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Environmental & Social Impact Assessment

Woodchip Biomass Production

Buchanan Renewables Fuel

Buchanan Renewables

Prepared By:

EARTHTIME INC.

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LIST OF ABBREVIATIONS

BOD	Biochemical Oxygen Demand
BR	Buchanan Renewables
BR FUEL	Buchanan Renewables Fuel
°C	Degrees centigrade
CO	Carbon Monoxide
CO_2	Carbon Dioxide
COD	Chemical Oxygen Demand
CRSIM	Community Relations and Social Impact Management
dB	Decibel
DO	Dissolved Oxygen
E. Coli	Escherichia coli
EPA	Environment Protection Agency
EMP	Environmental Management Plan
°F	Degrees Fahrenheit
FDA	Forestry Development Authority
IFC	International Finance Corporation
HC	Hydrocarbon
Ha	Hectares
Km	Kilometer
KVA	Kilovolt Ampere
m	Meter
mm	Millimeter
Ma	Million Years
MW	Mega Watt
NAAQS	National Ambient Air Quality Standards
NH_4-N	Ammonia Nitrogen
NO_x	Nitrogen Oxides
OPIC	Overseas Private Investment Corporation
OSHA	Occupation Safety and Health Administration
P	Phosphorous
PCBs	Polychlorinated biphenyls
PM	Particulate Matter
PPE	Personal Protective Equipment
POP	Persistent Organic Pollutants
SO_2	Sulphur Dioxide
SS	Suspended Solids
STW	Specialized Training Workshops
SW	Solid Waste
TDS	Total Dissolve Solids
TSP	Total Suspended Particles

TN	Total Nitrogen
TSS	Total Suspended Solids
USEPA	United States Environmental Protection Agency
VOC	Volatile Organic Compound
WHO	World Health Organization

EXECUTIVE SUMMARY

Buchanan Renewables Fuel (BR Fuel) is a biomass generation company that converts rubber trees that are no longer producing latex at economically viable rates into woodchips. These woodchips are primarily used