems are able to run on lower mix-ratios without having to convert the engine. This includes B5, B10 or B20 grades of biodiesel fuel mixtures (NREL, 2009) and up to E20 grades of ethanol-petrol mixtures (DOE, 2008 [(2)]).

Waste Management

A waste management system should be established to minimize waste. Considerations should include reducing all types of waste and recycling/reusing waste. Unavoidable carbon-based solid wastes should be treated in a thermal oxidiser (incinerator) and/or utility boilers.

Possible options for the treatment of waste water (sewage) from the site include:

- Standard treatment and reuse of waste water for industrial purposes, and solids being disposed of at sea or used as compost; and
- Organic rich waste can be filtered through man-made mangroves to clean the water naturally and to sequester carbon deep within the mangrove root systems and soil and thus acting as a carbon sink.

Business Travel

Face to face meetings are an integral part to most businesses; however, unnecessary travel can be minimized to save on time and carbon emissions. A travel policy should be instituted to encourage technological alternatives like video conferencing, teleconferencing and web-based meetings.

Reduced Deforestation and/or Offsets

Land clearance in advance of construction of the facility can be offset by progressive rehabilitation of unused land on site as well as a 'biodiversity offset' elsewhere in the region which will could act as a carbon sink and offset some, if not more than the emissions from land clearance. Whilst not contributing to a reduction in WCL's direct carbon footprint, it supports national efforts to reduce deforestation and to improve air quality and living standards in rural communities. However, the expected benefits of such projects can easily be outweighed by technical challenges and transaction costs, such as the costs of measuring initial carbon stocks, monitoring technology, associated skills and labour requirements, and verification of additionality of the proposed project at national level.

Recommendations for mitigation

Recommendations regarding the WCL Project include the following:

- Consider alternative sources of fuel for energy production;
- Consider effective driving and vehicle use to optimize transport as well as heavy (mining) vehicle use;
- Consider minimizing business travel;
- Optimize transport logistics;
- Incorporate 'green building' features in the design of offices and accommodation;
- Consider alternative energy technologies for electricity supply; and
- Consider the development of a waste to energy plant for non-hazardous, carbon-based waste.

16. NOISES

This Chapter presents an assessment of potential noise impacts during the construction and operation of the Bomi Hills Mine.

16.1 Scope of Assessment

This Chapter provides:

- A description of the site from an environmental noise perspective including a description of meteorological conditions governing noise propagation through the atmosphere;
- A description of existing environmental noise levels based on the results of the sampling campaign conducted in October 2012 in comparison with guidelines;
- The identification of noise sources and quantification of associated sound levels (noise 'emissions');
- Noise propagation modelling to determine cumulative environmental noise levels and the increase in day-and night-time noise levels as a result of proposed Bomi Hills mines operations in comparison to guidelines; and
- The recommendation of suitable noise management and mitigation measures.

16.2 Impact Assessment

Potential sources of noise associated with the construction and operational phases of Bomi Hills Mine have been identified and are presented in the following sections. Identified noise sources and associated noise impacts have been evaluated and the impact significance determined considering the nature and magnitude of impacts and sensitivity of identified NSR.

It should be noted that no unplanned events were considered in the assessment.

For the Impact Assessment carried out in the following sections, the following embedded controls have been assumed:

- Majority of the construction activities are carried out during day-time hours
- Equipment/ Machinery used are supplied from reliable vendors who guarantee optimized equipment design noise levels.
- Re-locate noise sources to less sensitive areas to take advantage of distance and shielding.
- Site permanent facilities away from community areas where possible.
- Retain vegetation as far as feasibly possible

16.2.1 Nuisance Impact as a Result of Increased Environmental Noise Levels during the Construction Phase

Source of Impacts

- ✓ Sources of noise during the construction phase may include:
  - Bulk earthworks and the operation of diesel mobile equipment;
  - Blasting;
  - Construction material transport; and
  - Metal work.

The extent and character of construction phase noise will be highly variable as different activities with different equipment will take place at different times, over different periods, in different combinations, in different sequences and on different parts of the construction site. In the absence of a detailed construction schedule, the construction phase is assessed qualitatively.

Potential Consequence

Construction phase related sources listed above may increase environmental noise levels at NSRs and result in nuisance impacts.

Significance of Impacts

During the construction phase, the potential for nuisance noise impacts on NSRs is considered. The impact significance is provided in *Table 32*.

An increase in environmental noise levels as a result of construction phase activities is a *negative* impact that *directly* affects NSR. Increased noise levels will continue for a limited period and will cease at the end of the construction phase. The impact is therefore considered to be *short term*.

Since an increase of more than 3 dBA over ambient environmental noise levels is expected to be limited to the project area, the extent of the impact is considered *local* and the impact magnitude *small.*

In light of the fact that noise is considered from a nuisance perspective, receptor sensitivity is considered *low* during the day and *medium* during the night.

From the above impact magnitude and receptor sensitivity, the impact significance is considered between *negligible* and *minor*.

Table 32: Potential noise nuisance impact significance during construction

Impact	Potential nuisance noise impacts as a result of construction phase activities.				
Impact Nature	Negative		Positive		Neutral
	Impact on air quality is negative.				
Impact Type	Direct		Indirect		Induced
	Impact on air quality is direct.				
Impact Duration	Temporary	Short-term		Long-term	Permanent
	Impacts will continue for a limited period and cease at the end of the construction phase.				
Impact Extent	Local		Regional		International
	Impacts on air quality are local to Bomi Hills mine and surrounding communities.				
Impact Scale	The scale of the impact is estimated to be restricted to the site and surrounding areas.				
Frequency	Throughout the life time of project.				
Impact Magnitude	Positive	Negligible	Small	Medium	Large
	The impact will affect some of the AQSR in the study area.				
Receptor Sensitivity	Low during day-time		Medium during night-time		High
	The receptor sensitivity is considered as low to medium.				
Impact Significance	Negligible during day-time	Minor during night-time		Moderate	Major
	The significance of **day-time** impacts is considered **Negligible** The significance of **night-time** impacts is considered **Minor**				

Mitigation Measures, Management and Monitoring

Other general good practice noise management measures that should be considered include:

- ✓ All diesel-powered equipment must be regularly maintained and kept at a high level of maintenance. This must particularly include the regular inspection and, if necessary, replacement of intake and exhaust silencers. Any change in the noise emission characteristics of equipment must serve as trigger for withdrawing it for maintenance.
- ✓ Investigate the use of natural topography and or stockpiles a noise buffer.
- ✓ Develop a mechanism to record and respond to complaints.

Significance of Residual Impacts

With the above-mentioned measures in place residual impacts will be reduced to *negligible*.

16.2.2 Operational Phase

Source of Impacts

The following sources of noise were identified from the feasibility report:

- Diesel powered mining equipment;
- Power generation;
- Crushing, screening and milling;
- Beneficiation;
- Haul truck movements;
- Conveyor transfer, waste rock and ore handling; and
- Product transport truck movements.

Potential Consequence

In order to determine the *potential consequence on NSRs* it was necessary to quantify noise 'emissions'(sound power levels) and predict the increase in environmental noise levels as a result of the sources.

Sound power levels were estimated as follows:[16]

[16] SANS 10210. (2004). Calculating and Predicting Road Traffic Noise. Standards South Africa.

- ✓ For diesel powered mining equipment and power generation sources, sound power levels were estimated by applying predictive equations published in the Handbook of Acoustics by Crocker (1998);
- ✓ Crushing, screening, milling, beneficiation, conveyor transfer, waste rock and ore handling sound power levels were obtained from a comprehensive database compiled by Francois Malherbe Acoustic Consulting cc; and
- ✓ Noise from haul truck movements and product transport truck movements were determined in accordance with the methodology set out in SANS 10210 (2004) 'Calculating and Predicting. Road and traffic.

A detailed inventory of noise sources, estimated sound power levels and road traffic source parameters applied in the study are provided in *Table 33* and *Table 34* respectively. The noise inventory established for the operational phase was used to populate the noise propagation model. The model was applied to simulate environmental noise levels over the study area at a grid resolution of 250 m and at NSRs.

Predicted cumulative noise levels and the increase in noise level above the baseline over the study area and at NSRs were compared to IFC noise guidelines. An increase of 3 dBA is considered indicative that a nuisance noise impact may occur.

Predicted cumulative day-time noise levels are shown in *Map 16-1 (ERM baseline study, 2013)* and the increase in noise level above the baseline in *Map 16-2 (ERM, 2013)*. Bomi Hills Mine activities are not expected to result in an increase of more than 3 dBA at any of the NSRs in the study area and will therefore not result in cumulative noise levels that exceed the IFC day-time guideline. During the day, the maximum extent of the 3 dBA impact area is 1.2 km.

Predicted cumulative night-time noise levels are shown in *Map 16-3 (ERM, 2013)* and the increase in noise level above the baseline in *Map 16-4 (ERM, 2013)*. Baseline night-time noise levels in the area are already exceeding that of the IFC night-time guideline. An increase of more than 3 dBA may be expected at Borbor village which is situated to the east of the pit, between the pit and the eastern waste rock dump. The predicted increase of 3.9 dBA at Borbor village during the night may, according to SANS 10103 (2008), result in *'little'* community reaction and *'sporadic complaints*. During the night, the maximum extent of the 3 dBA impact area is 1.2 km.

Table 33: Noise inventory sound levels

Source Types[a]	Qty.[a]	SoundPower Levels (LW_i) at Octave Band Centre Frequencies in dB							A-weighted Sound Power Level (LW_A in dBA)
		63 Hz	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	
Drill Rigs (165 mm)[b]	5	111.8	116.8	119.8	114.8	112.8	109.8	103.8	**118.0**
Excavators (10 m^3) [b]	6	113.3	118.3	121.3	116.3	114.3	111.3	105.3	**119.6**
Ore Dump Trucks (135 tonnes) [b]	25	114.3	119.3	122.3	117.3	115.3	112.3	106.3	**120.6**
Waste Dump Trucks (135 tonnes) [b]	33	114.3	119.3	122.3	117.3	115.3	112.3	106.3	**120.6**
Dozers (410 HP) [b]	2	108.9	113.9	116.9	111.9	109.9	106.9	100.9	**115.1**
Dozers (646 HP) [b]	4	110.8	115.8	118.8	113.8	111.8	108.8	102.8	**117.1**
Wheeled Loader (7 m^3) [b]	3	110.2	115.2	118.2	113.2	111.2	108.2	102.2	**116.4**
Rock Breaker[b]	3	108.8	113.8	116.8	111.8	109.8	106.8	100.8	**115.0**
Power Generation Plant[b]	1	107.0	108.0	108.0	108.0	106.0	104.0	101.0	**111.1**
Primary Crusher[c]	1	115.5	115.1	113.8	112.4	109.7	107.4	102.7	**115.0**
Secondary Crusher[c]	1	103.4	107.4	110.0	111.8	111.2	109.5	105.2	**115.8**
Screening[c]	2	115.0	109.7	105.3	104.2	103.5	103.1	99.9	**109.1**
Mill[c]	2	106.9	108.2	109.3	106.8	106.2	101.1	97.2	**110.1**
General Noise[c]	1	95.0	100.0	103.0	105.0	105.0	100.0	100.0	**108.8**
Materials Handling[c]	18	80.0	90.0	98.8	97.6	100.7	101.4	95.4	**105.8**
Conveyor[c]	4	81.7	87.5	85.4	89.5	84.2	78.2	69.4	**89.3**

a) The list of equipment and quantities were extracted from the feasibility study for Bomi Hill Mine
b) Sound power levels quantified by applying predictive sound power level equations published by Crocker (1998)
c) Sound power levels obtained from Francois Malherbe Acoustic Consulting cc.

Table 34: Road traffic noise parameters

Traffic Types	Maximum no. of Vehicles per Hour	Assumed Average Vehicle Speed (km/h)
Haul Truck Traffic to Waste Dumps	36[a]	30
Haul Truck Traffic to Primary Crusher	17[a]	30
Product Transport Traffic	30[a]	30

a) Return trips calculated from average waste removal, ore mining and product export rates and truck capacities reported in the feasibility study.
b) The list of equipment and quantities were extracted from the feasibility study for Bomi Hill Mine.

Significance of Impacts

During the operational phase, the potential for nuisance noise impacts NSR is considered. The impact significance is provided in *Table 35*.

An increase in environmental noise levels as a result of the operational phase activities is a *negative* impact that *directly* affects NSRs. Increased noise levels will continue for the life of the project and will cease at the end of the mine's life. The impact is therefore considered to be *long term*.

Since an increase of more than 3 dBA is expected to be limited to the project area (within 1.2 km from operational areas), the extent of the impact is considered *local*.

The impact magnitude is considered *small*, in light of the fact that the 3 dBA impact guideline is only exceeded at one NSR and only during the night. Since noise is considered from a nuisance perspective, receptor sensitivity is considered *low* during the day and *medium* during the night.

From the above impact magnitude and receptor sensitivity, the impact significance is considered *minor* during the night and *negligible* during the day.

Table 35: Potential noise nuisance impact significance during operation

Impact	Potential nuisance noise impacts as a result of operational phase activities.				
Impact Nature	Negative		Positive		Neutral
	Impact on air quality is negative.				
Impact Type	Direct		Indirect		Induced
	Impact on air quality is direct.				
Impact Duration	Temporary	Short-term		Long-term	Permanent
	Impacts will continue for the life of the project.				
Impact Extent	Local		Regional		International
	Impacts on air quality are local to Bomi Hills mine and surrounding communities.				
Impact Scale	The scale of the impact is estimated to be restricted to the site and surrounding areas.				
Frequency	Throughout the life time of project.				
Impact Magnitude	Positive	Negligible	Small	Medium	Large
	The impact will affect some of the NSRs in the study area.				
Receptor Sensitivity	Low during day-time		Medium during night-time		High
	The receptor sensitivity is considered as low to medium.				
	Negligible	Minor during		Moderate	Major

Impact Significance	during day-time	night-time
	The significance of **day-time** impacts is considered **Negligible**	
	The significance of **night-time** impacts is considered **Minor**	

Mitigation Measures, Management and Monitoring

Apart from the embedded controls to be included in project design, the following mitigation measures will reduce the significance of noise during operations:

Good Practice

- ✓ All diesel-powered equipment must be regularly maintained and kept at a high level of maintenance. This must particularly include the regular inspection and, if necessary, replacement of intake and exhaust silencers. Any change in the noise emission characteristics of equipment must serve as trigger for withdrawing it for maintenance.
- ✓ Take advantage of the natural topography or stockpiles as a noise buffer.
- ✓ Develop a mechanism to record and respond to complaints.
- ✓ Retain vegetation as far as practically possible.

Blasting

Predicting the noise caused by blasting events is a highly complex and unreliable process. For this reason, it was not included in the impact assessment. Although not causing significant noise impacts, blasting at the surface will be audible over long distances and may cause a startling reaction at receptors in close proximity. This can be mitigated by adhering to blast schedules that have been communicated to affected parties (See *Chapter 16* for Blasting and Vibration mitigation measures).

Noise Monitoring

It is recommended that; periodic ambient noise measurements be conducted to assess and confirm the project's impact area. Periodic noise measurements can also serve to assess the efficiency of implemented management and mitigation measures aimed at reducing noise impacts.

The frequency of noise monitoring as well as the parameters that should be determined are summarized in *Table 16.5*. Specific attention should be paid to noise at Borbor village, the most likely affected NSR.

In addition to the measurement of sound pressure levels, the 3rd octave band frequency spectra should also be recorded. Frequency spectrum data can provide useful insight into the nature of recorded sound pressure levels and assist with distinguishing between potential sources of noise that contribute to noise levels at a certain location. Source noise measurements could be conducted to confirm equipment manufacturer sound power data and assumed sound power data used in the current study.

Table 36: Proposed monitoring plan

Parameters to be Measured[a]	**Frequency**
$L_{Aeq}(T^{(b)})$, during daytime hours (07:00 to 22:00)	One campaign a year
$L_{AIeq}(T^{(b)})$, during night-time hours (22:00 to 07:00)	
3rd Octave band frequency spectrum	

Notes:

a) Measurements should be conducted in accordance with IFC Guidelines (IFC, 2007).

b) Measurements duration should be selected so as to be representative of noise climate, typically between 20 minutes and an hour.

Significance of Residual Impacts

With the abovementioned measures in place residual impacts will be *negligible* during the day and *minor* during the night.

17. BLASTING AND VIBRATIONS

When mining starts at Bomi Hills, there will be numerous mining related disturbances that may impact on people and structures located in the vicinity of the operation. When blasts are set off, ground vibration and air blast disturbances occur. They however, diminish in intensity with an increase in distance. Fly rock, after blast fumes and dust will also occur.

To help manage this situation a systematic approach to the drill and blast operation needs to be adopted. This approach should initially assess the potential environmental impact of the drill and blast operation and then control and manage the day-to-day operations to ensure that the impacts are kept to acceptable levels. The aim of this assessment is to review the possible impact of the drill and blast operation and to provide guidelines to help ensure that the blasting process is correctly implemented so as to cause the lowest levels of disturbance.

17.1 SCOPE OF ASSESSMENT

The possible impact of the blasting operations on the surrounding neighbourhood is considered with an assessment of the disturbance levels that may be experienced at various distances from the mine. The preliminary work that should be carried out prior to the start of blasting is described below.

The following aspects of the blasting operation are assessed:

- ✓ Blast design and general safe blasting practice;
- ✓ Ground vibration,
- ✓ Air blast;
- ✓ Unwanted side effects such as fly rock, after blast fumes and dust;
- ✓ Pre blast surveys;
- ✓ Disturbance monitoring;
- ✓ Legal requirements; and
- ✓ Mitigation measures.

17.2 IMPACT ASSESSMENT

17.2.1 Impacts of Blasting

Source of Impacts

Explosive is used for blasting hard rocks comprising ore and waste rock. The ore is feed into the beneficiation plant to produce concentrate, while waste rock, which is required to be removed to expose ore, is dumped at designated dumps.

Potential Consequences

The potential impacts caused by blasting are:

- ✓ Ground Vibration;
- ✓ Air blast;
- ✓ Fly Rock;
- ✓ Post Blast Fumes and Dust; and
- ✓ Water Pollution.

Significance of Impacts

The significance and extent of the impacts vary in response to the mass of explosive detonated and the distance to the receptor from the mine. In general terms, the smaller the charge mass the lower the disturbance levels and similarly, further away from the blast the lower the level of disturbance.

Blasting in the north centre of the pit will have the greatest impact on the community located close to the mine boundary. The villages of Be Tape and Malia will not be significantly affected, meaning there is the potential that they will hear the blast and feel the air blast but vibration is less likely (air blast is, however, often mistaken for vibration so the receptor could still believe that they have felt ground vibrations).

As blasting moves towards the eastern end of the mine, during end of the mine life, the community located about 460 m away from the mine boundary may be affected.

Blasting in the centre and southern areas of the pit will have a significant (as described above) impact on the planned future mine. The impact on Tubmanburg will be minor.

Blasting in the western area of the pit will have the impact on the Be Mawi community.

The communities located close to the mine will experience the highest levels of disturbance. Those further away may hear the blast or feel slight ground vibrations but the levels will be insignificant. The overall impact is considered to be negative and significant at locations close to the mine, becoming more insignificant as the distance from the mine increases.

Table 37: Significance of blast related impacts

Impact	Blasting related disturbances –ground vibration, air blast, fly rock, dust and fumes, possible water pollution.			
Impact Nature	Negative	Positive	Neutral	
	Impact on nearby communities is negative.			
Impact Type	Direct	Indirect	Induced	
	Impact is direct. Physical and socio-economic.			
Impact Duration	Temporary	Short-term	Long-term	Permanent
	Impacts are considered long-term, as the impacts will continue throughout life of mine.			
Impact Extent	Local	Regional	International	
	Impacts will be experienced at distances ranging from the mine boundary up to potentially 2 000 m away (2000m derived from blast modeling. The impact will vary in response to rock type, soil cover, wind speed and direction, cloud cover and other factors).			
Impact Scale	Varies from small to large depending on proximity to the blast.			
Frequency	Daily (possibly excluding weekends and public holidays).			
Impact Magnitude	Positive	Negligible	Small	Medium	Large
	Impact magnitude is considered to be large at locations close to the mine, medium at distances of around 1 000 m and small at locations far (2 000 m +) from the mine. (Blast modeling shows the predicted PPV levels at various distances. The distances are based on the PPV levels relative to the USBM standard as well as human response criteria.)			
Receptor Sensitivity	Low	Medium	High	
	The receptor sensitivity is regarded as high at locations close to the mine and low at locations far from the mine (Shock waves and airblast typically attenuate with distance. The closer you are to the source the greater the impact and similarly the further away the less the impact).			
Impact Significance	Negligible	Minor	Moderate	Major
	Significance of impact is considered to be **Major** at locations close to the mine. Significance of impact is considered to be **Minor** at locations far from the mine This will depend on the number of holes that are fired together. If individual hole firing is achieved than the disturbance will be major up to around 350m. From 350m to 600m the PPV level drops considerably but remains within the disturbing human response category (2.54mm/s to 7.62mm/s). At distances greater than 600m the human response ranges from strongly perceptible to barely perceptible.			

Mitigation Measures, Management and Monitoring

This section describes the embedded controls that have been assumed and mitigation measures that are suggested in order to minimize the residual impact due to blasting and vibrations.

Embedded Control Measures:

- Fly Rock - A blasting zone of 500 m is to be assumed as an acceptable safe distance together with applicable procedures and methods of clearing this area and making safe prior to the blast. When the blasting operations are carried out, it is recommended that people within the blasting zone be moved to a position of safety. When executing the blasts it is essential to design and execute all blasts correctly. This must be supported with care and good control during the charging up of the blast. Holes must receive the correct quantity of explosive and correct stemming lengths must be used. If there is significant change in geological conditions, the charging up procedure must be amended to recognize these and correct for them in advance.
- Disturbance Crack Monitoring - Continual monitoring of movement across a crack. A gauge is placed across a crack in a structure and is set to sample at a pre-set rate or to trigger off movement at a predefined level. The crack is monitored continually. Temperature and humidity information is collected at each crack gauge. Any movement of the crack can be correlated to the blast schedule, seismograph records, temperature / humidity conditions and rainfall figures if monitored. This combined information shows very effectively which elements contribute to movement of the crack. This is a useful tool to have available especially when one is confronted with unsubstantiated claims from property owners. It can be implemented as and if required.

Mitigation Measures –Actions

A number of measures are suggested that may be useful in helping to ensure that the drill and blast operation proceeds smoothly. Some of the measures (e.g. quality acceptance) apply to specific areas of the operation. Others apply to a number of aspects of the operation to varying degrees.

- Prior to the start of blasting the proposed blast design should be modelled to determine the firing sequence, number of holes firing together and the combined charge mass per delay. Based on these figures the peak particle velocities should be calculated at the points of concern. These predictions should be compared to recognized standards to ensure compliance. The approved blast design should be marked and drilled off in the field.

- Initial blasts should be monitored in order to identify potential problems allowing these to be corrected during subsequent blasting. The monitoring helps in ensuring blasting as per design and helps in avoiding problems such as overfilled holes, under burdened holes etc.
- Prior to charging up of blast, the drilled holes should be inspected and all 'problem' holes identified for corrective action. Examples of 'problem' holes could include holes that are under burdened, holes that are short drilled, holes surrounded by badly cracked ground and off pattern holes that could potentially lead to problems.
- A blasting plan including quantity of explosive to be placed in each hole and the final stemming length required must be discussed with explosive supplier.
- After charging -- is completed and prior to stemming the holes -- they should be measured to determine the explosive column to ensure that the required stemming length is achieved. Any errors must be corrected before the hole is stemmed
- The correct stemming material should be used to stem the holes.
- Quality control checks must be implemented as part of the Standard Operating Procedures. This is particularly important if Ammonium Nitrate Fuel Oil (ANFO) or bulk explosives are used. The bulk explosive product should be sampled to ensure acceptable quality.
- The blasting schedule should be followed according to the blasting plan to ensure the timing and sequence of firing the charged holes.
- Avoid prolonged sleeping of blast holes- (i.e. charging a blast and letting it stand for an extended period of time before firing it) particularly in wet ground conditions. It is preferable to charge and fire the blast in the shortest possible time frame.
- To minimize the air blast impact, appropriate control of the blasting operation must be implemented. This includes postponing blasts when temperature inversions occur, when the cloud base is low especially if the prevailing wind is blowing towards a sensitive area.
- Suitable blasting pattern depending upon the strata conditions and desired fragmentation should be designed to minimize the ground vibrations, fly rocks and air-blasts.
- Short stab holes can (and often do) crater, resulting in high airblast levels. Stab holes should be avoided if possible. If required, they should be lightly charged. Alternatively, a small satellite

charge can be positioned higher up in the primary blasthole to help break the rock in the collar region.

- Accurate control is required when marking out hole positions to ensure that holes are not positioned too close to poor areas of the face that could result in the hole/s being under-burdened as this could result in face blowouts.
- Seismographs should be positioned at sensitive or potentially sensitive locations. Seismographs should be set up on a permanent basis at pre-determined locations around the pits.
- The ground vibration and air blast levels measured must be compared to the blast design and modelling results as well as to recognized and accepted industry standards to ensure compliance. Use the seismograph information to check that the disturbance levels are compliant. If not the blast designs should be reviewed and modified accordingly.
- The ground vibration modelling results shows the delay pattern required to limit disturbances when the mining takes place close to the communities. The number of holes that can be fired together will vary depending on the location of the blast/s relative to these communities.
- Electronic detonators shall be used to ensure individual hole firing which is essential in helping to limit the vibration levels.
- If sensitive structures are present in an area, then specific design work may need to be carried out to ensure that the disturbances caused by blasting are kept as low as possible.
- The possible causes of fly rock were outlined above. Rigorous control of the charging up operation must be exercised to reduce this risk to acceptable levels. Avoid overcharged holes or under burdened holes along the free face.
- Shallow stab holes with short stemming lengths should be avoided as there is a high risk of cratering.
- Ensure the selection of optimum delay interval and sequencing of the blast for adequate relief of burden so that holes are not choked.
- As a safety precaution a minimum safe distance from the blast area must be cleared of people and animals. A Blasting zone of 500 m radius is frequently used. This can be increased depending on circumstances.

- If fumes occur after a blast, then the immediate vicinity of the blast area must be kept clear until these have dissipated. The wind direction and conditions must also be kept in mind to ensure that the fumes do not impact further afield.
- Procedures must be put into place to clean up and dispose of explosive spillage. Good housekeeping is essential to help keep water pollution in check.
- The bulk explosive storage areas should be bunded to contain spillage that may occur during transfer of raw materials to or from the storage silos. A method of handling and disposing of this waste some of which is oil based, must be approved and implemented.
- Clear notification of blast times and location should be given. This information should be posted at the entrance to the mine for information of mine personnel. The blast times should also be made available to members of the community. A method for distributing this information will need to be put into place.
- Blasting should be carried out in such a way that disturbance due to blasting to the members of the community is minimum. It is advisable to schedule the blast for a time during rest intervals. Avoid blasting early in the morning or late in the afternoon when school children and many adults are at home.
- A complaints/ grievance register should be implemented which should include information on the nature of the complaint, the date and time of the incident, the name/s of the person/s making the complaint and their contact details. Take photos immediately of the scene of the complaint. The complaint must then be investigated, tracked and closed out. Report back must be provided to the complainant(s).

Mitigation / Safety Measures

- The mandatory safety requirements (clearing the area, posting guards, closing of roads, evacuating people as required, blasting siren, making safe etc.) must be laid out and implemented.
- Clearing the area prior to blasting must include areas around the mine that appear to be used for agriculture and / or corralling animals. These areas may be used frequently. If there are tracks or pathways that cross the area these must also be controlled.
- The public areas found around the disused mine pit must also be cleared and made safe as and when applicable.

- Place guards to ensure that no people or animals enter the blast area.
- Closing of roads and pathways within a defined safety radius may need to be considered.
- Traffic moving in all directions should be stopped at least 500 m away from the blast area. A larger distance than 500 meters should be used for the first blasts to understand and safeguard against the risk of fly rock.

Blasting Records

In addition to the requirements of the authorities in Liberia, additional procedures associated with blasting operations should be applied. Records documenting the various stages of the blast operation must be kept. This information will be required in the event of a query, complaint or investigation.

- The company operating at Bomi Hills Mine must familiarize themselves with the applicable regulations in Liberia and comply with these.
- Keep accurate and comprehensive blast records. To facilitate this, the company shall maintain accurate records of the following, which are essential inputs to the blast vibration report:
    - Blast type (e.g. Overburden waste, capping, secondary etc.);
    - Hole diameter drilled;
    - Blasting location
    - Blast pattern –dimensions, number of rows and holes per row, burden and spacing, staggered or square pattern;
    - Final drill depths - indicate hole depth and sub-drill;
    - Total number of holes per blast –design and actual;
    - Position of any additional or relieving holes;
    - Any irregularities in the blast such as under burdened or overburdened holes, excessive water, extensive back cracking, wedge failures in free face and others;
    - Explosive type used to charge the blast;
    - Explosive charge mass per hole and total amount of explosive per blast;
    - Final explosive column rise and stemming length achieved in each hole;
    - Final stemming length and stemming material used;
    - Details of the final blast tie up with a schematic showing the position and value of the time delays used as well as the number of holes per delay;
    - The date and time of firing the blast;
    - The prevailing weather conditions at the time of the blast.

- In addition to the any statutory record keeping requirements it is recommended that the blast records also show the date and time of the blast, any unusual occurrences such as collapsing holes, misfires, blown out shots, fumes, flyrock, the prevailing weather conditions and other relevant information.

Monitoring

- Pre-Blast Surveys - Cracks occur in most structures but the owners are usually unaware of them. The purpose of the pre-blast survey is to document the crack damage in the various structures located around the mine that fall within blasting zone of the mine. All structures within this area should be examined. In addition, sensitive structures that are located outside the distance should be considered. Any damage identified should be quantified using an engineering reference framework and photographed and a report describing the damage and linking it to a photo database should be produced.

- Disturbance Monitoring, Ground Vibration and Airblast - this monitoring is very important and should be carried out on regular basis. The information obtained can be used to ensure that the recommended vibration amplitudes and air blast levels are not being exceeded. The disturbance levels recorded should be compared to the predictions as well as accepted industry norms to ensure compliance with design and standard. The records give a clear indication of whether or not changes to the blast design need to be considered. The records can also be used to demonstrate compliance. Disturbance monitoring should be carried out using industry standard seismographs and plotted directly against the DIN standard. Air blast can be measured at levels in excess of 100 dB with various industry accepted seismographs. The peak air blast level as well as the associated frequency spectrum is measured. Seismographs should be positioned at sensitive or potentially sensitive locations and remain in place for as long as is required, being moved to different locations as areas of the mine are mined out. A reference database should be established and all data saved therein.

Significance of Residual Impacts

It is impossible to completely reduce the impacts of blasting and as such there will always be impacts felt by the communities. It is thus imperative that the mitigation/ safety measures are put in place and implemented and the impacts reduced as far as possible.

17.2.2 Knowledge Gaps

The prediction of the possible disturbance levels at various distances is based on reasonable assumptions regarding the blast patterns to be adopted. Generally accepted equations and modeling methods were used to design the blasting patterns on which the predictions are based. However, prior to the start of the drill and blast operation these figures must be reviewed to correct for any variances between 'actual' versus 'modeled'.

18. SOCIAL AND COMMUNITY HEALTH IMPACT ASSESSMENT

18.1 Pre-Construction Phase

Definition of Pre-Construction Phase

For the purposes of the social and community health impact assessment, the pre-construction period is assumed to commence from the date of public announcement of the signing of Mineral Development Agreement (MDA). The announcement included a mine lay-out plan showing locations of different project components including the identified production area. The dissemination of this information to the public who will be affected by the Project has a direct influence on their behavior and expectations and therefore on the impact assessment of social and community health impacts. Taking possession of the Project site is a pre-requisite for starting construction activities.

The social and community health impacts envisaged during the pre-construction phase includes:

- The effects of the loss of private property and productive assets; and
- The effects of psychological stress and uncertainty linked to displacement.
- The effects of revenue income from surface rentals of the Government Land;

A brief discussion on these areas of social and community health impact is provided in sub-sections below.

18.1.2 Revenue from Surface rentals for the Government land within Project footprint

Source of Impacts

The requirement of surface rights was examined taking the project lay out map prepared as part of the Feasibility Report (BMFR) for Bomi Mines. The FRBM lists and describes permanent facilities and temporary facilities that will be required for 4MTPA production from Bomi Mines. The temporary project facilities/components include storage yard, laydown areas, and space for labour colony. Permanent facilities include all other components that would be required for Mining operation which are numbered in the project lay-out map from 1 to 31. Thus, the project operation phase is illustrated using this project lay-out map.

The surface rights of the temporary and permanent project facilities and infrastructure will be obtained from Government of Liberia as per provisions as per MDA and pay relevant charges as identified therein in various stages of the project as well as Mining Operation.

Potential Consequences:

The revenue generation from surface rental for the land required by WCL will augment the financial capacity of Government of Liberia. As discussed in baseline section, based on revenue generated from the project, Government of Liberia is will provide basic services and expand the infrastructure for expediting country's development. Hence, this contribution will have a positive impact on country's economy.

Significance of Impact

Table 38: Revenue from Surface rentals for the Government land within Project footprint

Impact	Revenue generation from collecting surface rentals from WCL for Mining area.				
Impact Nature	Negative	Positive	Neutral		
	The right of ownership of land in project footprint is vested on Government of Liberia. WCL will pay necessary surface rental as per MDA. This would enhance the revenue of Government of Liberia.				
Impact Type	Direct	Indirect	Induced		
	The surface rentals as per MDA will be paid to GoL which are directly linked to the mining operation.				
Impact Duration	Temporary	Short-term	Long-term	Permanent	
	The surface rights of the land will be with WCL till the end of the lease term, or, if earlier, at such time as it Hence, it is expected to continue till the end of the mining operation.				
Impact Extent	Local	Regional	International		
	The leasing of the land for surface rights to WCL will generate regular revenue to Government of Liberia.				
Impact Scale	The surface rights for concession area are granted by Government with nominal rentals as per MDA. Hence, the revenue generated for the surface rental will not be significant.				
Frequency	The charges for surface rental will be collected on annual basis.				
Impact Magnitude	Positive	Negligible	Small	Medium	Large
	The income from surface rental of the land in project foot-print will contribute to the revenue of Government of Liberia.				

18.1.3 Impact from Economic Loss of Properties/Assets

Source of Impacts

As discussed in previous section, the project layout was prepared to avoid impact on any land occupied by private parties other than the Government of Liberia. As a result the possibility of impinging on any land occupied by any private party is negligible. However, the communities living close to some of these components may have customary territorial rights over these areas or have private ownership of

plantations on these land parcels. Hence, the name of the communities/towns which are closely located to some of the project components and the potential economic loss to them is listed in the table below.

Table 39: Summary of Project Footprint & nearby Habitations

Ref No (Lay-out Map)	Facility Name	Existing Land Owner/ occupant	Adjacent Social Receptors/ Communities with Territorial Rights	Potential Economic Loss/ Gain
	Mine Pit/Production Area	GoL	UNMIL, Disused Mine Pit Facilities, LBBC facilities, Borbor and Jalakai Towns	Disused Mine Pit Facilities The agricultural fields and households falling in 500m buffer zone
PERMANENTT FACILITIES				
3	Primary Crushed Ore Stock Pile	GoL	Bomi to Mano Road	Eco-system Services-Provisioning[1]
5	Beneficiation Plant	GoL	New Road colony of Tubmanburg	Eco-system Services-Provisioning
6	Product Stock Pile	GoL	Agriculture buildin g	Increased Maintenance Costs
9	Gate for Township Entry	GoL	Mountain view Club	Gain in turn-over
12	Gate No-1 (Official Entry)	GoL	LRRRC office	Increased Maintenance Costs
13	Gate No-2 (Commercial Entry)	GoL	BMI office	Increased Maintenance Costs
14	Plant Water System	GoL	Scattered houses at New road colony.	Obstructing the access roads, partial loss of land from its productive use, cultural properties.
15	Ancillary Building Complex	GoL	Scattered houses at New Road colony.	Obstructing the access roads, partial loss of land from its productive use, cultural properties.
16	Township Area	GoL	Mountain view Club	Gain in turn-over
17	Repair shop and store complex	GoL	Scattered houses at New Road colony.	Obstructing the access roads, partial loss of land from its productive use, cultural properties.
19a	Waste Disposal Area (Alt-1)	GoL	Todemai town and Borbor Town	the access road to WDA will pass through Borbor causing loss of productive land.
25	Geological Shed	GoL	Earlier Bomi Woods	

			Shed	
28a	Tailing Disposal Area (Alt-1)	GoL	Barclay town	Some of the residents are still cultivating farmlands here.
28b	Tailing Disposal Area (Alt-2)	GoL	Fahn Seh Town, Coffesua	Eco-system Services- Provisioning and loss of farmlands
28c	Tailing Disposal Area (Alt-3)	GoL	Gorbla, Willie Moore, CoffeSua, Wilson	Eco-system Services- Provisioning and loss of farmlands
TEMPORARY FACILITIES				
40	Batching Plant Storage of Civil Construction Material	GoL	Around Tubmanburg	Change of land-use and loss of Eco-system Services- Provisioning
41	Steel Storage Yard	GoL		
42	Laydown Area for Fabricated Steel Structures/ Depot	GoL		
43	Labour Colony	GoL		
44	Aggregate crushing area	GoL		

It is significant to note that Section 11.3 of the Minerals and Mining Law 2000 states that Government's right as owner or minerals in the Republic of Liberia are absolute and supersede the rights of any Landowners or Occupants of Land in respect of the Exploration or Mining of Minerals, provided that such Landowner or Occupants of Land shall be entitled to just, prompt and adequate compensation for any diminution in the value of Land caused by disturbance, disfigurement or other factors occasioned by the Government's exercise of its rights. However, WCL will have the surface rights to enter upon and utilize the land in footprint area once the mining license is granted by GoL as per MDA.

Potential Consequences

The most significant economic loss was caused in the mining pit and the buffer area around it. The Blue-lake facilities which were mostly used for recreation purposes (since 2003- after the end of the civil war) was dismantled and brought to an end recreational activity (primarily swimming on weekends by expat population coming from as far as Monrovia on the weekends.) at the Blue Lake.

All these facilities within the mining pit are owned by Government of Republic of Liberia and it would gain access to them as per the provisions under MDA. Apart from the land and assets owned by Government of Republic of Liberia, the loss of privately and family/community owned assets has included loss of farm land, territorial rights and access to natural resources in few locations. The impact of territorial rights and eco-system services is discussed elsewhere in this report.

Significance of Impact

Impact	Economic loss or diminution in the value of such land or the products thereof attributable to operations of WCL.				
Impact Nature	Negative		Positive		Neutral
	The impact is negative since, once the mining resumes the existing economic activities will be under threat.				
Impact Type	Direct		Indirect		Induced
	Most of the direct impact on private properties and assets is avoided in careful planning of mining lay-out. Hence, most of these economic losses are expected to be indirect.				
Impact Duration	Temporary	Short-term		Long-term	Permanent
	The impacts of the temporary project facilities will be for the construction period. The permanent project facilities will continue all through the operation phase.				
Impact Extent	Local		Regional		International
	The impact will be within the project foot print area.				
Impact Scale	Only a few private assets fall within the project foot-print and the community assets within it would be only plantations with economic value.				
Frequency	As per requirement				
Impact Magnitude	Positive	Negligible	Small	Medium	Large
	Mostly, communities may have ownership of plants with economic value within the project footprint area. As all structures and other tangible assets are avoided during preparation of the project lay-out, the loss of property and asset is expected to be small.				
Vulnerability of Social Receptor	Low		Medium		High
	The project area is re-populated after civil war. The households in Bomi County were identified deficient in household assets. Hence, any further economic loss will have a great impact on their household economy. Hence, their vulnerability is rated as high.				
Impact Significance	Negligible	Minor		Moderate	Major
	Though the scale of the impact is small, considering the receptor sensitivity and impact type, the impact significance is rated as minor.				

Mitigation Measures, Management and Monitoring

As per Clause 7.1 of the MDA, WCL need to pay reasonable compensation to the landowners or occupants of land for loss or diminution in the value of such land or the products thereof attributable to operations. Keeping this in view, following mitigation measures are proposed:

- A joint survey of any land parcel of the project foot print should be conducted along with representatives from the Government of Liberia, WCL and the concerned Town Chief to identify all privately owned

- plantation and other community resources which requires to be compensated.
- The affected parties are entitled to just, prompt and adequate compensation for any loss caused due to the proposed project operations. The entitlements for such losses and process of compensation will be as per the Resettlement Policy Framework/WCL SOP on Compensation for Agricultural Loss for the project.
- A consultative process with all affected parties should be made for reaching a mutually agreeable compensation amount. And the compensation payment should be made before any project activity on the land parcel is initiated.

18.1.4 Psychological Stress from Uncertainty

Source of Impacts

The community living close to Bomi-lake are aware of the possibility of their resettlement from the locality; there is a general understanding that this area was earlier mined and belonged to the government. The towns where the exploration work has been carried out have a greater apprehension on their resettlement. Most of their perception on the impact of mining on them is based on the casual information exchange with people engaged in exploration work and similar non-official sources. It is important to note that these areas were worst affected during the civil war. Most of the towns were abandoned and almost entire population had moved to urban centres or refugee camps run in Monrovia and other safe locations; the out flux from this area started primarily in 1992, three years after the civil war started. These communities returned to their bases and rebuild their personal and community life in the last decade or so, while some of them did not return at all. Hence, any disturbance in their household economy or community life creates a strong psychological impact.

The security of rights to land and administration of the land rights in Liberia is in nascent stage. Though, the Land Commission has come up with strong recommendation of honouring the customary territorial rights of the communities, the legislative process regarding new land administration is far from being conclusive; the new draft land policy is being presently discussed in regional consultations and is likely to bring more clarity in terms of land ownership rights and ownership. Hence, people both at individual and collective level are uncertain about their rights over the land and other assets. The uncertainty breeds apprehensions and makes them susceptible to rumours and un-official communications.

The socio-economic sample survey found that people of local area in Senjeh District are more aware than the population staying in Bopolu District. 45 percent of households in Bopolu District and 14 percent of households in Senjeh District did not have enough information about the project. Most of the people got the information from Radio. 9 percent of households in Bopolu District and 22 percent households from Senjeh District have received information directly from WCL. Community leaders are seen to be another significant source of information about the mining operation.

Table 40: Level of Awareness and Sources of Information about the mining in Local Area of Influence

Project Area	Not Aware	Gover-nment	News-papers	Neigh-bours	Community elders.	From WCL	Radio	Grand Total
Bopolu Dist	**45%**	**0%**	**9%**	**9%**	**9%**	**9%**	**18%**	**100%**
Rural	45%	0%	9%	9%	9%	9%	18%	100%
Senjeh Dist	**14%**	**2%**	**5%**	**14%**	**27%**	**22%**	**17%**	**100%**
Rural	23%	0%	0%	16%	19%	23%	19%	100%
Urban (Tubmanburg)	4%	4%	11%	11%	36%	21%	14%	100%
Grand Total	**19%**	**1%**	**6%**	**13%**	**24%**	**20%**	**17%**	**100%**

Potential Consequences

The psychological stress and an atmosphere of uncertainty increase the vulnerability level of the concerned communities. The consequences of this are psychosomatic but can also reflect in the kind of livelihood decisions being taken. The impacts can be observed in the social behaviour of the people as well as on their physical and mental health. The community has reported drastic drop in their participation in farm land development and creating new personal or community assets. This has slowed down the efforts put by individuals for economic progress.

This manifestation of psychosomatic impacts will be more prominent as the construction phase activities are intensified. The experience in other mining sites shows that this leads to breed timid behaviour, developing pessimistic attitude and suspicion of some evil design to victimise them by project authorities. Thus, it creates greater challenges for the project authorities to establish trust and seek cooperation from the communities.

Significance of Impact

Impact	**psychological stress from uncertainty**		
Impact Nature	Negative	Positive	Neutral
	Communities living within Mining Lease Area anticipate their evacuation and insecure about continuity of their living in these locations.		

Impact Type	Direct	Indirect	Induced	
	The psychological stress is caused due to Government of Liberia signing the Mineral Development Agreement with WCL and continuing exploration work within it.			
Impact Duration	Temporary	Short-term	Long-term	Permanent
	The uncertainty will prevail till exact project details are shared and a reliable communication channel is established.			
Impact Extent	Local	Regional	International	
	The impact is felt across the local area of influence,			
Impact Scale	The impact is more in Borbor and Jalakai Towns due to their proximity to the Blue-lake.			
Frequency	The impact will continue till exact project details are shared and a reliable communication channel is established.			
Impact Magnitude	Positive	Negligible	Small	Medium	Large
	The impact magnitude is rated medium as WCL has initiated CSR activities in the region, and people have a communication channel with WCL.			
Vulnerability of Social Receptor	Low	Medium	High	
	The sensitivity of the community is high, and they have an established network at the regional and national level to protect their collective interests.			
Impact Significance	Negligible	Minor	Moderate	Major
	Looking at the fragile environment of peace and recent history of ethnic violence, the impact is rated as moderate.			

Mitigation Measures, Management and Monitoring

- Psychological stress can be mitigated through a regular and transparent stakeholder engagement process, through a plan that includes a communication plan and suggest a channel of communication to bring transparency and build mutual trust
- The impact can be minimized by implementing a robust stakeholder engagement plan. The regular and meaningful communication with communities is recommended to provide people with reliable information. This will minimize the levels of apprehension and predictive posturing by the community to guard their interests. The management of community relationship and monitoring of its implementation should also be addressed in stakeholder engagement plan and its implementation will ensure that the general awareness levels about the project and its activities and impacts will increase
- Grievance redressal process to enable people to contact WCL to put forward their concerns and get responses to address those.

18.2 Construction Phase

18.2.1 Definition of Construction Phase

The construction phase of the project involves erection or establishment of facilities and infrastructure that are essential to support the mining operation. The proposed facilities and infrastructures are located to the north of Tubmanburg Town. This area has lower density of residential structures, though it has a sprinkling presence of residential houses and office buildings. The physical separation or distance of the construction site from the Tubmanburg town will help minimizing a range of social and community health impacts. Nonetheless, a few impacts discerned on the basis of propensities of impacts to the workforce and communities that are discussed in this section are as follows:

- Impact on regional economy
- Exploitation of natural resources
- Labour Influx
- Workforce Health and Safety
- Labour Working Conditions and Human Rights
- Public and Community Health Impacts
- Impact on Cultural Heritage

18.2.2 Impact on Regional Economy

Source of Impacts

The Mining Laws, Mineral Policy and Poverty Reduction Strategy-II for Government of Liberia hope outcomes from mining sector to include increase in exports, income from concession revenue and increased demand for labor, goods and services from the domestic economy. The construction of the facilities and infrastructures will create demand for labor, goods and services in local economy.

The construction phase works will include civil works for structures, which will require semi-skilled and un-skilled works. Further the structural work will also involve electro-mechanical and plumbing works. The components related to industrial installations will require skilled and semi-skilled labor with specialized skills in their respective areas of operation.

The civil construction work will involve procurement of construction materials. The construction material will include the bricks, stones, aggregates, sands and logs which are derived from the natural resource base. In addition to this the construction work will involve use of cement, iron reinforcements, paints, glasses, and a variety of fixtures built in a wide range of metals and alloys.

The construction work will involve mobilization of materials and skilled/un-skilled workmen. This in turn will create scope for a spectrum of services including transportation, supplying of essential services like food, communication, clothing and entertainment services.

Potential Consequences

These economic activities in project area will generate employment opportunities. As per the current estimate, it is expected that the construction phase will involve a minimum of 2090 man days of employment. More than half of this (55 percent) will be semi-skilled workforce which will involve a variety of skills. Skilled work will involve 37 percent of the estimated work which will include masonry, electrical, structural, plumbing etc. Only eight (8) percent of the estimated employment opportunity will be for un-skilled work.

Table 41: Man Power requirement during Construction Phase

Category	Civil Concrete (Man-day)	Erection (Structural, Electro-Mechanical, piping) (Man-day)	Miscellaneous Construction Work (Man-day)	Total (Man-day)	Percentage of Total
Skilled	160	600	10	770	37%
Semiskilled	615	525	10	1150	55%
Unskilled	150		20	170	8%
Total				2090	100%

Source: WCL: Project Feasibility Report

The 2013 ESIA sample survey in the project area showed that only one (1) percent was skilled workers. Hence, the local population could not fulfil the demand of skilled labors. Part of the semi-skilled workers were from the local area. Hence, there was a need for fulfilling this requirement from other parts of the Bomi County or from the nearby Counties. Hence, the impact of employment opportunity has been created at local, county and country level.

The demand for goods and services have also created employment opportunity and economic benefits. The scope of supply of construction materials derived from natural resources is limited. This is primarily because WCL has sourced stones from within the Mining Lease Area and has a plan to establish a stone crusher unit. The crusher unit will fulfil requirement of stones and also partial requirement of sands which will be produced as a by-product. Hence, the scope for supply of construction material will be limited to bricks, sands and logs. The consequences of this are discussed subsequently in this report.

The socio-economic sample survey points out that only **4 percent** of the population is engaged in small businesses. As there is very little construction work in the locality, the number of traders dealing with construction material at Tubmanburg is few. Hence, this requirement will be fulfilled by traders based in

Monrovia or other urban growth centers in Liberia. Most of the fixtures and other construction material are imported from outside as they are not manufactured within the country.

As a majority of the fixtures and construction materials will be imported, it would create a limited employment opportunity downstream. However, the country would gain revenue from the levies to be put on the materials imported. On the contrary to the positive impacts on the local and regional economy, the demand for construction material that the local people use for the construction of their houses are expected to go up. The rates of cement, labour and logs which are required for construction of houses by local people would increase. However, this impact will be temporary and once the construction phase is over, the prices would undergo correction over a time.

Significance of Impact

Table 42: Impact on Regional Economy

Impact	impact on regional economy due to introduction of industrial and market economy				
Impact Nature	Negative		Positive		Neutral
	The impact will be mostly positive, apart from the price rise and short supply of construction material for local population.				
Impact Type	Direct		Indirect		Induced
	Mostly the impact will be direct as the indirect employment creation through local enterprises in supply chain is limited.				
Impact Duration	Temporary	Short-term		Long-term	Permanent
	The impact will span the construction phase.				
Impact Extent	Local		Regional		International
	The impacts will be at multiple levels including both local and regional.				
Impact Scale	The scale of the impact will be minor to moderate due to limitations of the Local people to meet the specialised requirement under the project.				
Frequency	Upto the end of construction phase				
Impact Magnitude	Positive	Negligible	Small	Medium	Large
	Overall impact of the construction phase over the regional economy will be positive.				
Social Receptor Vulnerability	Low		Medium		High
	The un-employment in Liberia is quite high. Hence, each employment opportunity is welcomed and there is a steep competition to take its benefit.				
	Negligible	Minor		Moderate	Major

Impact Significance	Since the construction phase activities will be providing employment opportunity and economic benefits to the locals, the significance is considered as Major.

Embedded Provisions

The clause 5.6(e) of MDA mentions a Project Linkage Plan (PLP) provides a roadmap for linking the mining project to local economy and beat the 'enclave effect'. The PLP will identify (i) the potentials for local suppliers, contractors and service providers to service the project, (ii) key interventions to grow the minerals input industrial sector, and (iii) sets out a project local purchase plan with clear milestones identified in terms of an increasing percentage of local purchases of goods and services, and providing for bidding preferences for local suppliers, contractors and service providers (provided that such Persons offer quality, terms, delivery, service, quantity and price at least comparable to those obtainable from other sources).

The clause 11.1(b) of MDA restricts WCL or any other contractor or sub-contractor of WCL to hire non-Liberian citizens for un-skilled labor positions. and clause 11.1(c) of MDA has the provision to give preference to qualified citizens of Liberia in the employment for financial, accounting, technical, administrative, supervisory, managerial and executive positions and other skilled positions, as and when such positions become available unless and to the extent that such competent and suitably qualified citizens are not available for such positions.

Further, clause 12 of MDA deals with use of Liberian Goods and Services. It expects reasonable efforts to be put by WCL and its 'Major Contractors' to give preference to the material and goods produced in Liberia. It also puts reporting obligation on WCL to report on the extent to which the Company and its Major Contractors acquired materials, goods and services from the preferred sources.

WCL and sub-contractors exclusively rendering goods or services are exempted from import duties and excise charges, but will pay a Customs User Fee (1.5 percent) on all modules, plants, equipment, construction material, machinery, heavy vehicles, capital spare parts, and raw materials. However, a substantial income from the mining would come from the Royalty payments 4.5 percent of the fair market value of the ore. Apart from this, the MDA under clause 16.7 makes provision of an up-front payment of 25,000,000 USD to the revenue account of the Government.

Mitigation Measures, Management and Monitoring

The magnitude of the impact on regional economy will depend on the extent to which Project Linkage Plan (PLP) and Local Procurement Plan (LPP) is executed to meet the intents stated in policy and provisions in MDA. The MDA though further linkages to Liberian Citizens, it is not specific on how the opportunities are divided at various levels, i.e., project affected area (foot print area), Local Area, Counties and National Level. Looking at the employment scenario and expectation of people from the project, intense competition among stakeholder groups is anticipated. The Clarity over these issues needs to be brought out in Project Linkage and Local Procurement Plan.

The PLP and LPP should reflect the capabilities and expectations of different stakeholder groups in a transparent manner. The WCL's project management structure and process should integrate these provisions. There should be an internal monitoring of execution of these plans with the involvement of the project leadership.

Considering the provisions in MDA to provide economic linkage of the project beyond the local economy to the wider region, it is expected that the project will have positive impact and the impacts would be equitably divided among different stakeholders for their optimum benefits.

18.2.3 Exploitation of Natural Resources

Source of Impacts

As discussed earlier, the construction will involve five major local natural resources, i.e., stone, clay, sand, logs and water. The stone will be used for construction of buildings and roads. The concreting and other masonry works will require water for preparing concrete mixtures and curing purposes.

The construction for different components and facilities will be sub-contracted. The procurement and provisioning of these raw materials will be under their responsibility; hence, sustainable resource extraction for construction purpose will depend on the practices followed by these sub-contractors.

Potential Consequences

The extraction of stones, sands, water and logs should be done keeping the sustainability requirements in mind. The sources identified for stone is mainly from the mining area where the stone overlay is to be cleared for mining. Hence, it would not create separate quarry areas for stone. This would also enhance the use of the waste rocks and thereby reducing the burden of waste rock disposal facility.

The use of the bricks in the construction is not specified. The use of bricks in construction increases extraction of clays. Similarly, the sources of sands are not identified for the project. The sourcing of bricks

and sands has potential to be procured from local enterprises. The local enterprises supplying these items may not have sufficient screening system to ensure sustainable extraction of these natural resources.

The sourcing of construction water will be a combination of surface water is mainly from Bomi Lake and from ground water at a few other places if required. The water requirement in construction stage is not huge in comparison to the water requirement at operation stage. Considering the rainfall and water availability in the catchment areas, the impact on water resources in construction stage will be negligible.

The use of logs for construction work is made for several purposes including for erecting scaffoldings, packaging materials, building components etc. These usages will create more demand. If the sources for the procurement of these logs is not regulated it would encourage indiscriminate logging. Consequently, there will be threat of environment degradation.

Significance of Impact

Table 43: Exploitation of Natural Resources

Impact	impact on natural resources such as stones, sand, logs and water to be used during construction and changes made to land use and land cover in project foot print area.				
Impact Nature	Negative	Positive	Neutral		
	The rapid extraction of the required raw materials has an imminent threat on these natural resources.				
Impact Type	Direct	Indirect	Induced		
	The raw material extraction will be both by WCL and its sub-contractors in the supply chain.				
Impact Duration	Temporary	Short-term	Long-term	Permanent	
	The impact will be for the period of construction phase.				
Impact Extent	Local	Regional	International		
	The raw material will be sourced both from local area and from other parts of Liberia.				
Impact Scale	The impact scale will be minor since the construction areas are not located within primary forests and will be limited to township, office buildings, and industrial facilities.				
Frequency	till the end of construction phase				
Impact Magnitude	Positive	Negligible	Small	Medium	Large
	Impact magnitude is expected to be small as the resources are likely to be sourced both locally and regionally.				
Vulnerability	Low	Medium	High		
	The bio-diversity and habitat studies in the local area indicates that the bio-diversity around project area is less compared to other parts of the country due				

of Social Receptor	to historic mining and anthropogenic activities. Also , the rural population living within mining lease area depends on subsistence farming and dependent on forest and wildlife. As such the vulnerability of social receptor is considered as medium				
Impact Significance	Negligible	Minor		Moderate	Major
	Though the impact magnitude is small, yet considering the medium receptor sensitivity the impact significance is rated as minor.				

Embedded Provisions

The stone is a major raw material for construction and water requirement for the construction phase is expected to be met without creating scarcity for local users. Exploitation of major raw materials for construction is to be extracted in a sustainable manner.

Mitigation Measures, Management and Monitoring

The impact on the natural resource exploitation linked to the construction phase cannot be avoided. However, its impact can be minimized through careful sourcing of raw materials. The sources for minor items such as sand, clay and logs will depend on the sources to be selected by the sub-contractors. The Project Proponent will require local sub-contractors and vendors to source the raw materials required for the construction phase in a sustainable manner. Where local sub-contractors and vendors do not have the business skills to meet the Project Proponent's requirement on sustainable sourcing, the Project Proponent will facilitate a vendor capacity building program. The program will explain the Project Proponent's sustainable procurement objectives and provide training in basic business skills to encourage local sub-contractors and vendors to supply sustainably-sourced materials to the Project. .

18.2.4 Impacts of Labor Influx

Sources of Impact

The construction of listed essential project facilities will require a minimum of 2090 man days of employment (Refer *Table 41* for details). The number of labours employed for achieving this work will depend on the construction period planned to achieve this. The project schedule for completion of important project milestones is provided below and gives an idea about the pace of construction phase activities.

Construction activities began in September 2013 and is still continuing with planned expansion project (10 Mtpa ramp up) and development of alternative transport facilities for ore to the Freeport of Monrovia.

The estimated man-days for this have been spread across a period of three years. The break-up of the labor deployment for construction of each component is being worked on. Even if there would be concurrent construction activities at the initial stage, the daily labor deployment is likely to be exceedingly more than 50-60 labors. The un-skilled laborers which would constitute 8 percent of the total labor requirement are likely to be employed from the immediate project vicinity. Hence, the labor requirement for semi-skilled and skilled workers (approximately 40-50 labors) will be met through workers migrating from other parts of Liberia.

Potential Consequences

Influx of labor not only depends on the actual opportunity of work; it greatly depends on the perceived opportunity by labor force looking for work. Though a host of other reasons attract migrant population to a project area, in construction phase, it is primarily the employment opportunity with the project and opportunity to provide support services to the project and people employed in the project.

The ethnic composition of the Liberian society reveals strong social ties along tribal and clan identity. There is a strong territorial ownership based on tribe/clan identity in rural areas. In urban areas, the territorial control by specific tribe/clan is found on a lesser degree. Considering the social fabric of the Liberian society, it is predicted that the project area will mostly see a kinship-based migration and the migrants will therefore share the residential areas and share the kinship rights with the host population to a great degree. There is a strong possibility of return of former residents of the area or re-union of extended family members who live elsewhere. The information based on Census 2008 shows that there is still 6 percent of the population originating from Bomi County live outside of the county.

Tubmanburg, being a peri-urban area, has accommodated some non-kinship-based migrants. Hence, there is an emergence of new pockets of residential areas in and around Tubmanburg.

The rate and magnitude of the labour influx depends on the project characteristics, area characteristics and labour requirements. Though, the daily labour requirement may exceed 50-60 labourers during construction phase, the actual number of migrants aspiring for availing employment opportunity will be certainly higher. In mining sector, it is estimated that every formal job with mine creates between 3 and 10 additional jobs in the project area (Projects and People: A handbook for Addressing Project-Induced In-Migration. Sep 2009). The migration forecast is done taking low, medium and high migration rates and average number of labors per day is presented in table below.

Table 44 Migration forecast in terms of average number of labors per day in construction phase

Category	Estimated Man-days	Influx Forecast		
		Low (3x)	Medium (6x)	High (10x)
Skilled	770	2310	4620	7700
Semiskilled	1150	3450	6900	11500
Unskilled	0	0	0	0
Total	1920	5760	11520	19200
Average Man-days per month	160	480	960	1600
Average No of Labours per day	7	22	44	73

The migration forecast for the construction phase shows that the average number of migrants will vary in the range 22 to 73 persons per day. The actual presence of number of migrated labors in construction stage however will depend on the concurrence scheduling of construction of project components. If the construction period is reduced to 6 months, even then the average number of migrated labors would be in 44-145 range.

Table 45: Forecast of geographical dispersion of influx population

District	Host Area Characteristic	2008 Popn	2013 Popn*	Influx Forecast					
				Low		Medium		High	
				Nos	%	Nos	%	Nos	%
Senjeh	Urban (Tubmanburg)	14576	18220	33	0.2%	65.	0.4%	109	0.6%
	Rural	1946	2238	11	0.5%	21	1.0%	36	1.6%
Bopolu	Urban	0	0	0		0		0	
	Rural	233	268	0		0		0	
Total Population		16755	20726	44	0.2%	87	0.4%	145	0.7%

It is safe to presume that most of the in-migrant labour population would stay close to the construction site (Tubmanburg) either at Labour Camp or along with their kins. Hence, we assume 75 percent of the total influx population will be in Tubmanburg and the rest would be dispersed in the rural areas in the vicinity. The area in the eastern most side falls in Bopolu district, and due to distance and lack of communication facilities would not receive any influx population. As the influx rate in construction phase is low, the percentage of influx population will range from 0.2 percent to 0.7 percent considering the rate and magnitude of the influx in construction stage.

Table 46: Impacts of Labor Influx

Impact	Impacts of labor influx to project area for availing direct and indirect employment opportunities		
Impact Nature	Negative	Positive	Neutral
	The temporary presence of a large number of people will surge the demand on commodities and will comprise on the quality of life for both host and in-migrants.		

Impact Type	Direct	Indirect	Induced	
	The cause of influx is requirement of workforce for large scale and fast paced construction work as well as opportunities for business ventures.			
Impact Duration	Temporary	Short-term	Long-term	Permanent
	The construction period will be for approximately 12 months though the intensity will vary from initial phase to later phase.			
Impact Extent	Local	Regional	International	
	It would be mostly concentrated within Tubmanburg Town with possibility of dispersion to the rural areas in the vicinity.			
Impact Scale	Maximum of 45 to 145 persons			
Frequency	Till the end of construction phase			
Impact Magnitude	Positive	Negligible	Small	Medium	Large
	The in-migrants would constitute less than 1 percent of the host population (will vary in a range of 0.2 to 0.7 percent)			
Receptor Sensitivity	Low	Medium	High	
	As Tubmanburg is an emerging urban area, the host population is acclimatized to migrant population in the area.			
Impact Significance	Negligible	Minor	Moderate	Major
	Considering the influx rate and receptor sensitivity the significance of the impact is minor.			

Embedded Controls

The project has earmarked an area for establishing workforce accommodation facility for the construction phase. Hence, most of the workforce engaged are expected to be accommodated within it. The workforce accommodation facility will reduce the dependence of the labor influx population on the social services and resources of the host population.

Mitigation Measures, Management and Monitoring

- The construction of the labor camp should be completed before mobilization of migrant labours to the site.
- Most of the migrant labors should be accommodated in labor colony to the extent possible.
- The workforce accommodation facility will be managed as per IFC's guidance on workforce accommodation and other international good practices to minimize impact on host population and ensure sustainable use of local natural resources.

18.2.5 *Workforce Health and Safety*

Sources of Impact

The construction phase works includes masonry work, concreting, fabrication, stone crushing, plumbing and electrical works. Each of these activities has a varied degree of risks to the health and safety of the labor engaged.

The migrant labors would constitute approximately 90 percent of the total labor requirement. A large proportion of the migrant labors are expected to live in labor camp/colony. The temporary structures of the labor colony would be a source for accidents such as structural collapse and fire accidents. The intermingling of migrants from different locations will also have greater possibilities of spreading of contagious diseases from one group to other. The bulk cooking and food preparation will have the risk of food adulteration and infections affecting the health of the workforce.

Potential Consequences:

Different construction activities have inherent risks associated with them. If these risks are not assessed and preventive measures are not adopted it could lead to injury and fatalities to the workforce. The spread of contagious diseases has the potential to impact the local labors as they would work together in work-sites. This therefore, will affect the health of the workers and may affect the progress of construction work as per the schedule.

Table 47: Workforce Health and Safety

Impact	Impact on safety and physical well being of the construction workers				
Impact Nature	Negative		Positive		Neutral
	The risk to health and safety of the workers who would be doing works which has the potential to affect their physical health or has probability of accidents.				
Impact Type	Direct		Indirect		Induced
	The injury and illness is caused due to the nature of work assigned to the construction workers.				
Impact Duration	Temporary	Short-term		Long-term	Permanent
	The impact will spread across the construction phase which is 12 months				
Impact Extent	Local		Regional		International
	The impact will be limited to the project footprint, and to a certain extent may spread to local area from where the local labour is sourced.				
Impact Scale	The impact is considered to be low scale due to smaller magnitude of the in-migration required at construction phase.				
Frequency	Till the end of construction phase				
Impact	Positive	Negligible	Small	Medium	Large

Magnitude	The impact magnitude is considered to be small due to short duration of the construction activities.			
Social Receptor Vulnerability	Low	Medium	High	
	The migrant population will be mostly from Liberia and therefore would be resistant to the local weather and is expected to have the same health profile. However, lack of previous experience of similar work mayresult in greater propensity for accidents and injury.			
Impact Significance	Negligible	Minor	Moderate	Major
	Considering the scale of the impact, impact duration and sensitivity of the receptors, the impact significant is assessed as Minor.			

Provisions

WCL as a company under the Vedanta Group will follow the health and safety policy and standards.

Mitigation Measures, Management and Monitoring

The risk assessment for each class or category of the construction activities should be conducted and appropriate personal protection equipment should be provided to the workforce. The workforce should be trained in safe work processes and procedures and a close monitoring of safety compliances should be made.

All migrant workers should be screened for their health conditions and to be fit for the work and do not carry any communicable disease with them. The cleanliness and hygiene at the labor camp/colony should be maintained.

18.2.6 Labor Working Conditions and Human Rights

Sources of Impact

The construction phase often sets very steep targets for completion which drives the work to be accomplished in fast pace. As a result, workers are mobilized in short time and often without expanding infrastructure or facilities required for them. Consequently, the working conditions for all employees do not meet the standards.

The unemployment rate in project locality suggests that there will be high competition among the local labour force to get the opportunity to work. Due to this assured supply of labour, the project proponent will be in a position to dictate the terms including wage rates, working hours and other benefits. The labours will be on a disadvantage for asserting their rights to collective bargaining.

WCL is planning to undertake the construction works through sub-contractors. Hence, there is a possibility of gaps in policy and systems to ensure the desired working conditions and protecting the human rights of labors.

Potential Consequences

The consequence of lapses in providing desired working conditions to labors will lead to non-compliance to the national laws or violation of the internal policies. Apart from the risks of penal provisions for violation of local labor laws, there may be widespread dissatisfaction among labor. The dissatisfaction among labor may lead to labor unrest and deterioration of the working atmosphere and public trust.

Significance of Impact

Table 48 Labor Working Conditions and Human Rights

Impact	dissatisfaction arising out of poor working conditions for workforce and violation of labor and human rights			
Impact Nature	Negative	Positive	Neutral	
	violation of labor rights will result in legal non-compliance and loss of reputation			
Impact Type	Direct	Indirect	Induced	
	Impact type is considered as Direct.			
Impact Duration	Temporary	Short-term	Long-term	Permanent
	The impact will span over the construction period			
Impact Extent	Local	Regional	International	
	The impact will be mostly within the project footprint.			
Impact Scale	The impact will be less as the scale of employment is limited to 45 to 145 labours.			
Frequency	Till the end of Construction phase			

Impact Magnitude	Positive	Negligible	Small	Medium	Large
	Smaller local contractors are expected to not having systems and experience in ensuring desired working conditions. Hence the impact magnitude would depend on the contractor capability which may vary from one to another. Therefore the impact magnitude will vary from negligible to small.				
Receptor Sensitivity	Low	Medium		High	
	The local population is quite aware about the human rights and is sensitive to exploitation.				
Impact Significance	Negligible	Minor	Moderate	Major	
	Although, the receptor sensitivity is medium, considering the lower scale, short term impact and local contrac international contractors, there is a strong possibility of timely action and maintaining uniformity of provisions for working conditions and protection of human rights. Therefore, the impact significance is rated as minor.				

Embedded Provisions

Vedanta has adopted a Human Rights Policy and has commitment to comply with the local laws and follow international good practices.

Mitigation Measures, Management and Monitoring

- The WCL has to standardize the out-sourcing and contracting procedure to ensure the obligation to comply with the human rights protection and ensure desired working conditions.
- Ensure all local contractors are trained and assisted in these issues.
- A monitoring plan and mechanism should be put in place to ensure compliance at vendor and supply chain level.
- Grievance redressal procedure to be in place and
- Training to staff and contractors on human rights, cultural sensitivities and behavioural issues.

18.2.7 *Public and Community Health- Vector Borne and Communicable Diseases*

Sources of Impact

There are a few project components which are located close to a few residences and public offices. For example, the residences and offices located in the vicinity of crusher unit which would be affected by dust and air-pollution. In addition to the menace of dust and noise, the construction work would create ditches and pools which will lead to stagnant water in the area. Such places will help breeding of the vectors responsible for transmitting diseases.

The local labors employed in project will work along with the migrant labors. This would create possibility of contagious diseases to be transmitted to local population.

Table 49: Public and Community Health- Vector Borne and Communicable Diseases

Impact	Increase in vector borne and communicable diseases due to change in land use and in-migration of construction workforce.				
Impact Nature	Negative		Positive		Neutral
	The vulnerability of the local population to diseases and increase in incidences of prevalent diseases.				
Impact Type	Direct		Indirect		Induced
	Direct impact from dust and noise, and indirect impact from communicable diseases				
Impact Duration	Temporary	Short-term		Long-term	Permanent
	Impact duration will span over the construction period of 12 months.				
Impact Extent	Local		Regional		International
	the impact would be in Tubmanburg and its vicinity				
Impact Scale	The scale of the impact would be limited.				
Frequency	Till the end of construction phase				
Impact Magnitude	Positive	Negligible	Small	Medium	Large
	Most of the migrant population will reside in labour camp				
Receptor Sensitivity	Low		Medium		High
	The project area has a hospital and health care system capable of handling medical emergency.				
Impact Significance	Negligible	Minor		Moderate	Major
	The impact significance is considered a Minor based on the existing scenario.				

Embedded Provisions

WCL has presently employed a doctor to provide support to the health care system at Tubmanburg and is providing health care extension services in the project locality. Therefore, a health screening system for the migrant labors will be easily feasible.

Mitigation Measures, Management and Monitoring

WCL needs to take preventive measures to minimize the spread of communicable diseases through the migrant population.

- The segregation of the local workers and the migrant workers should be practiced wherever possible. This would reduce the possibility of
- transmission of diseases to the community through the working population;

- There should be adequate washing facilities for the local labourers and they should be encouraged to wash before going home;
- The contractors and sub-contractors involved in earth and civil construction work should be advised not to create stagnation of water, as much as possible. The workers should be educated to ensure adequate ventilation for storage areas to avoid being breeding places for vectors.
- Health camps in project area should be organized more frequently and people should be made more aware about the possibility of spreading of specific diseases and to educate them on how to prevent and protect themselves.

18.2.8 Impact on Cultural Heritage

Sources of Impact

Cultural heritage in the project area includes tangible structures such as graves, memorial stones and natural spaces such as sacred graves or forests reserved for *poro* and *sande* groups. It is important to note that the project footprint does not include any archaeological or protected heritage structure. The project lay-out has avoided all significant cultural structures within the footprint. The forest where traditional knowledge or training is imparted to boys and girls are natural spaces covered with thick foliage and other natural bounties. These areas are forbidden spaces for anyone who does not belong to the community. Thus, the impact on cultural heritage is envisaged due to transgressing these designated cultural spaces or physically impacting the structures with cultural significance.

Potential Consequences

As the proposed production area and location of facilities and associated components are located in brown field areas which were earlier used for mining operation by LMC, it neither has dense forest patches nor has any culturally significant spaces or natural elements. The inquiry with the traditional council and clan chief has confirmed that the *poro* and *sande* forests are located at the extreme end of the Mining Lease Area on Western side. The proposed mining activities therefore will not interfere in conducting the traditional training and rituals associated with *poro* and *sande* groups. The labor colony is located in the western side of the production area and there is a chance that residents can stray into nearby forest.

Significance of Impact

Table 50: Impact on Cultural Heritage

Impact	Impact on structures and spaces considered sacred due to their cultural or heritage significance			
Impact Nature	Negative	Positive	Neutral	
	There are no structures need to be relocated			
Impact Type	Direct	Indirect	Induced	
	The relocation or encroachment into the cultural space, if any, is associated with the project planning and technical requirements of the project.			
Impact Duration	Temporary	Short-term	Long-term	Permanent
	The space required for supporting construction activities if any, will be required till completion of the construction. After the construction is over these areas can be restored to their earlier condition and put to their respective use.			
Impact Extent	Local	Regional	International	
	The project lay-out has avoided any cultural significant structures within the footprint area to a great extent.			
Impact Scale	The impact is only perceived to the poro and sande forests in western part of the production area.			
Frequency	Till the end of construction phase			
Impact Magnitude	Positive	Negligible	Small	Medium	Large
	The impact magnitude is small since there are no cultural significant structures within the footprint area.			
Receptor Sensitivity	Low	Medium	High	
	Local Community is quite supportive of the project in anticipation of employment and development in the area. They would cooperate to shift the graves if required, after preforming the necessary rituals with adequate support and assistance.			
Impact Significance	Negligible	Minor	Moderate	Major
	Considering the receptor sensitivity to the particular cultural structures and the magnitude and scale of impact, the impact significance is assessed to be negligible.			

Embedded Provisions

Vedanta has a Cultural Heritage Policy which sensitises its employees and workers on cultural and heritage issues.

Mitigation Measures, Management and Monitoring

- Before any construction work is initiated at any location, WCL should consult with the local community and traditional leaders to check and identify sites of cultural significance, if any;
- All migrant population in the labour and staff colony should be made aware about the customary norms to avoid any transgress into *poro* and *sande* areas;
- consultative process should be carried out with the mediation of the traditional leaders to regulate activities in areas with sensitive heritage structures or features; and
- Chance Find Procedure for the project to be developed in case such sites are identified during construction.
- Any damage to a cultural site will be compensated/repaired/replaced in consultation with the community and traditional leaders.

18.3 Operation Phase Social and Community Health Impacts

18.3.1 *Definition of Operation Phase*

The operation phase involves mining of the ore, processing and transportation to the port for export. The extraction of the iron ore from the production area involves removing overburden and transporting the waste rock to designated waste dump locations. The removal of the overburden and extraction of the ore is through blasting and mechanical removal of the rocks and ores. Hence, it involves the use of heavy machinery by skilled and semi-skilled workers. The ore is crushed into smaller sizes and subject to beneficiation for separation of impurities before it is transported to the port.

Operation phase is planned to ramp up from the current 4 Mtpa to 10 Mtpa ore extraction rate. This desired level of ore extraction will be achieved gradually over a period of 3 years. The operation activities as envisaged in the feasibility report for the Bomi Mines would bring following impacts.

- Economic loss of property and assets attributable to mining operation
- Nuisance to social receptors attributable to mining operation
- Impact on subsistence and livelihood
- Impact on workforce health and safety
- Public and community health
- Labor and human rights
- Related to migrant and transient population

- Governance and administration
- Social infrastructures
- Public and community safety and security
- Cultural heritage

18.3.2 Loss of property and assets attributable to mining operation

Sources of Impact

Borbor and Zalakai settlements are located close to the mining pit, part of their farmland and other assets come within the safety buffer zone required to be maintained for safe blasting operations towards the end of project life.

Zalakai is situated to the north of the proposed mining pit. The houses and farm lands of Zalakai are situated 450 m (approximately) away from the ultimate mining pit boundary and in the beginning of the mining operation they would be at a distance of 2000 m (approximately) from mining location. As per the projected mining schedule, the farmlands would come within the safe buffer area required for blasting only after 10 years.

Borbor is situated to the eastern side of the mining pit and is approximately 450 m (approximately) away from the ultimate mining pit boundary. In the beginning of the mining activity, the farmlands and residential assets would be at a distance of 1100 m (approximately). These private assets of the Borbor Town community will come within the safety buffer zone for blasting after 5 years from the start date of the mining operation.

Potential Consequences

There is a risk of flying rock generated from the blasting operation to reach up to 500 m and cause damage to property and life. Hence, as per international safety norms, a blasting zoneof 500 m is evacuated during the blasting operation. The blasting zone is to be cleared of all living beings including men and domestic animals to avoid risk to their life. The immovable assets such as standing crops, plantations, and such other physical assets which can be replaced by paying compensation however may be allowed.

If such immovable assets are damaged due to blasting and such other activities clearly attributable to the mining operation, the owner of these assets needs to be compensated. Keeping this prospect of getting compensation from the project, the affected area may see a rush of opportunistic settlers primarily to derive benefits of compensation and other benefits.

Significance of Impact

Table 51: Loss of property and assets attributable to mining operation

Impact Scale	Only Borbor and Zalakai would fall within the blasting zone from the ultimate mining pit-line. As per the mining progression plan, the Borbor farmlands would come within blasting zone after 5 years; and that of Zalakai would take nearly 10 years. At present both these settlmentshave approximately 80-90 house holds.				
Frequency	Daily for blasting operations.				
Impact Magnitude	Positive	Negligible	Small	Medium	Large
	Impact magnitude is considered as small because the nearby villages are far from the ultimate mining pit boundary.				
Vulnerability of Social Receptor	Low	Medium	High		
	The project area is re-populated after civil war. The locations for settling down were carefully selected keeping the ethnic relationships, peace and security in mind. Further, displacement will seriously compromise their security of tenure. Hence, their vulnerability is rated as high.				
Impact Significance	Negligible	Minor	Moderate	Major	
	Though the scale of the impact is small, considering the receptor sensitivity and impact type, the impact significance is rated as minor.				
Impact	Economic loss to land, the products thereof, or properties thereon attributable to blasting, ore-transportation and other operations of WCL.				
Impact Nature	Negative	Positive	Neutral		
	The impact is negative due to economic loss on account of loss of property and assets due to mining operations.				
Impact Type	Direct	Indirect	Induced		
	The impact is envisaged from flying rocks in blasting operations.				
Impact Duration	Temporary	Short-term	Long-term		Permanent
	The impacts of the temporary project facilities will be for the construction period. The permanent project facilities will continue all through the operation phase.				
Impact Extent	Local	Regional	International		
	The impact will be within the project foot print area.				

Embedded Provisions

The blasting process will be as per International Standards on Mining Practices which has following safety provisions:

- Use of control blasting procedure and carrying out blasting by trained and certified professionals.

- Clearing of all human beings and domestic animals withinblasting zone of 500 m from the blasting location.
- Communicating the blasting timings to the nearby communities well in time.

Mitigation Measures, Management and Monitoring

Borbor and Zalakai settlements at present do not fall within blasting zone. It is expected that, farmlands of Borbor will come within the blasting zone after 5 years' time which is contingent upon the progress of the mining operation. Similarly, Zalakai would face these restriction and risks much later, i.e. after 10 years. Hence, we propose following mitigation measures to prepare these communities and facilitate an informed decision process.

- The communities in both these settlements should be educated on risks of flying rocks to their assets and possible mitigation measures.
- A detailed census of the households and their economic assets in these two communities should be conducted to prepare the list of residents and prevent any other opportunistic settlers to settle in these locations.

18.3.3 Nuisance to social receptors attributable to mining operation

Sources of Impact

Some of the project activities may cause disturbance to the neighboring social receptors which are as follows:

- Nuisance of noise and dust to the office complexes near product stockpile in beneficiation plant complex.
- Increased traffic causing noise, pollution and congestion at approach roads of the Tubmanburg Town from Northgate.
- Transportation of waste rock to waste rock dump Alt-1 passing through Borbor will be a safety risk and expose them to noise and dust.
- The road connectivity between Todemai Town and Tubmanburg will be affected if it is used for ore-transportation.

Significance of Impact

Impact Nature	Negative	Positive	Neutral
	There will be effects on the life of the social receptors.		

Impact Type	Direct		Indirect		Induced
	The impacts are directly linked to the mining operations.				
Impact Duration	Temporary	Short-term		Long-term	Permanent
	These impacts will continue throughout the life of mining operation.				
Impact Extent	Local		Regional		International
	These impacts will be local.				
Impact Scale	The scale of the impact is minimised by selection of locations away from dense habitations. However it would still affect a few offices and residential houses.				
Frequency	Continuous, till the end of the mining operation.				
Impact Magnitude	Positive	Negligible	Small	Medium	Large
	Considering the reduced scale of this impact, the impact magnitude is rated as small.				
Vulnerability of Social Receptor	Low		Medium		High
	The offices will be mostly devoid of children and aged population. Hence, most vulnerable social receptors are not expected to be impacted. However, looking at the multiple factors of nuisance, the receptor vulnerability is rated as medium.				
Impact Significance	Negligible	Minor		Moderate	Major
	The degree of nuisances such as noise, dust and traffic congestion can be significantly reduced through mitigation measures. Hence, the overall impact significance is rated as minor.				
Impact	Nuisance from noise, dust, traffic congestion etc. to the adjacent social receptors causing disturbance and affecting their quality of life.				

Stakeholder Feedback:

Stakeholder consultations were conducted with the concerned communities on the issue of impacts from mining. It was suggested that keeping the health and safety concerns of the community WCL will ensure its operations does not unnecessarily impact these communities since there would be no relocating in the future.

Mitigation Measures, Management and Monitoring

- An alternative access road to connect Borbor and Todemai to road connecting Tubmanburg to Mano should be ready for public use before waste dump alt-1 location is used.

18.3.4 Impact on Subsistence and Livelihood Strategies

Sources of Impact

As per the feasibility report the project footprint is limited to 11 sq. km of area within the mining lease area. This land use of this area will change during the course of mining operation. The local community will need to forego their rights to access natural resources within this area and will be deprived of the benefits they were deriving out of them. The eco-system in surrounding areas will also experience indirect impacts and changes are expected in a wider area too. The key drivers of the eco-system changes include the following:

- Changes in land use and land cover
- Removal of species and introduction of new species through landscaping, promotion of new crops and farming practices etc.
- Changes in farming system and use of external inputs such as pesticides and fertilizers.
- Increase in demographic pressure due to in-migration.
- Increase in resource consumption (meat, logs, fire wood, charcoal etc.) and premature harvesting.
- Increased extraction of water both from surface and underground sources
- Changes in water quality due to effluent discharge and contamination.

As discussed in Chapter-18, following eco-systems and their beneficiaries will be impacted due to the mining activity.

Table 52: Impacted eco-system and their users

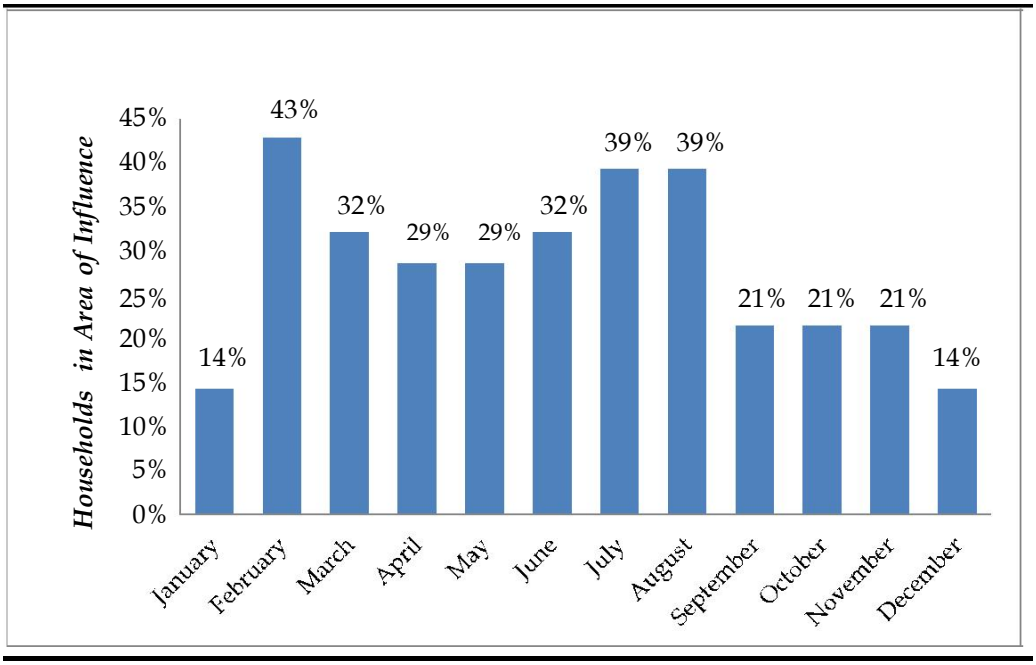
Type of Eco-system	Impact Characteristic	Impacted Eco-system users
Highland forested areas	• Used for shifting cultivation or slash and burn agriculture. • Source for logs, firewood for domestic use. • Used for charcoal making.	• The rural community with territorial rights within mining lease area practicing farming.
Swamps and Lowland Valleys	• Drying up of the swamps due to change in hydrology after dewatering of blue lake. • Reduction in productivity from farming swamps.	• Communities using Swamp land for farming. For example- Jalakai. • The practice of swamp land farming is not very common practice. But, Government is promoting and upgrading farming techniques for swamp lands.

Type of Eco-system	Impact Characteristic	Impacted Eco-system users
Natural Streams or flowing waters	• The flowing water is used for domestic consumption and bathing. • Artisanal fishing is done to supplement the food supply of the household.	• Communities without any alternate access to flowing water.
Water bodies	• Small and medium water ponds and lakes at several locations with natural depressions.	• Communities accessing them for artisanal/capture fishing. • The cultural and supportive services derived out these water bodies.

Potential Consequences

The consequences of reduction of access to natural resources and eco-system services would be reflected in the livelihood of local communities. The contribution of the eco-system services to the local economy and livelihood is through its contribution in four aspects, i.e. provisioning, regulating, supporting and cultural services.

The natural resource base for a subsistence community provides food, fresh water, wood, fibre and fuel. Availability of food round the year was examined in the socio-economic sample survey within Local Area of Influence. The responses from the households indicate that food insufficiency is faced by households in urban area of Tubmanburg. The people living in rural parts of both Senjeh and Bopolu District do not face insufficient food supply because of their access to edible items available in forest. In Tubmanburg, the insufficient food supply is encountered by greater number of households from February to August. Deforestation and forestland degradation will further curtail the supply or availability of these resources for local people.



Source: ESIA 2013 HH Survey

Apart from the food items produced in farm land and kitchen garden, food supply from natural sources plays a significant role in provisioning of food. The meat of wild life in forest and fishing from streams and creeks is obtained by male members by hunting and fishing practices. The availability of bush meat/fish was examined in project local area of influence as an indicator for dependency. The supply of wild meet is adequate in urban area of Tubmanburg from January to March.

Less percentage of households in rural areas of Bopolu report adequate supply of bush meat/fish in comparison to that of rural areas of Senjeh District. The supply of bush meet in Bopolu District however shows less variation which indicates a steady dependence on this source. The rural areas of Senjeh District on the other hand show greater consumption of bush meat/fish from November to March.

In sum, households living in the interior parts of the local area of influence have a steady consumption of bush meat/ fish. The urban area like Tubmanburg mostly purchases the bush meat sold by the households living in interior areas. The households feel the need to sale meat and forest produce in dry months of the year. Hence, consumption in urban locations surge in these dry months of the year. As number of people with more buying power would increase in Tubmanburg, it would be seen as a bigger market for selling Bush meat. Hence, intensity of hunting in the surrounding areas would also escalate and threaten the bio-diversity of the area.

Similarly, the dependency of the households on the supply of edible plants was assessed from the responses of the households surveyed during sample socio-economic survey. The dependency and consumption of edible plant parts collected from the forest was reported higher in rural areas falling in Senjeh District. The consumption and supply do not show much variation round the year.

The supply and consumption of edible parts of plants is comparatively less in urban area of Tubmanburg. The consumption is reported higher in dry months from January to March. Correspondingly, the consumption is reported lower in dry months in adjacent rural areas falling in Senjeh District. The consumption of the edible plant parts collected from the forest in rural areas shows a marginal increase in wet months from June to October.

Charcoal is an important source for domestic fuel which is used for cooking both in rural and urban areas. The socio-economic sample survey reported 64 percent of the rural households in Bopolu District, and 71 percent of the households in rural areas in Senjeh District practice charcoal making. Only, 14 percent of the households in urban area of Tubmanburg indicated their involvement in charcoal production.

The average number of charcoal bags produced in a year is higher in rural areas of Bopolu District. This shows the intensity of use of forest resources is higher in this area. The average number of bags produced in Tubmanburg is lowest. As demand for domestic fuel for cooking surge up due to increase in the number of inhabitants in project area, the local market for charcoal will grow manifold. This in turn will intensify the charcoal making endeavour in rural parts of local area of influence.

Table 53: Practice of Charcoal Making in Local Area of Influence

Characteristic of Local Area of Influence	Average No of Charcoal Bags	Percentage of HHs making Charcoal
Urban Area (Tubmanburg)	91	14%
Rural- Senjeh District	118	71%
Rural Bopolu Dist	130	64%

The practice of slash and burn or shifting cultivation is completely dependent on supporting services such as soil formation and nutrition cycling. The local community follows a cycle of 3 to 5 years to practice farming for a patch of land. It takes them 15 to 20 years to come back to the same plot of land. The socio-economic sample survey in the mining concession area shows that 44 percent of people in Tubmanburg are not dependent on agriculture. Out of the remaining population, 22 percent do their farming in Upland, 19 percent in Plains, 11 percent in lowland, and 4 percent in forest land. In rural areas of Senjeh District, 45 percent of households use upland and 29 percent use lowland. It is significant that only 3 percent

households use the Swamp land for farming. A significant section of Zalakai uses the Swampland for farming, and in other villages the use of swampland is limited. Mining area within Bopolu District is completely rural area. The farming is reported to be done in lowland (36 percent) and forest area (36 percent) and only 18 percent use upland.

Table 54: The farming practices and land preference by households within project Local Area of Influence

Area Characteristic	Urban	Upland	Plain	Lowland-Simple	Lowland-Plotted	Forest	Swamp
Bopolu District	**0%**	**18%**	**0%**	**36%**	**9%**	**36%**	**0%**
Rural	0%	18%	0%	36%	9%	36%	0%
Senjeh District	**21%**	**34%**	**16%**	**21%**	**0%**	**7%**	**2%**
Rural	0%	45%	13%	29%	0%	10%	3%
Urban-Tubmanburg	44%	22%	19%	11%	0%	4%	0%
Grand Total	**17%**	**32%**	**13%**	**23%**	**1%**	**12%**	**1%**

The natural process takes care of soil formation and restoring the depleted nutrition. Hence, the current farming system is not dependent on any external inputs such as fertilizers or pesticides. The production from the land depends on the nutrition levels restored through the natural processes. The reduction in their customary rights over territory will result in shorter cycles for shifting cultivation. Hence, soil formation will be incomplete and nutrition cycle will be premature at the time of re-use of the land for shifting cultivation. Hence, the mining lease area within Bopolu District appears more reliant on forest and lowland areas. The land close to the tailing ponds will face the menace of dispersion of tailing soil to the adjacent land and may enter into the natural drainage lines polluting the flowing water.

The subsistence slash-n-burn farming is dependent on rainfall. The socio-economic sample survey points out that 76 percent of the households do not provide irrigation in the plots they hold. The crops are raised solely by relying on the rainfall. Only 9 percent households reported to use water from well to supplement the rainfall and only 4 percent use bore-well. Creeks are reported as an important source for irrigation for 10 percent of plots under farming. The reliance on creeks for irrigation is higher in rural areas of Bopolu District.

Table 55: Use of surface and ground water for Irrigation

Local Area Characteristic	No Irrigation	Well	Bore-well	Creek	Grand Total
Urban (Tubmanburg)	81%	11%	7%	0%	100%
Rural- Senjeh District	77%	6%	3%	13%	100%
Rural-Bopolu District	60%	10%	0%	30%	100%
Grand Total	**76%**	**9%**	**4%**	**10%**	**100%**

The area affected by the mining will lose its aesthetic and spiritual value due to open pit mining and dumping of the overburden and mining wastes. The water bodies in the area not only provide aquatic resources for food, they are also used as locations for recreation. The local community uses these locations for swimming, relaxation and taking strolls. The blue lake is used as a recreation spot for local community as well as those living in other parts of the county. The loss of water in other water bodies located close to the human habitations will have greater impact on aesthetic and cultural services derived from these sources.

Water filtration, flood and erosion control, pollination and climate stabilization are some of the eco-system regulating services which have an integral link to the agricultural production. The subsistence farming system is heavily dependent on these services. The yield and availability of other forest produces used for food and other supplies also depend on purity of water, nutritional cycle, pollination and natural mechanism of pest control.

The forest as a hunting ground and creeks as places of recreation are intricately woven to the social life of inhabitants in the rural area. However, none of the creeks within the local area of influence is reported to have religious or spiritual significance.

Significance of Impact

Table 56: Impact on Subsistence and Livelihood Strategies

Vulnerability of Social Receptor	Low	Medium	High	
	The local population is dependent on subsistence farming and forest resources. The process of industrialisation therefore would bring a wide range of adaptation opportunities for them. The youth group being active will adapt to the situation and may upgrade their skill sets to meet the requirement whereas the older generation people may find difficult to shift from their traditional skills there could be a possibility of this group being vulnerable.			
Impact Significance	Negligible	Minor	Moderate	Major
	The impact on natural resource extraction and deprivation from the eco-system services will have a considerable impact on livelihood. However, the impacts can be abated at source by minimizing the population influx, meeting firewood/domestic fuel requirement through non-forest sources, supply of alternate sources of meat/fish etc.			
Impact	The subsistence and livelihood strategies which are linked to natural resources and economic benefits of the eco-system services will be impacted due to changes in current environment conditions.			
	Negative	Positive	Neutral	
	The mining operations may change the environment parameters and bring			

Impact Nature	wide ranging changes in natural resources harvested by local community. The population increase in project local area of influence will increase extraction of natural resources to meet human requirements of food, shelter and cooking fuel.				
Impact Type	Direct		Indirect		Induced
	The impact is linked to changes in environment and natural capital which plays a significant role in livelihood of the local communities.				
Impact Duration	Temporary	Short-term		Long-term	Permanent
	The impact may change the livelihood practices of the present generation; and also may have impact on livelihood options to be available for the next generation.				
Impact Extent	Local		Regional		International
	Impact zone will coincide with the impact pathway of environment parameters. Hence, it would be mostly in the local area of influence.				
Impact Scale	The scale of the impact will depend on changes in environment parameters and status of natural resources.				
Frequency	Till the life of mine.				
Impact Magnitude	Positive	Negligible	Small	Medium	Large
	The livelihood practice of population living within project area of influence depends on slash-n-burn farming in highlands, low land farming near creeks, and supplementing from the edible plants in forest, hunting wild-life and catching fish from water pools. These livelihood options are practiced in different combinations as per the resource availability and options exercised by households. The employment opportunity as un-skilled labour will be an additional livelihood option for these people. Considering the alternative livelihood options offered by the project; the impact magnitude is rated as medium.				

Mitigation Measures, Management and Monitoring

- The impact on natural resources such as water, soil fertility, and bio-diversity and their impact on local livelihood should be monitored.
- In order to minimize the impact on harvest of natural resources, alternate sources of food, building material, and cooking fuel should be promoted for in-migrant population in Tubmanburg.
- The wild-life conservation and forest conservation programs should be implemented to ensure sustainable harvest of forest and wild-life resources.
- Technological improvement in farming should be encouraged to increase the crop yield for increasing supply of food grains. Increased supply of food grains will reduce reliance on edible plant components from forest and bush meat.
- The employable population from local area of influence should be given preference in employment in mining operation to help them diversify their livelihood options.

- The women from the local area of influence should be encouraged to take employment in mining operation based on the suitability.
- Women Groups should be linked to the supply chain through skill training and financial assistance to enhance their participation in local economy through formation of SHGs (Self Help Groups).

18.3.5 *Workforce Health and Safety*

Sources of Impact

The mine workers are the most vulnerable to the ill-effects of the mining operation. Dust concentration and emission levels in production area are maximum and people working within the area are exposed to it on a regular basis. The workers operating heavy machines or working in vicinity of it are exposed to high noise levels. Constant exposure to such high level of noise is potentially harmful for human health.

In addition to the exposure to dust, emission, and noise, the workforce is also prone to accidents and injuries. Further, if the workforce is served food at the canteen or at labour colony. As the food is cooked in such a large scale, there is possibility of adulteration and infections which can result in medical emergency. As so many people work together, contagious or communicable diseases can spread rapidly and cause epidemic.

Potential Consequences

The workplace safety and health risks are of paramount concern in any mining operation. The sickness of the workforce reduces productivity and serious illness or injuries can have financial implications. The inhalation of dust can cause respiratory or pulmonary diseases.

In addition to the exposure to higher iron contents, the workforce is also vulnerable to get impacted by use of other harmful chemicals and explosives used in the mining process. Hence, exposure to hazardous and chemical substances may create a variety of health risks.

Significance of Impact

Table 57: Workforce Health and Safety

Impact	impact on workforce health and safety		
Impact Nature	Negative	Positive	Neutral
	The impact nature is negative since it may result in health and safety issues for the workers.		
Impact Type	Direct	Indirect	Induced
	workforce is directly impacted by the dust, noise and exposed to injuries and		

	fatalities				
Impact Duration	Temporary	Short-term	Long-term	Permanent	
	The impact will be throughout the operation phase of the mine				
Impact Extent	Local	Regional	International		
	The workforce is expected to live in the nearby places, though there will be a small section of transit population. However, the health risk of the local population will be more and could be due to the mining operation.				
Impact Scale	The primary estimate of the labour force to work in the mining operation is over 500 including the workers engaged in ore-transportation and other supportive services.				
Frequency	Till the life of the mine				
Impact Magnitude	Positive	Negligible	Small	Medium	Large
	Considering the scale, duration and extent of the impact, the impact magnitude is assessed as medium.				
Receptor Sensitivity	Low	Medium	High		
	The health and nutrition status of the local population is quite vulnerable. Their exposure to pollution and industrial hazards is also limited.				
Impact Significance	Negligible	Minor	Moderate	Major	
	Considering the impact magnitude and high receptor sensitivity the impact significance is assigned as minor.				

Embedded Provisions

Vedanta has a health and safety policy and has established technical and operational standards for carrying out safe operations.

Mitigation Measures, Management and Monitoring

The use of environment friendly technology wherever possible

Adopting safe work procedures and practices at work.

Regular safety audits and monitoring of implementation of the health and safety policy.

18.3.6 Public and Community Health

Sources of Impact

The mining operation results in scarring the local landscape, increases the erosion, contaminates the water and soils in the project area. The extraction of the ore and its transportation through heavy machinery contributes emissions into the atmosphere. Besides occupational health hazards, the community living in

the areas where mining is carried out may suffer from a range of health problems. Acute Respiratory Illness (ARI), Malaria, and Silicosis are some of the major diseases which are associated with mining activities.

The mining operation includes a number of activities which produces fugitive dust which travels along the wind direction and increases suspended particles in air. Some of these activities which have the potential to produce fugitive dust include blasting, ore crushing, tailings and movement of the trucks and heavy vehicles on unpaved roads. The vehicular and power plant emissions and operation of other machines also contribute to the air pollution. The production area of the mine is merely 2kms away from the Tubmanburg which at present has more than eighteen thousand population. The population of Tubmanburg is expected to grow manifold after mining operation starts. Hence, a large number of people may be exposed to air pollution which can cause a range of respiratory illnesses.

The digging of earth surface and dumping of the waste rocks will produce ditches and pools where water will be accumulated. The tailing pond will also create swampy conditions which would create favourable conditions for mosquitoes and other vectors to breed and multiply. In addition to the vector borne diseases, migrant and transient population in the project area will have the potential to bring a host of communicable diseases including STIs, HIV and AIDS.

Potential Consequences

The Malaria is reported as one of the most prevalent diseases in the project area. Further increase in vector population in the area may accelerate the spread of Malaria and make the population more vulnerable. In addition to the Malaria, due to the presence of migrant and transit population may attract commercial sex workers to the area. The incidences of transactional sex will increase the possibility of spread of Sexually Transmitted Diseases. Though, there is no reliable estimate of prevalence of HIV&AIDs in project area, STI/STIs are reported in high proportion too. Hence, the probability of spread of STDs including HIV and AIDS is very high.

Iron is an important component for human health and deficiency of iron in human body leads to anaemia. A man needs an average daily intake of 7 mg and a woman 11mg of iron. Iron is found in meat, potatoes and vegetables. Iron is an essential part of haemoglobin that transports oxygen through our bodies. However, excess of iron in human body is harmful. Iron may cause conjunctivitis, choroiditis, and retinitis if it contacts and remains in the tissues. Chronic inhalation of excessive concentrations of iron oxide fumes or dusts may result in development of a benign pneumoconiosis, called siderosis. Inhalation of excessive concentrations of iron oxide may enhance the risk of lung cancer development in workers exposed to

pulmonary carcinogens. Thus, dusts with iron content will cause a range of acute respiratory Infections increasing sufferings of the local community.

Significance of Impact

Table 58: Public and Community Health

Impact	Impact on public and community health due to increase in level of pollution and spread of contagious diseases				
Impact Nature	Negative		Positive		Neutral
	The impact nature is negative				
Impact Type	Direct		Indirect		Induced
	The impact on health will be indirect through air pollution and deterioration of environmental sanitation.				
Impact Duration	Temporary	Short-term		Long-term	Permanent
	The impact will continue throughout the mining operation.				
Impact Extent	Local		Regional		International
	The impact will be mostly local, but can spread into larger area through vectors and transmission through human contacts.				
Impact Scale	There could be incremental increase in existing diseases like Malaria, STI/STDs and there is all probability of new diseases being introduced to the locality.				
Frequency	Recurrent				
Impact Magnitude	Positive	Negligible	Small	Medium	Large
	Considering the scale, baseline conditions the impact magnitude will be medium				
Receptor Sensitivity	Low		Medium		High
	The local population is not exposed to air pollution, but they have some level of prior exposure to Malaria and STIs. Hence, the overall receptor sensitivity is rated as medium.				
Impact Significance	Negligible	Minor		Moderate	Major
	impact on community and public health is assessed as minor.				

Embedded Provisions

The generation of fugitive dusts would be reduced and its spread will be decelerated through adopting mitigation measures at the source. For example, sprinkling of water on the unpaved transport routes, using covered conveyor belts, using water sprinkler at crusher and use of dust suppression measures at sources of emergence of dust are commonly practiced. As much as possible stagnation of water will be prevented in order to avoid breeding of mosquitoes and health programs for community will be conducted to spread

awareness about STDs. A more detailed description of the embedded dust control provisions are discussed elsewhere in the report.

Mitigation Measures, Management and Monitoring

- The control of vector population in project area should be done through maintaining environmental sanitation.
- Care should be taken not to create ditches that can hold stagnant water. Thereby , improving local drainage pattern.
- The dust suppression measures and emission control measures should be practiced.
- The health screening of the local population should be done periodically and health infrastructure should be strengthened.
- The local population should be educated on adopting sanitation measures at home to protect them adequately.
- The population should be made aware about the special care required for children and elderly population.
- A medical care facility should be made available for curing the affected individuals and arrest further spread of communicable diseases.
- The migrant worker population should be subjected to health screening to diagnose other possible communicable diseases which they may carry with them.

18.3.7 *Impact on Labor and Human Rights*

Sources of Impact

The mining operation will require 857 employees. The primary estimate of man-power requirement for operation of different divisions is provided in table below. The executive and supervisory category employees would constitute 8 percent and unskilled employees will constitute 13 percent of the total employees. The skilled employees however would comprise the majority of the employees and would be 53 percent of the total workforce.

Table 59: Man Power requirement for Operation of Mines

Manpower Category	Mines	% of Total
Executive/supervisory	65	8%
Skilled	457	53%

Unskilled	115	13%
Township Maintenance & Misc	20	2%
Drivers and Helpers	200	23%
Total Manpower	857	100%

Each class or category of employee has been subjected to a distinct work environment and would enjoy specific entitlements. For example, the skilled and un-skilled workers are protected under labor laws of the country. However, the human rights issues would be common to all class and category of employees. The universally debarred labor practices include use of child labor, forced labor and extending equal rights to contract and migrant labors.

The workers are exposed to accidents and diseases due to nature of their work. The workers operating machines are more prone to accidents and exposure to the contaminants linked to their respective operations. The executives or supervisory staffs on the other hand face health problems due to sedentary life and ergonomic issues. This however affects the quality of work and quality of worker's life. Such practices, when continue on a regular basis, impact the health of the worker and reduces his life expectancy.

The WCL's right to mining at Bomi would impinge on some pre-existing rights over the mining lease area. Such conflicts of rights are to a certain extent was acknowledged during MDA preparation and remedial measures have been stated for them. However, there are many aspects and issues where pre-existing rights needs to be addressed. Where local communities have to surrender or compromise on their pre-existing rights or privileges because of Government's action for national interest, conflict situation emerge. Such a situation will hamper the company's interest in carrying out normal operations.

In these conflict situations, the project proponent has the responsibility to respect rights of others which are likely to be affected by their operation. Actions of the project proponent to protect their rights often show disregard to other existing rights. The vulnerable groups who do not have resources or capability to protect their interests suffer the worst. Human rights are the rights to which all individuals are entitled simply by virtue of their humanity, regardless of their race, national or social origin or other status. Hence, at all situations the rights of other stakeholders will be respected and people should be treated with dignity. Company will not play a complicit role to contribute to the process that abuses human rights of any stakeholder.

The WCL will employ a number of sub-contractors who would provide support services to its operation. Hence, indirectly, there is a possibility of human rights abuses by these sub-contractors or suppliers. WCL will also require security services to protect their assets and workers.

Potential Consequences

The flouting of the labor rights may result in non-compliance to local laws and bring labor dissatisfaction. This could further lead to labor unrest and pose risk to the smooth mining operation and ultimately commercial targets would not be met. It would also tarnish the corporate image.

The sub-contractors may not have same level of policy commitment or management systems to ensure compliance. Hence, this would create difference in levels of compliance of different operations. This would create a sense of unequal treatment and discrimination among groups of labor.

The white-collar employees or supervisory/executive staffs will face another set of human rights issues. Due to limited availability of skilled workforce in Liberia, the initial mining operation will involve deployment of migrant labors. Hence, there would be considerable diversity within the workforce. Work situations and workplace dynamics may result into discrimination or a sense of discrimination. Such conflicts at workplace will not only affect the work efficiency of employees, it would create possibilities of litigation.

The security requirement of WCL will be met by both private and public security agencies. The private security would be deployed to protect the assets of the WCL from trespassing, thefts or injuries may use disproportionate force and take law into their hand. Such unreasonable conduct of security personnel will comprise the dignity of the local population or employees and violate their human rights.

Significance of Impact

Table 60: Impact on Labor and Human Rights

Impact	Impacts on labour and human rights			
Impact Nature	Negative	Positive	Neutral	
	The impact nature is negative			
Impact Type	Direct	Indirect	Induced	
	The direct impact will be due to WCL run operations and indirect impact will include the sub-contractors providing services.			
Impact Duration	Temporary	Short-term	Long-term	Permanent
	The impact will continue throughout the project duration			
	Local	Regional	International	

Impact Extent	Thought the impact of WCL operation will be local, the impacts associated with the sub-contractors providing services will be spread across the region.				
Impact Scale	The impact could be on employees and many more in the supply chain.				
Frequency	till the life of the mine				
Impact	Positive	Negligible	Small	Medium	Large

Magnitude	Considering the impact characteristics and the company's e procedures the impact magnitude is assessed as small			
Receptor Sensitivity	Low	Medium	High	
	The local socio-political situation after the balanced and quite fragile. The local citizens are quite sensitive to the issues of discrimination and quite protective of their right.			
	Negligible	Minor	Moderate	Major
Impact Significance	Due to high receptor sensitivity, limited availability of skilled people and difference of skill levels and experience of local workforce there is a possibility of conflicts and opportunity for violation of labour and human rights. Hence the impact significance is rated as minor.			

Embedded Provisions

Vedanta has policies for Labor, equal opportunity and non-discrimination. It also has a policy for human rights and security personnel.

The Labor Law 1956 (and amended in 1989) provides guidelines, restrictions and penalties relating to recruitment, wages, hours of work and other conditions of employment. The labour law also contains provisions for Labor Organizations and freedom of associations of employees and employers.

Mitigation Measures, Management and Monitoring

The impacts on labor and human rights could be considerably reduced if they are avoided by regulating the conducts of workforce and improving work environment. Therefore, we recommended the following:

- An efficient management system should be followed for early identification of the issues and to ensure forums are available to discuss these issues;
- The labor law of Liberia recognizes freedom of association and collective bargaining. It is recommended that formation of a workers' organization should be encouraged; and
- Grievance Committees at various levels should be formed to provide platforms for discussion of issues and complaints. These committees should be encouraged to identify sensitive issues and conduct awareness and education programs for effective communication.

18.3.8 Impact of Migrated and Transient Population

Sources of Impact

In mining sector, it is estimated that every formal job with mine creates between 3 and 10 additional jobs in the project area (Projects and People: A handbook for Addressing Project-Induced In-Migration. Sep 2009). The migration forecast is done taking low, medium and high migration rates and average number of labors per day is presented in table below.

Table 61: Forecast of migration of different categories of manpower

Manpower Category	Total Man Power	Man Power Percentage from Local Area	Migrant Population	Migration Forecast		
				Low (3x)	Medium (6x)	High (10x)
Executive/supervisory	65	25%	49	147	294	490
Skilled	457	25%	343	1029	2058	3430
Unskilled	115	50%	58	174	348	580
Township Maintenance & Misc	20	50%	10	30	60	100
Drivers and Helpers	200	50%	100	300	600	1000
Total Manpower	857		560	1680	3360	5600

Thus, the project area will have an additional population in the range 1680 to 5600 due to mining operation. In addition to this migrant population, a large number of transient people will visit the project location to provide an array of services. Some of them will be day time visitors and would return back. However, it is expected that a few of them who would require spending a couple of days at project site will be required to stay for brief periods. Though, it is not possible to predict the volume of transient population, yet there will be a continuous presence of some transient population in project area. The service requirements will be mostly technical specialisation which is less likely to be available within Liberia. Hence, a large portion of the transient population will be international. Therefore, the transient population will belong to several ethnic groups, speaking a range of languages, and belonging to different nationalities.

Potential Consequences

The obvious consequence of in-migration to project area is increased demand for meeting the basic requirements of additional population in the area. However, the fundamental difference between the existing local population and the migrant population would be occupational. The local population leads a

subsistence life where they produce a large part of their basic needs. They sale a part of their products or undertake secondary activities to earn in cash to pay for additional requirements or to access civic services. In contrast to this subsistence life, the migrant population will be mostly non-producers. Hence, their requirement of food and other basic supplies will be met through the market transaction. As a result, the market economy in the area will tread a trajectory of expansion. The magnitude of the impact will depend on the resource base of the host area and scale of in-migration.

The migrant population is expected to settle close to the project location. The workers engaged in mining operation will be accommodated in the township or workforce accommodation facilities. However, the residential facilities will be provided only to a section of the workforce. Those who would not get residential accommodation in township or workforce accommodation facility will look for accommodation at a convenient location from where they can access the modern amenities and access to their workplace will be stress-free.

Thus, there would be natural tendency to concentrate in and around Tubmanburg which is the only urban center in project area. Nonetheless, there would be some part of migrant population; despite of their preference to share space in Tubmanburg will be forced to live outside of it. On the basis of studies of similar mining sites, we presume that 70 percent of the migrant population will be in Tubmanburg and the rest of them will be in other rural areas. Most of the rural population will be in Senjeh District of Bomi County as these areas have better connectivity in comparison to Bopolu District of Gbarpolu County. Hence, it is presumed that 20 percent of the migrant population will be rural areas of Senjeh District and 10 percent in Bopolu District. The spatial distribution of migrant population as per this presumption is presented in table below for low, medium and high influx scenarios.

Table 62: Spatial distribution of in-migrants in local area of Influence

District	Host Area Characteristic	2008 Population	2013 Projected Population	Influx Forecast					
				Low		Medium		High	
				Nos	%	Nos	%	Nos	%
Senjeh	Urban (Tubmanburg)	14576	18220	1176	6%	2352	13%	3920	22%
	Rural	1946	2238	336	15%	672	30%	1120	50%
Bopolu	Urban	0	0	0		0		0	
	Rural	233	268	168	63%	336	125%	560	209%
Total		**16755**	**20726**	**1680**	8%	**3360**	16%	**5600**	27%

In a low influx scenario, Tubmanburg will have 1176 additional population that would constitute 9 percent of the current population (projected population from 2008 census with an assumption of 5 percent annual

growth rate). The rural area around the Tubmanburg, that fall in Senjeh District will have 336 additional populations. Due to low population density in these areas, the migrant population will constitute 15 percent of the current population (the current population is estimated with a projection of population at 3 percent annual growth rate over 2008 census figures). Although only 10 percent of the estimated migrant population is likely to move into far off places in Bopolu District, it would be a huge (63 percent) addition to the current population in these areas. Hence, demographically, the far off rural areas would be far more impacted than the Tubmanburg.

In medium and high influx scenario and assumptions on spatial distribution of the migrant population being the same, the magnitude of impact in far off rural areas will be so much that migrant population will outnumber the current population. The demographic changes in Tubmanburg will be considerable which would be substantial to affect the socio-political life.

Tubmanburg is recognized as one of the seventeen urban centers in Liberia. The definition of the urban centers in Liberia is based on the population size, i.e, towns with more than ten thousand population are considered urban centers. Though Tubmanburg is considered as an urban center, its infrastructure and utility services are inadequate. Due to its connectivity to Monrovia, it acts as a trading center for many exported goods for local consumption. Tubmanburg has been the place for a number of small or medium enterprises such as Bomi Woods and Blue Lake Water. Mostly, these enterprises have used the natural resources such as logs, water or mineral in the area. The project area has limited capability in terms of providing specific services that a modern mining operation would require. A summary assessment of the Tubmanburg's capacity to service the migrant population is provided in table below.

Table 63: Screening of host area capacity to service in-migrant population

Social Infrastructure and Services	Capacity		
	Low	Medium	High
Working Age Population			√
Education	√		
Skills useful for Mining	√		
School Facility		√	
Higher Education Facility	√		
Health Care Facility		√	
Sanitation Facility	√		
Drinking Water Supply	√		
Electricity Supply	√		
Internal Road network	√		
Market Place	√		
Entertainment	√		

Tubmanburg is used as the epicenter for accessing modern services and goods for the towns located in and around the mining lease area. Hence, the social infrastructure available at Tubmanburg is already under stress leaving very little space for accommodating the requirements of additional in-migrant population. There is already a local trend of migration to Tubmanburg from its surrounding Towns/villages. This would further intensify as it grows and urbanization intensifies. As the northern part of the city is identifies as the mineralized area, hence the expansion of the city would be to the southern part of the city. Therefore, the physical space for additional habitation in Tubmanburg is restricted. Tubmanburg was an important location during the civil war and held a strategic significance. Its civil war legacy is a significant factor for ethnic relationships. In sum, Tubmanburg has a limited assimilative capacity for the migrant population.

On the basis of the socio-economic characteristics, communication facility, population density and existence of other social infrastructures, the in-migration footprint could be broadly predicted. Due to existence of good road and frequent transportation facility along the Tubmanburg-Monrovia road, the initial dispersion is predicted to follow this corridor. In subsequent years, as Tubmanburg-Mano River road is developed it is expected that communication along this road corridor will improve. The improvement in road transport will also have impact on other social services. Hence, this corridor would subsequently be in-migrant hotspot. It appears that the regional development will result a ribbon development along Monrovia-Mano River Road rather than being dispersed radially.

The social and community health impacts linked to in-migration will be experienced in following broad areas:

- Negative impacts on infrastructure, utilities and services;
- Negative impact on environment, natural resources and Eco-system services;
- Impacts on local economy and livelihood strategies; and
- Impact on Community Health.

The internal road network within Tubmanburg is under developed. The roads connecting important public offices and the main road with shops and markets are partially paved. The roads have congested stretches and require strengthening for intensive use. Road conditions in residential locations is worse and do not have rain water drainage system. Hence, road condition in rainy season deteriorates. Tubmanburg does not have sewage system and has limited capacity for solid waste disposal. Tubmanburg uses the old piped water supply infrastructure developed at the time of LMC operation. The supply of electricity is mostly

through diesel generators and not sufficient to meet the current demand. Hence, affluent residents and institutions use private Generators. Tubmanburg has a hospital which was established at the time of LMC and community from far off places depend on this. The health care system is heavily supported by donor funding and do not collect any user fee. Therefore, additional pressure on the existing infrastructure, utilities and services will require their planned expansion and efficient management.

There would be a significant impact on the local environment due to in-migration too. The point specific environment impacts such as air, noise, water and soil pollution though would be minimized and mitigated, yet changes in the environmental parameters will cause some level of discomfort at Tubmanburg and habitations close to the production area. Other environmental impacts linked to the in-migration would be change in land-use, depletion of natural resources (firewood, water and wild animals), exploitation and loss of bio-diversity, logging and deforestation. (please refer Section Chapters 11, 12 and 19 for detailed discussion on these environment impacts). Increased demand for natural resources will not only deplete these resources, it also creates possibilities of dispute over land use and user rights on common property resources.

The local economy will undergo fundamental changes and have different impacts on different classes of people. The benefit of the project will have unequal distribution of benefits widening the economic disparity in local population. As the economy is integrated into the mainstream market economy, subsistence producers will be further marginalized and would face impoverishment. The availability of cash income with a section of people employed in mining operation or related activities will create demand for daily consumables. The cost of the land, housing, fuel and food will surge up.

Consequently, the cost of living of the area will increase and give way to relative poverty. The vulnerability of the marginal groups such as women and elderly population will proliferate.

Increase in traffic and use of heavy machinery will see a corresponding rise in incidence of accidents and fatalities. Increased pollution levels will also affect the physical wellbeing of local populace. As economic activities rise and more and more people use public space, the public hygiene facilities need to be expanded and maintained. Due to the migration and transient population chances of proliferation of communicable diseases including sexually transmitted infections, respiratory infections, water-borne and vector borne diseases will be more frequent. The collective impact on environment, economy, public infrastructure and health risks will demand better planning, governance and social control.

Significance of Impact

Table 64: Impact of Migrated and Transient Population

Impact	Impacts of in-migration and transient population				
Impact Nature	Negative		Positive		Neutral
	Though in-migrants will fill the skill gap and contribute to the local economy, there would be a wider array of adverse impacts too.				
Impact Type	Direct		Indirect		Induced
	The in-migration will be both due to direct employment opportunity and indirect opportunities for employment or even to take other associated project benefits.				
Impact Duration	Temporary	Short-term		Long-term	Permanent
	It would span over the operation period.				
Impact Extent	Local		Regional		International
	The impact of in-migration would be local.				
Impact Scale	Taking multiple factors into consideration, the influx rate is expected to be medium to high.				
Frequency	Recurrent, though the scale will be low in subsequent period				
Impact Magnitude	Positive	Negligible	Small	Medium	Large
	Depending on the influx rate, the magnitude will vary from medium to large.				
	Low		Medium		High
Receptor Sensitivity	The public support and expectation from the project is high. However, Tubmanburg was a strategic location in civil war and it has limited social infrastructure to support the migrant population. Considering both the aspects, the receptor sensitivity is assessed as medium.				
Impact Significance	Negligible	Minor		Moderate	Major
	Overall, the significance of the impact of migrated and transient population will be minor.				

Embedded Provisions

Clause 8.1 of the MDA states that it is the obligation of the Company to develop programs for the development and maintenance of the economic and social viability of the centres of population that have formed and they may form as a result of operations during the term of agreement. However, the Company shall be under no obligation to provide financial assistance or otherwise commit resources for the purpose of achieving such plans and programs other than as specified in this agreement.

The mandatory obligations of the company in this regard are as follows:

- The Company shall pay to the Government a fee of US$25,000,000 (the “Up-Front Payment”);

- Company shall provide 'annual social contribution' of 2million USD for the first year, 2.5million USD for second year, 3.1million USD from the third year and thereafter adjusted annually for inflation;
- The Annual Social Contribution and utilization of such funds for specific projects shall be managed by a dedicated committee (the "Committee") in accordance with the structures established by the Government in consultation with the Committee from time to time;
- The Company shall at all times have at least one representative on the Committee. The structures and processes of this Committee will be established to provide for the participation (in a decision-making or advisory capacity as the Government shall determine from time to time) of officials, businesses and residents from the affected counties in the identification and selection of projects to be supported with funds from the Annual Social Contribution;
- No funds shall be disbursed from the Annual Social Contribution, if, in the Company's view, the disbursement of the funds or the project supported by the funds would cause the Company to be in violation of applicable Law, including any applicable anti-corruption laws;
- Funds from the Annual Social Contribution may be disbursed (A) only for direct delivery of services and community Infrastructure improvements, and not to fund the general work programs of administrative offices or officials save funding of customary and reasonable compensation and benefits for the Committee's administrative assistant and of reasonable amount for basic office supplies;
- Projects supported with funds from the Annual Social Contribution and the actual disbursements from the Annual Social Contributions shall be publicly disclosed and shall be subject to the same audit procedures provided for expenditures by the Government of Liberia;
- The Company shall, either directly or indirectly, ensure access to housing for the employees of the Company and their resident family members;
- Access to housing under Section 9.3, will include provision for a clean and safe pipe-borne water system for all houses and at workplaces. All drinking water shall meet or exceed the approved Government standards for drinking water quality;
- Medical Care Facilities for Company Workers and 'Reasonable Access' to local communities;
- The Company will, directly or indirectly in conjunction with the Ministry of Education, ensure that there is available free primary and secondary education (K-12) to the resident dependent children (up to the age of 21) of

- the Company's employees and of Government officials and/or employees assigned to and regularly employed in a Production Area in an official capacity and who are resident in or adjacent to such Production Area;
- The Company shall plan for the installation of one or more Power Plants in order to meet the Company's reasonable needs for conducting Operations in Liberia and an excess electricity to supply third party users within a 10 Kms radius with appropriate arrangement of charging necessary users fee based on the market price;
- The Government may limit the access of the Company to any such infrastructure to the extent necessary to meet the demands of the general public, but in any such case of insufficient capacity to provide for the needs of both the general public and the Company (and users similarly situated with the Company), the Minister and the Company (and such similarly situated users) shall in good faith consider how additional capacity can be provided in a manner that fairly allocates the additional costs of providing and operating capacity in excess of that required by the general public to the Company (and others similarly situated); and
- The Government shall use its reasonable efforts to assist the Company to integrate any item of Infrastructure acquired or constructed by the Company under an approved Feasibility Report with similar existing public utilities to the extent required by the Company and to the extent reasonable in connection with Operations and consistent with the needs of the general public.

Mitigation Measures, Management and Monitoring

The embedded provisions in MDA include water supply, sanitation and health care facilities for employees. The health care facilities and education facilities will be extended to others on imposition of a reasonable users' fee. The energy requirement will be met by designing a power plant that would be sufficient to meet the power requirement. Apart from this, WCL is also making up-front payment and an annual social contribution which could be used for further expansion of the public infrastructure and civic amenities in project area. Thus, the embedded provisions address the infrastructure gaps. Hence, the impact significance on count of public infrastructure and civic services would be negligible or minor.

However, a strategy is required to limit the influx to a manageable level. The influx management strategy needs to cover the following aspects:

- Promotion of regional diversified growth strategies;
- Access control to remote areas;

- Spatial planning and administration for effective squatter regulation;
- Planning infrastructure services and utilities;
- Including migrants as an important stakeholder group in stakeholder engagement.

18.3.9 Impact on social Infrastructure and amenities

Sources of Impact

The social infrastructure and amenities are crucial to create sustainable communities. Communities need access to schools, shops, road, public transport, electricity, telecommunication, water supply, sanitation, and health services to lead a quality life. These resources reflect the basic framework of society to facilitate formation of social capital (mutual trust, reciprocity, relationships, communications, and interconnectedness between groups). The formation of the social capital is crucial for social sustainability[17].

The mining operation is expected to bring 1680 to 5600 more people to the project area. The mining operation and other services linked to it would provide the economic opportunity to these migrants. However, their quality of life will depend on their access to basic services and their peaceful integration into the host community.

Potential Consequences

The satisfaction of the local residences is affected by the growth and rapid urbanization of the area. These factors shape how inclusive, peaceful, and tolerant host communities feel for the in-migrants and have a direct impact on local issues. Hence, we include here a brief assessment of the existing level of social services in local area of influence and the consequences of project induced migration would have upon these services.

The socio-economic sample survey in project area included questions on basic social services and quality of the amenities. The drinking water supply in the project area is mostly through hand pumps or wells in urban area of Tubmanburg. The rural areas though have access to hand pump, households equally access natural springs/ creeks for sourcing their water (See *Table 65* for details).

Table 65: Source of Drinking Water for households within Local Area of Influence

Area Characteristic	hand dug well	hand pump	natural spring/creek	river/ marshland	Grand Total

[17] One of the Definition is: '*Social sustainability is: a life-enhancing condition within communities, and*

Urban (Tubmanburg)	14%	71%	0%	14%	100%
Rural- Senjeh District	0%	45%	55%	0%	100%
Rural- Bopolu District	9%	64%	27%	0%	100%
Grand Total	**7%**	**59%**	**29%**	**6%**	**100%**

Increase in water extraction from these sources will reduce the water volume and increase in anthropic use will increase the pollution level. Hence, population in rural areas need to have better access to the ground water and reduce the burden on natural springs and creeks to meet their ecological functions.

Households in project area already face water scarcity. 61 percent of households within Tubmanburg also report water supply scarcity for 1 to 3 months in a year. The water scarcity situation is worse in rural areas in Bopolu District, where 91 percent households report scarcity for 1 to 3 months. For another 9 percent households, the water scarcity is faced for a long period ranging between 3 to 6 months. Hence, more people in the project area are likely to worsen the situation of access to drinking water.

Table 66: Scarcity of Water reported by households within Local Area of Influence

Area Characteristic	No Scarcity	Scarcity for 1 to 3 Months	Scarcity for 3 to 6 Months
Urban (Tubmanburg)	21%	61%	18%
Rural- Senjeh District	3%	68%	29%
Rural- Bopolu District	0%	91%	9%
Grand Total	**10%**	**69%**	**21%**

The sanitation facility in project area is limited. 39 percent of the total households in project area (refer Table 18.34) do not use latrine and go for open defecation. The open defecation is highest in rural areas falling in Senjeh district. Pit latrines are used both in Tubmanburg and the rural hinterlands. Use of flush toilet is only limited to 7 percent of the urban population living in Tubmanburg. Increase in population density in Tubmanburg will reduce the availability of sufficient open space to shift the pit latrines. Hence, safe disposal of human excreta and maintenance of environmental sanitation for a larger population at Tubmanburg will be a big challenge.

Table 67: Sanitation Facilities of the households within Local Area of Influence

Area Characteristic	no latrine	pit latrine	flush toilet/ septic tank	Grand Total
Urban (Tubmanburg)	21%	71%	7%	100%
Rural- Senjeh District	65%	35%	0%	100%
Rural- Bopolu District	9%	91%	0%	100%
Grand Total	**39%**	**59%**	**3%**	**100%**

The project area lacks access to electricity. Only 7 percent of the households in Tubmanburg and 3 percent of the households in rural-Senjeh have electric connection to their houses. The entire rural area falling in Bopolu district do not have electricity supply. People use palm oil, kerosene for lighting and firewood or charcoal for cooking. Hence, increase in population will also increase the consumption of fire wood, charcoal and extraction of palm oil.

Table 68: Electricity Supply to households within Local Area of Influence

Area Characteristic	No Electricity	Have Electricity	Grand Total
Urban (Tubmanburg)	93%	7%	100%
Rural- Senjeh District	97%	3%	100%
Rural- Bopolu District	100%	0%	100%
Grand Total	**96%**	**4%**	**100%**

Access to education institution is also not satisfactory in project area. Only 23 percent towns in rural-Senjeh and 27 percent towns in rural Bopolu have primary schools in their township. The junior secondary and senior secondary schools are only located in Tubmanburg.

Table 69: Access to Education Infrastructure within Local Area of Influence

Area Characteristic	In the Same Town		
	Primary School	Junior Secondary	Senior Secondary
Urban (Tubmanburg)	96%	75%	75%
Rural- Senjeh District	23%	0%	0%
Rural- Bopolu District	27%	0%	0%
Grand Total	**53%**	**30%**	**30%**

The towns for which education institutions are not present within their town access these services from the nearest town. The access to these institutions in terms of commuting time is presented in Table 18.37. It is significant to note that there are 14 percent households who need to travel more than an hour to send their children to school. The rural areas falling in Bopolu district have very limited access to junior secondary and senior secondary schools, and they need to travel more than an hour to reach these facilities. On the whole, education facilities are not adequate in project area. Hence, to ensure education to all children, there will be need to expand the school infrastructure.

Table 70: Commuting time to access the nearest education facility

Area Characteristic	< 30 Min			30-60 Min			>60 Min		
	Primary	*Junior Secondary*	*Senior Secondary*	*Primary*	*Junior Secondary*	*Senior Secondary*	*Primary*	*Junior Secondary*	*Senior Secondary*
Urban (Tubmanburg)	0%	100%	80%	0%	0%	20%	0%	0%	0%
Rural- Senjeh District	23%	0%	0%	64%	46%	52%	14%	54%	48%
Rural- Bopolu District	63%	0%	0%	38%	14%	14%	0%	86%	86%
Grand Total	**33%**	**15%**	**11%**	**57%**	**33%**	**40%**	**10%**	**51%**	**49%**

Source: ESIA HH Survey

Similarly, access to hospital in project area is also not satisfactory. Local community access health care from herbalists and small clinics located at Gokala, Jhalong, Johny Long, Nyeilah and Yomo Town. Tubmanburg has a referral hospital with strength of more than 100 beds for in-patients. Due to lack of good road and transportation system, time taken to reach hospital is more though physical distance may be less. Even in Tubmanburg, 46 percent households take more than half an hour to reach hospital. More than half the towns in rural areas (see details in *Table 18.38*) take more than an hour to reach nearest health care facility.

Table 71: Access to nearest medical facility in towns located within local area of influence

Area Characteristic	< 30 Minutes	30-60 Minutes	> 1 Hour	Grand Total
Urban (Tubmanburg)	50%	46%	4%	100%
Rural- Senjeh District	3%	32%	65%	100%
Rural- Bopolu District	9%	36%	55%	100%
Grand Total	**23%**	**39%**	**39%**	**100%**

The presence of other basic infrastructure such as road/ transport, telecommunication, solid waste management, and security/ law and order services were also found severely lacking. In Tubmanburg only half of the households are satisfied with the road and transport facilities, and there are 7 percent households which do not have road connection (refer *Figure 18.4*). The rural areas transport and road

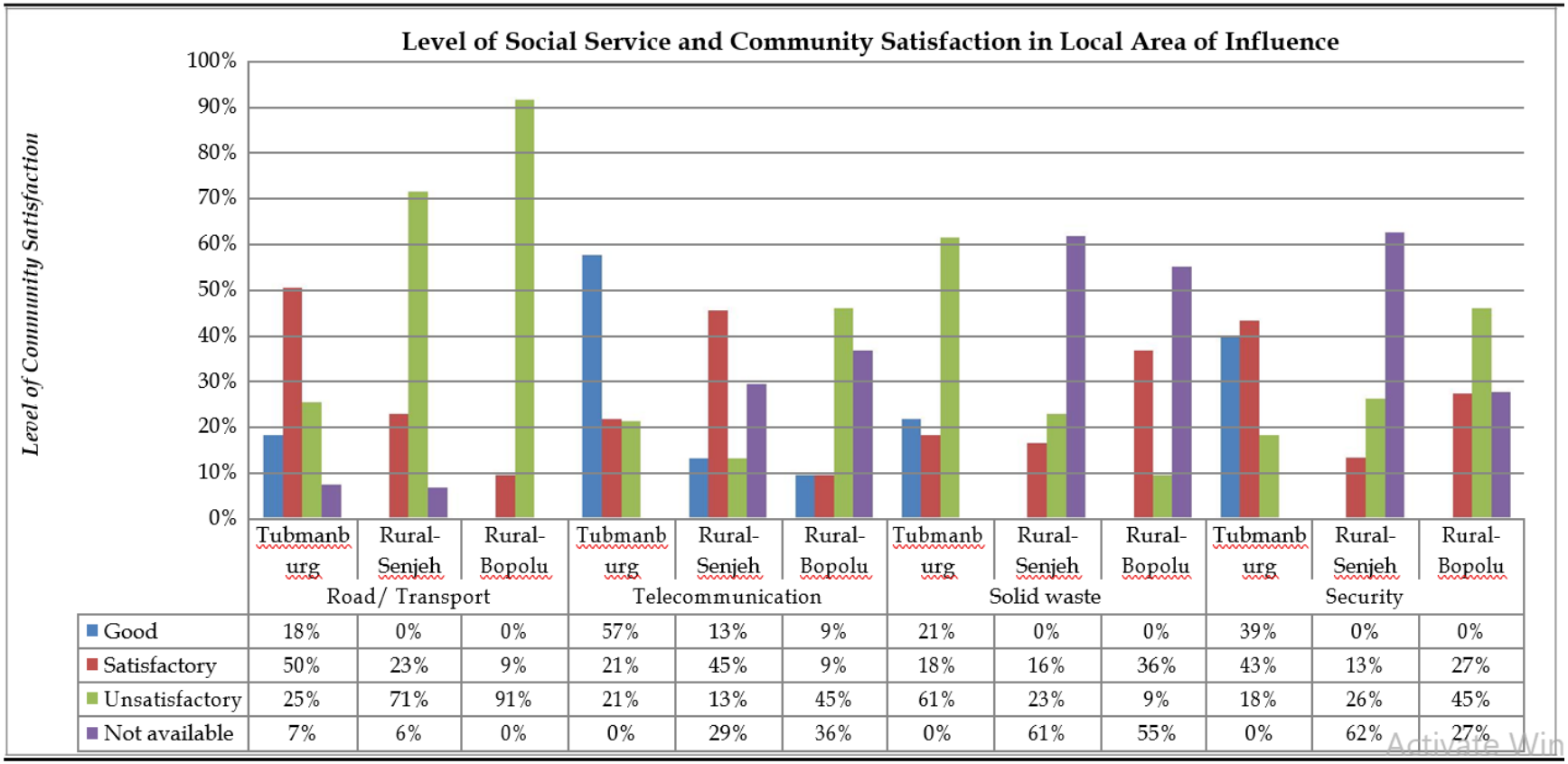
connectivity is not satisfactory. The rural areas falling in Bopolu district are remotely located and 91 percent households indicate their dissatisfaction.

The telecommunication services are not available to 29 percent of the households in rural area of Senjeh and 36 percent of the rural areas within Bopolu District (refer *Figure 18.4*). The telecommunication coverage is better in rural areas in Senjeh District in comparison to that of the rural areas in Bopolu district. In Tubmanburg, 57 percent say that telecom services are good, 21 percent say its satisfactory and the remaining 21 percent are not satisfied.

The waste management in Tubmanburg is rated good by 21 percent households, 18 percent say satisfactory, and 61 percent are not satisfied (refer *Figure 18.4*). Majority of the households in rural areas report no waste management to be in practice. 23 percent in rural Senjeh and 9 percent in rural Bopolu find the waste disposition and environment sanitation as unsatisfactory. However 16 percent of households in rural Senjeh and 36 percent households in rural Bopolu are satisfied on the cleanliness and solid waste management in their towns.

The law and order and security services are only available at Tubmanburg. 39 percent of the households in Tubmanburg say the security services as good and another 43 percent are satisfied. Only 18 percent of the households (refer *Figure 18.4*) express dissatisfaction on the level of security service in Tubmanburg. A high percentage (62 percent) of households in rural Senjeh report security services do not exist. Rural areas of Bopolu have better existence of security services, but are not satisfied with the level of protection.

In sum, the existing level of satisfaction on the social infrastructure and amenities is poor. Hence, the host population would see any competition in accessing these services as undesirable. Therefore, the sensitivity of the host population to accept the in-migration is expected to be high. The in-migrant population will try to stay close to Tubmanburg due to presence of better social infrastructure. In this manner Tubmanburg as an urban center will face the challenges to meet these civic demands.



	Road/ Transport			Telecommunication			Solid waste			Security		
	Tubmanburg	Rural-Senjeh	Rural-Bopolu	Tubmanburg	Rural-Senjeh	Rural-Bopolu	Tubmanburg	Rural-Senjeh	Rural-Bopolu	Tubmanburg	Rural-Senjeh	Rural-Bopolu
Good	18%	0%	0%	57%	13%	9%	21%	0%	0%	39%	0%	0%
Satisfactory	50%	23%	9%	21%	45%	9%	18%	16%	36%	43%	13%	27%
Unsatisfactory	25%	71%	91%	21%	13%	45%	61%	23%	9%	18%	26%	45%
Not available	7%	6%	0%	0%	29%	36%	0%	61%	55%	0%	62%	27%

Source: ESIA HH Survey

Figure 6: Level of Social Services and Community Satisfaction in Local Area of Influence

Significance of Impact

Table 72: Impact on social Infrastructure and amenities

Impact	Impact on social infrastructure and amenities due to project induced migration to the project area.				
Impact Nature	Negative		Positive		Neutral
	the in-migration is predicted to put additional stress on the existing social infrastructure. It will deteriorate the quality of services and make access more difficult for people..				
Impact Type	Direct		Indirect		Induced
	The impact is linked to the in-migration which is induced due to mining operation.				
Impact Duration	Temporary	Short-term		Long-term	Permanent
	The impact will continue for a long time and keep pace with the expansion of the mining operation and industrialisation of the area.				
Impact Extent	Local		Regional		International
	The impact will be mostly local as in-migrants will try to settle at locations close to Tubmanburg.				
Impact Scale	The impact will be mostly on the infrastructure available at Tubmanburg.				
Frequency	Continuous				
Impact Magnitude	Positive	Negligible	Small	Medium	Large
	Tubmanburg serves as an urban hub providing education facility, medical services and market place for towns in its catchment. The social infrastructures here are already under pressure and would not be able to meet additional demands. Hence, we anticipate a large impact on the social infrastructures in project area.				
Vulnerability of Social Receptor	Low		Medium		High
	The social infrastructures and amenities are prerequisites for development and Government of Liberia with the help of aid agencies is expanding the basic services. The MDA signed between WCL and GoL also builds obligation of developing and expanding social infrastructure in project area in partnership with GoL through the social development fund. Considering the awareness on this possible impact and planning provisions the vulnerability of the social receptor is rated as moderate.				
Impact Significance	Negligible	Minor		Moderate	Major
	The impact on the social infrastructure will be shared through provisions of medical, housing, education, and electricity supply provisions for its employees which would be shared with the local community with a reasonable user's fees. Hence, the impact sign				

Embedded Provisions

WCL has agreed to make following improvements in social infrastructures:

- a two-lane asphalt paved all-weather road from Tubmanburg to Mano River (Kongo) for general public use with capacity of handling heavy traffic. (ref clause 6.6 of MDA)
- Provision for a clean and safe pipe-borne water system for all houses and at workplaces. (ref. clause 9.5 of MDA)
- Medical care facilities for company workers and reasonable access to local communities with imposition of reasonable fees. (clause 10 of MDA)
- Free primary and secondary education to resident dependent children of the company's employees and government officials and who are resident in or adjacent to such production area through the contribution of General Education fund. (clause 11.3(d) of MDA)
- The Government shall use its reasonable efforts to assist the Company to integrate any item of Infrastructure acquired or constructed by the Company under an approved Feasibility Report with similar existing public utilities to the extent required by the Company and to the extent reasonable in connection with Operations and consistent with the needs of the general public. (clause 19.8(b) of MDA)
- WCL will establish Power Plant that shall be designed to generate a quantity of electric energy in excess of the electric energy required by the Company for Operations to supply third party users located within a 10 km radius and charge third party users as per market price. (clause 19.3 of MDA)
- *Mitigation Measures, Management and Monitoring*
- The capacity and quality of social infrastructure and amenities should be planned keeping the influx magnitude in mind and should be futuristic to achieve sustainable social development of the community;
- Social infrastructure in rural hinterland should be developed in order to prevent concentration of all services and amenities at Tubmanburg. The planning for development of basic services should be based on the premise of equitable distribution of project benefits.

18.3.10 Impact on Public and Community Security and Safety

Sources of Impact

Some of the activities in mining operation will have community interface and thereby posing potential threat to public safety. The impact on public safety and security emerges from three sources.

 The safety of the community living close to the production area, particularly close to mining pit where blasting will be carried out regularly.

 The security arrangements made in mining operation area would restrict the public movement.

 The in-migrants and transient population in the project area may engage in illegal activities. Increase in these criminal activities will affect the public security and safety.

Potential Consequences

The blasting of rocks for extracting ore will be done by qualified skilled workers in compliance with standard operation procedure of WCL which follows the best technology and practices in mining industry. The safety regulations need clearance of 500m from the point of blasting to prevent any injury or loss due to chances of being hit by flying rocks. The Zalakai and Borbor are located close to the boundary of mining pit. The mining will progress from the eastern side of the mining pit. The distance of Zalakai and Borbor from the blasting spot during initial years of operation is 1100 mts and 2000 mts respectively. However, as per the mining progression plan, these towns and their farm lands will come within the 500m blasting zone in 5-10 years. Nonetheless, inhabitants of these towns may stray into the blasting zone and thereby jeopardise their safety.

The security staff will be deployed in the mining area and other operation zones to protect WCL assets and restrict any unauthorised entry. As there would be public roads that connect different premises of WCL operation, public entry and exit will be required to pass through security scrutiny. These restrictions are potential areas for the local community to feel unnecessary compromises with their freedom.

Significance of Impact

Table 73: Impact on Public and Community Security and Safety

Impact	The safety and security of the public and community will be affected due to blasting, movement of heavy vehicles on public roads and in-migration of transient population.		
Impact Nature	Negative	Positive	Neutral
	The nature of impact is negative		
Impact Type	Direct	Indirect	Induced
	The impact on safety of Communities at Borbor and Zalakai would be direct.		

Impact Duration	However impact on public security is indirect and linked to extraneous factors.				
	Temporary	Short-term	Long-term	Permanent	
	The safety concerns linked to blasting and public safety will be perennial and long term(till the life of mine).				
Impact Extent	Local	Regional	International		
	Blasting impact is limited to communities living close to the blasting site or mining pit. The public security issues may be surfaced in WCL operation area and in Tubmanburg.				
Impact Scale	There are several community interfaces with proposed mining operation. For example, the ore transportation route is close to a public school located at North Gate. There are several office complexes interspersed within different project component sites. However, the current public activities at the western side is minimum as most of the market place is on the other side of the city.				
Frequency	continuous				
Impact Magnitude	Positive	Negligible	Small	Medium	Large
	Considering the nature of few public offices located in operation area, it is anticipated that number of people who are not linked to mining operation will be less. WCL has policies and operation procedures for blasting and security. Hence, it is expected that impact magnitude will be small.				
Vulnerability	Low	Medium	High		

Embedded Provisions

WCL has a standard operating procedure for blasting to ensure safety of the workers and community around the blasting location. It also has a security and human rights policy which sets out requirements and procedures for security management.

Mitigation Measures, Management and Monitoring

- The communities of Borbor and Zalakai should be made aware about the blasting process and hazards associated with it. Volunteers from these communities should be incorporated to seek cooperation and coordination between community members and WCL staff carrying out the blasting.
- An effective grievance mechanism should be designed and executed to allow public to register their complaints regarding behaviours of the security staff. Each of these complaints should be investigated and appropriate action should be initiated as per the law.
- There should be greater coordination between the security engaged by WCL and the Policing operation by Government.

18.3.11 Impact on Cultural Heritage

Sources of Impact

During the process of ESIA studies, the cultural heritage sites found are depicted in Fig. 18.5. The by-pass road proposed for ore transportation to avoid the internal city roads in Tubmanburg at some stretches has a few graves built close to the current road alignment. Similarly, the road connecting Borbor and Todemai to the Mano River Road passes through the grave sites. In both these places, the road widening should be planned with utmost care to avoid any physical impact to the graves.

Potential Consequences

. The graves would be frequently trespassed by pedestrians using the road. There is a possibility of physical damage to these structures due to vehicle accidents.

Significance of Impact

Table 74: Impact on Cultural Heritage

Impact	Impact on cultural properties and spaces due to movement of machines, vehicles and people.				
Impact Nature	Negative		Positive		Neutral
	The loss of memorials, graves, and sacred spaces will hurt public sentiment.				
Impact Type	Direct		Indirect		Induced
	These impacts are directly linked to the project operations.				
Impact Duration	Temporary	Short-term		Long-term	Permanent
	The physical removal or relocation of these assets is ruled out by careful lay out of the project components. Hence, the impacts will be mostly of the nature of trespassing or accidental damage to some of the structures which lie too close to project operations. Hence, the impact is considered temporary.				
Impact Extent	Local		Regional		International
	The impact will be local and mostly restricted to a few locations.				
Impact Scale	The impact is limited to two road stretches on which graves are located on both sides. The total road length on which these graves are noticed would be around 500m. (See Fig 18.5) for spatial dispersal of identified structures with cultural significance.				
Frequency	continuous				
Impact Magnitude	Positive	Negligible	Small	Medium	Large
	Considering the scale and nature of cultural properties, the impact magnitude is assessed as negligible.				
Vulnerability of Social	Low		Medium		High
	The local population shows willingness to shift these structures if necessary after performing appropriate rituals and with prior consultation with them and				

Receptor	traditional leaders.			
Impact Significance	Negligible	Minor	Moderate	Major
	Therefore, the impact significance is assigned as negligible.			

Mitigation Measures, Management and Monitoring

- The detailed design for the by-pass road and other internal roads connecting the production area and waste-dump area should be prepared after a careful mapping of existing graves and other culturally significant structures.
- The road alignment should be adjusted to the extent possible to avoid any physical impact to the existing structure. If there is no scope to avoid the impact, then traditional leadership should be consulted to advise on the remedial ritual performance and to select an appropriate place for moving the concerned structure.
- Appropriate signage should be put along the road warning vehicles and pedestrians of trespass to avoid damage to these structures.
- These grave sites are used by the public to perform rituals and pay respect. The traffic restrictions and appropriate arrangements to facilitate peaceful observance of the rituals should be arranged in collaboration with the Government and Local Committee.

18.3.12 Multiple Impacts on Borbor and Zalakai Town

Sources of Impact

Borbor and Zalakai would experience multiple impacts. Some of the impacts will be felt at these two settlements owing to their proximity to the mining production area. The list of such impacts is provided below:

- psychological stress from the possibility of relocation.;
- loss of access to common property resources such as forest land, hunting ground etc.;
- impact of vector borne diseases and communicable diseases;
- loss of private properties such as farm land, plantations falling within the blasting zone;
- being target of the opportunistic settlers for claiming resettlement benefits;
- impact on its fresh water resources;
- loss of soil fertility and agricultural production;
- nuisances including movement of heavy vehicles, noise, air pollution; and

- Cumulative impact on their livelihood and community life.

Potential Consequences

The impacts will gradually build up on economic and social life of Borbor and Zalakai community with the progress of mining operation. A broad sequence and probable time-frame on which these impacts will be experienced is summarized in *Table 18.42* below.

Table 75: Sequence and scheduling of social and community health impacts at Borbor and Zalakai settlements

Impact Title	Probable Schedule
Psychological stress from the possibility of relocation	Borbor and Zalakai population is facing this situation at present.
impact on its fresh water resources	The dewatering of Blue Lake (old LMC pit) during the construction stage and in the beginning of the production stage may impact the fresh water resources in these adjacent villages.
Being target of the opportunistic settlers for claiming resettlement benefits	As the information on their resettlement possibility becomes public, these locations may be targeted by opportunistic settlers. This will create tension and hamper peace and security of these communities.
loss of access to common property resources such as forest land, hunting ground etc.	communities may lose access to the forest resources within the demarcated production area.
Gradual loss of soil fertility and agricultural production	As the production in mining increases, the impact on soil fertility, change in soil moisture, and increase in air pollution may impact the farm productivity. There will be limited options available for slash-n-burn practices too.

Impact Title	Probable Schedule
Impact of vector borne diseases and communicable diseases	Due to their proximity to the construction sites and production area, they may have health risks from vector borne and communicable diseases.
Nuisances including movement of heavy vehicles, noise, air pollution; and largely	As the production process starts the nuisance intensity will grow
Loss of private properties such as farm land, plantations falling within the blasting zone	As the mining operation progresses closer, the distance of the blasting location will reduce. Once the properties and residences comes within the blasting zone , community members will have to forego access to these assets.

The cumulative impact of these impacts will bring a significant change in the economic and social life of these two communities. Borbor is expected to cross the threshold of acceptable level of inconvenience and risks after 5 years. Zalakai would experience this somewhere around 10th year of starting of mining operation.

Significance of Impact

Table 76: Multiple Impacts on Borbor and Zalakai Town

Impact	Borbor and Zalakai will experience multiple challenges due to their proximity to the mines production area, which will impact their quality of life.			
Impact Nature	Negative		Positive	Neutral
	The impacts on Borbor and Zalakai Community will increase as the mining operation progress and production capacity is enhanced. Hence, exposure to the risks and inconvenience will gradually cross the threshold and would make relocation necessary.			
Impact Type	Direct		Indirect	Induced
	The impact is indirect and cumulative of both other direct and indirect project impacts.			
Impact Duration	Temporary	Short-term	Long-term	Permanent
	The impact will persist throughout the mining operation and intensity would grow over the time.			
Impact Extent	Local		Regional	International
	The impact will be limited to Borbor and Zalakai settlements			
Impact Scale	The impact will affect 80-90 households residing in both settlements.			

Frequency	continuous				
Impact Magnitude	Positive	Negligible	Small	Medium	Large
	Though multiple factors are affecting population at Borbor and Zalakai, the impact magnitude is assigned as medium considering the number of households residing in these settlements.				
Vulnerability of Social Receptor	Low	Medium	High		
	The locations for settling down post-civil war were carefully selected keeping the ethnic relationships, peace and security in mind. Further, displacement will compromise their security of tenure. People have invested on improvement of their land and construction of houses to stabilize their household economy. Relocation will mean restarting their life again. Hence, their vulnerability is rated as high.				

Mitigation Measures, Management and Monitoring

Keeping the nature of the impacts, overall risks, stakeholder feedback and the overall socio-economic context of the project we recommend following mitigation measures:

- A census of Borbor and Zalakai settlements should be carried out after the obtaining the mining license. The census should achieve the following objective:
    - Prepare a comprehensive list of residents of these two settlements.
    - Define the socio-economic baseline for a list of indicators linked to each of the social and community health impacts.
    - A photo and video documentation of all important natural resources and productive assets to be made for future reference.
    - The quality of ground water, surface water, soils, and economically significant plants should be recorded.
- Monitoring Program should be prepared covering community health, demographic, economic and ecological indicators/parameters. The frequency for monitoring each category of parameters would be as follows:
    - Demographic changes- Annual
    - Economic or livelihood indicators- Annual
    - Ecological indicators- Seasonal
    - Health Indicators- Seasonal
- Effectiveness of all mitigation measures suggested for environmental and ecological impact mitigations should be monitored on regular basis.

- A summary of monitoring results will be presented to 'Social Contribution Committee'/ Resettlement Committee constituted for the project every year for their review.
- The Social Contribution Committee/ Resettlement Committee will review the requirement of displacement and relocation of Borbor/ Zalakai settlments and if required will consult with the concerned community and take a final decision.
- WCL will organize to prepare a detailed Resettlement Action Plan (RAP) based on the Resettlement Policy Framework (*Annex 18-A*) submitted along with this report.
- The identification of the Resettlement Site will be done in consultation with the concerned community and Government of Liberia and relocation schedule will be communicated to the community well in advance.

18.4 Closure Phase Social and Community Health Impacts

18.4.1 Public and Community Health

Sources of Impact

There are some impacts which continue even after the mining operation ceases. The rocks which are exposed to atmosphere will react to several elements and may contaminate water. The use of these contaminated water directly or indirectly through the food chain will expose the local community to health complications.

Potential Consequences

The consequences of usage of contaminated water may lead to water borne diseases, hence, the local health services need to be prepared to diagnose the health issues related to contaminated water and advise/educate local people for prevention.

Significance of Impact

Table 77: Public and Community Health

Impact	The public and community health will be compromised due to water pollution resulting from the mining pit and waste dump area.		
Impact Nature	Negative	Positive	Neutral
	The impact will have health impacts on community members.		
Impact Type	Direct	Indirect	Induced
	The impact on health will be through consumption of contaminated water or		

	food items produced by using such contaminated water.				
Impact Duration	Temporary	Short-term		Long-term	Permanent
	The impact will continue till the contaminants exist in the water.				
Impact Extent	Local		Regional		International
	The water contamination is expected to affect the nearby locality more intensely than far off localities.				
Impact Scale	As Tubmanburg is a town of high population. The population of the project area is expected to rise rapidly after starting of the mining operation. Hence, it is expected that water contamination will expose a large number of people to ill health.				
Frequency	continuous till contaminants are drained off				
Impact Magnitude	Positive	Negligible	Small	Medium	Large
	Considering the higher population density in the locality, the impact magnitude is assigned as medium.				
Vulnerability of Social Receptor	Low		Medium		High
	The project area will have a better medical facility with improved diagnostic services. This would help detection and monitoring any such health complaints in local area. Hence, vulnerability of social receptor is considered low.				
Impact Significance	Negligible	Minor		Moderate	Major
	Considering the impact scale in one hand and vulnerability of social receptor on the other, the impact significance for this is assigned as minor.				

Mitigation Measures, Management and Monitoring

- Environment monitoring should continue post closure phase to identify any contaminated water and adopt remedial measures.
- The public health services should be prepared to diagnose and provide curative health services to reprieve the impacted population.

18.4.2 Containment Structure Maintenance (waste rock piles, mining slopes, tailing ponds etc.)

Sources of Impact

The containment structures in waste dump, tailing pond and within the mining pit get attention and maintenance while the production of the mining continues. Once the operation ceases, these structures may not be examined and monitored regularly. These structures, irrespective of their design to withstand natural processes, may develop breaches either due to natural calamities or being constantly exposed to weather conditions for a long time. In such circumstances, they could be seen as a threat to public safety and community health.

Potential Consequences

The collapse of the waste dump if any would result in landslide. The rolling stones or eroded soil can damage life and properties located close to the natural drainage line. Similarly, in case of any breach in tailing dam the wash away tailing soil would contaminate the watercourse and impact the riparian ecology. As the productive resources such as farmlands and eco-system service components are impacted, it would ultimately may have adverse impact on livelihood of the local community.

Significance of Impact

Table 78: Containment Structure Maintenance (waste rock piles, mining slopes, tailing ponds etc.)

Impact	The structural stability and safety of the containment structures including waste rock piles, mining slopes and tailing ponds/reservoirs could be affected in due course of time due to adverse natural processes.			
Impact Nature	Negative	Positive	Neutral	
	This would create the risk of collapse or breach that can result in loss of life, property, or damage of the ecosystem.			
Impact Type	Direct	Indirect	Induced	
	The damages are directly linked to the structural collapse of containment structures.			
Impact Duration	Temporary	Short-term	Long-term	Permanent
	The breach or collapse could be repaired or restored. Hence, the damage will be of short term.			
Impact Extent	Local	Regional	International	
	The impact will be mostly local, but it has potential to spread into wider area through natural drainage network.			
Impact Scale	The scale will depend on the scale of breach or collapse and vary from minor to major.			
Frequency	accidental			
Impact Magnitude	Positive	Negligible	Small	Medium	Large
	The designing of these containment structures include these risks of natural calamity, hence the breaches or damages are expected to be only minor. However, such minor damages if not attended in right time can cause major mishaps.			
Vulnerability of Social Receptors	Low	Medium	High	
	No community exist and would not be allowed to reside too close to these containment structures. Hence, the vulnerability is assigned as low.			
Impact Significance	Negligible	Minor	Moderate	Major
	Considering the design criteria for stability of these structures, their risk assessments, and vulnerability of the social receptors, the impact significance will be negligible.			

Mitigation Measures, Management and Monitoring

- The structural stability of these containment structures should be regularly monitored by qualified civil engineers. Repairs and maintenance required to these structures should be done as per requirement.
- The risk assessment of these structures should be done and the disaster management plan for the area should capture these risks.

18.4.3 *Retrenchment and Un-employment*

Sources of Impact

The closure of mining operation will result in loss of jobs for the direct employees and loss of employment and income for workers in supply chain. The closure of the mining operation can happen for following reasons:

- The ore deposits are exhausted
- Mining operation becomes uneconomical
- Labour unrest, strike, shut down
- Natural Calamities
- Political or Governmental decisions
- Change in market demand bringing down the production level

The closure due to first reason will be a permanent closure of the mining operation. The closure due to other reasons may result in temporary discontinuation. The discontinuation may be for a short period of few weeks to few months or a couple of years.

Potential Consequences

The consequences of the closure of the mining activities will result in loss of employment and income for people. The magnitude of the consequence will depend on the reason and period for which closure is effective. Closure for temporary period will result in partial loss of income, and may not lead to loss of employment. Scaling down the operation will also lead to partial retrenchment and loss of income for a section of population.

The closure due to exhaustion of ore deposit or unviability of the mining operation will lead to complete closure of operations. This will lead to retrenchment and loss of employment for a large number of people. People losing jobs need to look for alternate livelihood options to meet family needs.. Loss of employment and consequent impoverishment will lead to stress and depression.

Significance of Impact

Table 79: Retrenchment and Unemployment

Impact	The closure of mining operation will lead to retrenchment of employees. This in turn would also have effect on supply chain.				
Impact Nature	Negative	Positive	Neutral		
	The retrenchment and loss of jobs will have serious impact on economy of the employees households.				
Impact Type	Direct	Indirect	Induced		
	The impact of closure will be felt both on directly employed population and those who are indirectly earn their livelihood.				
Impact Duration	Temporary	Short-term	Long-term	Permanent	
	People will look for alternative livelihood means. But, adopting alternative livelihood would require re-skilling and availability of such opportunity.				
Impact Extent	Local	Regional	International		
	The impact of retrenchment and un-employment will be felt both at local and regional level.				
Impact Scale	The project is expected to have a large number of employment opportunity. Considering limited opportunity in other sectors, employment opportunity provided in mining sector assumes prominence. However, as Liberia progresses, employment opportunities in many other sectors will open up. Hence, in closure phase the employment scenario is expected to be better. This would keep the scale of the impact manageable.				
Frequency	one time				
Impact Magnitude	Positive	Negligible	Small	Medium	Large
	The impact magnitude is assigned as medium keeping the future prospects and growth of other sectors offering alternative livelihoods and employment opportunities.				
vulnerability of Social Receptors	Low	Medium	High		
	Different sets of employees will have different degree of vulnerability. However, the work experience will help them in getting into alternative livelihoods or to seek re-employment in similar projects.				
Impact Significance	Negligible	Minor	Moderate	Major	
	As the closure is foreseen only after a long operation period, it is difficult to predict the impact significance in advance and considering that there will be opportunities for reemployment, hence, impact significance is assigned as moderate.				

Mitigation Measures, Management and Monitoring

The impact of the employment loss can be mitigated through the following:

- Communication to the employees about closure well in advance if it is predictable.
- Adopting a closure policy to bring transparency to the entitlements of the employees in the events of closure.
- Assisting employees for re-employment opportunities

19. ECOSYSTEM SERVICES

20.1 Scope of Assessment

The first step in an ecosystem services assessment is a screening process to identify the potential ecosystem goods and services derived from the project area to support local livelihoods and social systems. This was done by completing a list to confirm which ecosystem services are known to exist or may exist around influence of the mine, divided into the mine lease area and the broader area of project influence.

The second step involves a prioritisation process in which the various identified ecosystem goods and services in the project area and the extent to which the mine will influence these are assessed. In addition, the degree of dependence of beneficiaries of ecosystem goods and services is explained.

20.2 Impact Assessment

19.2.1 Impact on Natural Resources and Ecosystem Services

Sources of Impact

As per the feasibility report the proposed production area is approx. 34 km² and the project footprint is limited to an area of 11 km² within the mining concession area. The land use of this area will change during the course of mining operation and the local community will need to forego their rights to access natural resources and may be deprived of the benefits deriving out of them. The ecosystem in surrounding areas will also experience indirect impacts and changes are expected in the wider area too. The key drivers of the ecosystem changes include the following:

- Changes in land use and land cover;
- Removal of species and introduction of new species through landscaping, promotion of new crops and farming practices etc.;
- Changes in farming system and use of external inputs such as pesticides and fertilizers;
- Increase in demographic pressure due to in-migration;
- Increase in resource consumption (bush meat, logs, firewood, charcoal etc.) and premature harvesting; and
- Effluent discharge and increased extraction of water both from surface and underground sources.

The ecosystems and their beneficiaries that will be impacted due to the mining activity are discussed in Chapter 7 and presented in Table 80.

Table 80: Ecosystems and beneficiaries that will be impacted by mining activities

Type of Eco-system	Impact Characteristic	Impacted Ecosystem Users
Highland forested areas	Used for shifting cultivation or slash and burn agriculture. Source for logs, firewood for domestic use. Used for charcoal making.	The rural community with territorial rights within mining lease area practicing farming.
Swamps and Lowland Valleys	Drying up of the swamps due to change in hydrology after dewatering of disused mine pit. Reduction in productivity from farming swamps.	Communities using Swamp land for farming, e.g. Zelakai. The practice of swamp land farming is not very common practice. But, Government is promoting and upgrading farming techniques for swamp lands.
Natural Streams or flowing waters	The flowing water is used for domestic consumption and bathing. Artisanal fishing is done to supplement the food supply of the household.	Communities without any alternate access to flowing water.
Water bodies	Small and medium water ponds and lakes at several locations with natural depressions.	Communities accessing them for artisanal fishing. The cultural and supportive services derived out these water bodies.

Potential Consequences

The consequences of reduced access to natural resources and ecosystem services are reduction of benefits to the ecosystem users. Many of the critical ecosystem services are linked to the state of natural capital. The natural capital of the area is maintained by pollination services, flood and erosion control, water

filtration and providing habitat for biodiversity. Hence, compromising on natural systems may trigger collapse of ecosystems or setting up irreversible trends of ecological change. The impacts on ecology and biodiversity are discussed elsewhere in the report (Chapter 11 and Chapter 12). Therefore, we would limit our discussion here on how local economy and livelihood strategy depending on the local ecosystem will be impacted.

Significance of Impact

Significance of the impact is expected to be moderate with regards to the loss of natural resources and consequent impacts on the ecosystem services.

Table 81: Assessment of significance to the disruption of ecosystem services

Impact	Impact on natural resources and ecosystem services			
	Negative	Positive	Neutral	
Impact Nature	The population increase in project local area of influence will increase extraction of natural resources to meet human requirements of food, shelter and cooking fuel. Indiscriminate extraction will lead to degradation of forest and threat to wild-life			
	Direct	Indirect	Induced	
Impact Type	The impact is indirectly linked to the in-migration and increased commercial exploitation of natural resources.			
	Temporary	Short-term	Long-term	Permanent
Impact Duration	The impact will continue as long as the human requirements exits and no alternative source is available to meet these requirements.			
	Local	Regional	International	
Impact Extent	The impact will be experienced in a higher degree within the local area			

	of influence. One cannot rule out supplies from other areas to reach Tubmanburg to meet the demand. Hence, extraction of these resources is possible from a wider area too.				
Impact Scale	The scale of the impact will depend on the rate of in-migration to the project area.				
Frequency	Recurrent				
Impact Magnitude	Positive	Negligible	Small	Medium	Large
	The impact magnitude will be medium considering the subsistence livelihood practice of population living within project local area of influence and dependence on creeks for farming, and the supplementary role of the food supply from the forest and wild-life.				
	Low		Medium		High
Vulnerability of Social Receptor	The local population is dependent on subsistence farming and forest resources. The process of industrialisation therefore would bring a wide range of adaptation challenges for them. As their traditional skill levels would be insufficient to meet the requirement, there are possibilities of further impoverishment.				
	Negligible	Minor	Moderate	Major	
Impact Significance	The impact on natural resource extraction and deprivation from the ecosystem services will have a considerable impact on livelihood. However, the impacts can be abated at source by minimizing the population influx, meeting				

	firewood/domestic fuel requirement through non-forest sources, supply of alternate sources of meet/fish etc.

Mitigation Measures, Management and Monitoring

The following mitigation measures are required to be implemented:

- HSEC team to investigate ways to stimulate and support local markets and encourage the import of alternate sources of food, fibre, building material, and cooking fuel with particular focus on the in-migrant population of Tubmanburg through devising suitable community development programs
- HSEC team to investigate design and implementation of wildlife conservation and forest conservation programs to ensure sustainable harvest of forest produce and conservation of wildlife resources within the project's Local Area of Influence
- HSEC team to investigate ways to stimulate and support technological improvement in farming to increase the crop yield for increasing supply of food grains, e.g. introduction of new farm practices, to reduce the need to continuously clear new areas for cultivation. Increased reliability in the supply of food grains will reduce reliance on edible plant components from forest and bush meat.

Residual Impact

The residual impact is assessed as minor provided the mitigation measures above are implemented.

20. CUMULATIVE IMPACTS

IFC Performance Standard 1 (2012) requires projects to assess cumulative impacts in a project. Cumulative impacts area encompasses of influence "impacts that result from the incremental or directly impacted by the project, from other existing, planned or reasonably defined developments at the time the risks and impacts identification process is conducted." The IFC (2012) defines cumulative recognised as important on the basis of scientific concerns and or concerns from Affected Communities. Examples given include incremental contribution of gaseous emissions to an airshed, reduction of water flows in a watershed due to multiple withdrawals, increases in sediment load, and increases in traffic congestion and accidents due to increases in vehicular traffic.

In line with IFC requirements, cumulative impacts summarised in this chapter refer to the additional impacts that may be generated by other developments or activities in the project area that when added to the impacts of the existing mine and predicted impacts of mine expansion project combine to cause a greater impact. Such impacts may arise due to spatial overlap in an impact (e.g. overlap in spatial extent of air or water quality changes) or temporal overlap (e.g. noise impacts caused by blasting at the same time from different sources). In most cases, cumulative impacts overlap in both space and time, except where the impact may be temporal in nature (e.g. blasting once a day).

Cumulative impacts in this chapter are limited to the potential influence of other projects or activities in the project area in conjunction with predicted impacts from the development of Bomi Hills mine.

Bomi Hills Mine is located in a largely rural area with no other mining or industrial activities taking place in the nearby vicinity. It is thus assumed that, in general, cumulative impacts will, at the current time, be low. Liberia is, however, becoming a hub for mining development and in years to come the cumulative impacts could be a more significant impact.

20.1 Surface Hydrology

The development of Bomi Hills Mine will potentially result in a number of cumulative impacts due to abstraction of water from the Mahe River, dewatering of the disused mine pit and the siting of various facilities including WRDs and TSFs within existing catchment areas. There are also likely to be diversion of water bodies. However, at this stage Bomi Hills Mine is the only mine/ industry proposing to use surface water resources and as such the cumulative impact at this stage is rated as moderate to low.

Table 82: Surface Hydrology - Predicted Cumulative Impacts

Impact	Cumulative impact on surface hydrology associated with Bomi Hills Mine			
Impact Nature	Negative	Positive	Neutral	
	The impact will be negative.			
Impact Type	Direct	Indirect	Induced	
	The impact will be direct in nature.			
Impact Duration	Temporary	Short-term	Long-term	Permanent
	The impact will occur for the life of the mine.			
Impact Extent	Local	Regional	International	
	As the Mahe is a large river and used by large numbers of people downstream, the impact could be felt on a regional scale.			
Frequency	The impact will occur on a continuous basis for the life of mine.			
Impact Magnitude	Positive	Negligible	Small	Medium	Large
	Impact magnitude is considered as small to medium.			
Vulnerability of Receptors	Low	Medium	High	
	The receptor sensitivity is considered as medium.			
Impact Significance	Negligible	Minor	Moderate	Major
	Significance of impact is considered to be minor to moderate.			

20.2 Hydrogeology

As there are no other mines or industries extracting groundwater to any large scale in the vicinity of Bomi Hills Mine the cumulative impact on groundwater is considered to be low to insignificant.

Table 83: Hydrogeology –Predicted Cumulative Impacts

Impact	Cumulative impact on hydrogeology associated with Bomi Hills Mine				
Impact Nature	Negative		Positive	Neutral	
	The impact will be negative.				
Impact Type	Direct		Indirect	Induced	
	The impact will be direct in nature.				
Impact Duration	Temporary	Short-term	Long-term	Permanent	
	The impact will be felt for the life of mine and up to approximately 14 years after mining ceases.				
Impact Extent	Local		Regional	International	
	The impact will be restricted to the area subject to the cone of draw down which will remain local in extent.				
Frequency	The impact will occur for the life of mine.				
Impact Magnitude	Positive	Negligible	Small	Medium	Large
	Impact magnitude is considered as small.				

Vulnerability of Receptors	Low	Medium	High
	Due to the local nature of this impact the cumulative impact is low.		

20.3 Soils and Land Capability

Currently the area is considered as a 'brownfields' site and there is minimal arable land that will be impacted by the development of Bomi Hills Mine. It must be remembered that communities in the area do depend on the soils for growing subsistence crops and future expansions must take this into consideration and footprints should, therefore be contained and restrict unnecessary spread wherever possible. As such, currently the impact is considered as low. The various components associated with the Bomi Hills mine, including the mine, road and rail can lead to additional loss of subsistence arable land. This impact is also deemed low, seeing that existing brownfields footprints will mainly be used. It is, however, essential that all footprints be clearly demarcated to avoid unnecessary spread of activities.

Table 84: Soils and Land Capability –Predicted Cumulative Impacts

Impact	Cumulative impact on soils and land capability associated with Bomi Hills Mine.			
Impact Nature	Negative	Positive	Neutral	
	The impact will be negative.			
	Direct	Indirect	Induced	
Impact Type	The impact will be direct in nature.			
Impact	Temporary	Short-term	Long-term	Permanent
	In some cases there will be a permanent loss of usable soils due to pit			

Duration	development as well as permanent structures such as the WRDs and TSFs.				
Impact Extent	Local	Regional	International		
	The impact will remain local.				
Frequency	Permanent loss of land use in some areas.				
Impact Magnitude	Positive	Negligible	Small	Medium	Large
	Impact magnitude is considered as small.				
Vulnerability of Receptors	Low	Medium	High		
	Due to the local nature of this impact the cumulative impact is expected to be low.				
Impact Significance	Negligible	Minor	Moderate	Major	
	Significance of impact is considered to be Minor.				

20.4 Terrestrial Ecology

There is currently clearing of natural forest taking place due to commercial logging, subsistence agriculture and artisanal mining which will have an impact on local terrestrial ecology. With the influx of people to the area in search of employment at the mine, as well as land clearance which is required for the construction and development of the mine, the amount of land being cleared is likely to increase significantly. Also in terms of the influx of people to the area in conjunction with existing levels of bushmeat hunting, is the potential for increased pressure on hunting for bushmeat which could have a significant cumulative impact on species numbers. As such the cumulative impact is considered to be moderate.

Table 85: Terrestrial Ecology –Predicted Cumulative Impacts

Impact	Cumulative impact on terrestrial ecology associated with Bomi Hills Mine			
Impact Nature	Negative	Positive	Neutral	
	The impact will be negative.			
Impact Type	Direct	Indirect	Induced	
	The impact will be direct in nature.			
Impact Duration	Temporary	Short-term	Long-term	Permanent
	It is possible if not controlled that some species could be lost permanently in the area.			
Impact Extent	Local	Regional	International	
	Loss of species could have a regional impact.			
Frequency	The impact on species could continue long after mining has ceased due to people that have moved into the area.			
Impact Magnitude	Positive	Negligible	Small	Medium	Large
	Impact magnitude is considered as medium.			
	Low	Medium	High	

Vulnerability of Receptors	Although there are not many highly sensitive/ vulnerable species in the area, due to the potential regional extent of the impact the vulnerability is rated as medium.			
Impact Significance	Negligible	Minor	Moderate	Major
	Significance of impact is considered to be Moderate.			

20.5 Aquatic Ecology and Water Quality

Similar to air quality impacts, there are a number of small-scale impacts taking place impacting on water quality and consequently on the aquatic ecology e.g. local communities washing vehicles, bathing, residual mining impacts etc. However, there are no other mines or industries in the area causing any large-scale impacts on the water quality and as such, at this stage the cumulative impacts are considered to be low. It must be noted that mining is likely to lead to an influx of people into the area increasing the dependence on local rivers and wetlands and as such the cumulative impact could increase to moderate in a relatively short time period. It is therefore important that the potential impacts associated with Bomi Hills Mine, including the employee housing, water and sanitation are managed according to the requirements indicated in the ESMP.

Table 86: Aquatic Ecology and Water Quality - Predicted Cumulative Impacts

Impact Duration	Temporary	Short-term	Long-term	Permanent	
	The duration of the impact is considered to be permanent as once people have moved to the area in search of employment they are likely to stay in the area.				
Impact Extent	Local	Regional	International		
	The extent of the impact is expected to be local as due to the high rainfall in the area dilution in downstream water is expected thus reducing the potential for impact further from the site.				
Frequency	The impact is likely to continue long after mining has ceased due to people that have moved into the area.				
Impact Magnitude	Positive	Negligible	Small	Medium	Large
	Impact magnitude is considered as small.				
Vulnerability of Receptors	Low	Medium	High		
	The vulnerability is considered to be medium at this stage.				

Impact Significance	Negligible	Minor	Moderate	Major
	Significance of impact is considered to be Minor at this stage.			
Impact	Cumulative impact on aquatic ecology and water quality associated with Bomi Hills Mine			
Impact Nature	Negative	Positive	Neutral	
	The impact will be negative.			
	Direct	Indirect	Induced	

20.6 Landscape and Visual Impact

Currently there are no other large developments in the area and as such, from a visual perspective, the cumulative impact is assessed as low. However, urban sprawl of Tubmanburg and surrounding communities due to the influx of job seekers could result in a change of the visual character of the landscape. The significance of this on the visual landscape as well as the sense of place is rated as low.

Table 87: Landscape and Visual Impact - Predicted Cumulative Impacts

Frequency	The change in landscape will increase as mining progresses and once mining ceases will be permanent.				
Impact Magnitude	Positive	Negligible	Small	Medium	Large
	Impact magnitude is considered as medium.				
Vulnerability of Receptors	Low	Medium	High		
	The vulnerability is considered to be low.				
Impact Significance	Negligible	Minor	Moderate	Major	
	Significance of impact is considered to be Minor.				
Impact	Cumulative impact on landscape and visual impact associated with Bomi Hills Mine				
Impact Nature	Negative	Positive	Neutral		
	The impact will be negative.				
Impact Type	Direct	Indirect	Induced		
	The impact will be direct in nature.				
Impact Duration	Temporary	Short-term	Long-term	Permanent	
	The visual character will be permanently changed.				
Impact Extent	Local	Regional	International		
	The impact will be local.				

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20.7 Air Quality

The Bomi Hills mine area can be described as rural with no other mines or industries in the area. There are other emissions occurring in the area, however, these are small scale emissions including biomass burning, artisanal mining and farming. The small scale of these in addition to the high rainfall in the area reduces the potential for fugitive PM generation to a large extent and as such the potential for cumulative impacts is considered as low to insignificant.

Table 88: Air Quality - Predicted Cumulative Impacts

Impact	Cumulative impact on air quality associated with Bomi Hills Mine				
Impact Nature	Negative		Positive		Neutral
	The impact will be negative.				
Impact Type	Direct		Indirect		Induced
	The impact will be direct in nature.				
Impact Duration	Temporary	Short-term		Long-term	Permanent
	The impact will occur for the life of mine.				
Impact Extent	Local		Regional		International
	The impact will be local.				
Frequency	Continuously for the life of mine.				
Impact Magnitude	Positive	Negligible	Small	Medium	Large
	Impact magnitude is considered as small.				
Vulnerability of Receptors	Low		Medium		High
	The vulnerability is considered to be low to medium depending on the distance from mining activities.				
Impact Significance	Negligible	Minor		Moderate	Major
	Significance of impact is considered to be Negligible.				

20.8 Noise

Currently background noise levels are largely from natural sources such as insects and wind. As there are no other mines or industries producing noise in the area the cumulative impact of noise is considered to be low.

Table 89: Noise - Predicted Cumulative Impacts

Impact	Cumulative impact on noise associated with Bomi Hills Mine				
Impact Nature	Negative		Positive		Neutral
	The impact will be negative.				
Impact Type	Direct		Indirect		Induced
	The impact will be direct in nature.				
Impact Duration	Temporary	Short-term		Long-term	Permanent
	The impact will occur for the life of mine.				
Impact Extent	Local		Regional		International
	The impact will be local.				
Frequency	Throughout the life of mine.				
Impact Magnitude	Positive	Negligible	Small	Medium	Large
	Impact magnitude is considered as small.				
Vulnerability of Receptors	Low		Medium		High
	The vulnerability is considered to be Medium.				
Impact Significance	Negligible	Minor		Moderate	Major
	Significance of impact is considered to be Minor.				

20.9 Vibrations

There is no other blasting being carried out anywhere in the vicinity of Bomi Hills mine and as such the cumulative impacts are at this stage considered as insignificant.

Table 90: Vibrations –Predicted Cumulative Impacts

Impact	Cumulative impact on vibrations associated with Bomi Hills Mine				
Impact Nature	Negative		Positive		Neutral
	The impact will be negative.				
Impact Type	Direct		Indirect		Induced
	The impact will be direct in nature.				
Impact Duration	Temporary	Short-term		Long-term	Permanent
	The impact will occur for the life of mine.				
Impact Extent	Local		Regional		International
	The impact will be local.				
Frequency	Throughout the life of mine.				

Impact Magnitude	Positive	Negligible	Small	Medium	Large
	Impact magnitude is considered as small.				
Vulnerability of Receptors	Low		Medium	High	
	The vulnerability is considered to be low.				
Impact	Negligible	Minor	Moderate	Major	

20.10 Socio-economic

The place may be affected negatively with the combination of the mining activities and the influx of job seekers. This can change the social structure and social dynamics of the area – if not managed properly this can have a moderate negative impact on the wider area. Usually, influx is also associated with social problems, including theft and crime, alcohol abuse and the potential increase in communicable diseases including HIV/Aids. Services may not be able to handle the additional people leading to competition for water, food etc. It is important that negotiations and planning sessions between all spheres of government and WCL commence to ensure that the huge potential positive outcome of the development is optimized and potential cumulative impacts negated in a pre-cautionary pro-active manner.

The cumulative impacts on the health of communities close to the mine are also likely to be impacted upon due to a number of aspects. The cumulative impacts on some of these communities have the potential to be moderate.

Table 91: Socio-Economic - Predicted Cumulative Impacts

Impact	Cumulative impact on socio-economics associated with Bomi Hills Mine			
Impact Nature	Negative	Positive	Neutral	
	The impact will be negative.			
Impact Type	Direct	Indirect	Induced	
	The impact will be direct in nature.			
Impact Duration	Temporary	Short-term	Long-term	Permanent
	The impact will most likely be on a permanent basis as once people have moved to the area a large number of them are likely to stay on, even once mining ceases.			
Impact Extent	Local	Regional	International	
	The impact will be regional as people will be coming from other areas in search of employment which will have a cumulative impact on services etc for the dependent communities.			

Frequency	Throughout the life of mine.				
Impact Magnitude	Positive	Negligible	Small	Medium	Large
	Impact magnitude is considered as Medium.				
Vulnerability of Receptors	Low	Medium	High		
	The vulnerability is considered to be Medium.				
Impact Significance	Negligible	Minor	Moderate	Major	
	Significance of impact is considered to be Moderate.				

20.11 Ecosystem Services

In *Chapter 19* a number of ecosystem services currently being impacted upon have been identified. Increased pressure on the land for food supply, water, clearance of land for housing and food production can lead to a cumulative reduction in most of the provisioning ecosystem services. Should there be proper planning and collaboration between the mine and the various spheres of government to address and plan for and around these potential issues in a pre-cautionary and pro-active manner the significance of the impacts should be low. The same applies to regulating, cultural and supporting services.

Table 92: Ecosystem Services - Predicted Cumulative Impacts

Impact	Cumulative impact on ecosystem services associated with Bomi Hills Mine				
Impact Nature	Negative	Positive	Neutral		
	The impact will be negative.				
Impact Type	Direct	Indirect	Induced		
	The impact will be indirect in nature.				
Impact Duration	Temporary	Short-term	Long-term	Permanent	
	The impact could become permanent.				
Impact Extent	Local	Regional	International		
	The impact will be local.				
Frequency	Throughout the life of mine.				
Impact Magnitude	Positive	Negligible	Small	Medium	Large
	Impact magnitude is considered as small.				
Vulnerability of Receptors	Low	Medium	High		
	The vulnerability is considered to be medium.				
Impact Significance	Negligible	Minor	Moderate	Major	
	Significance of impact is considered to be Minor.				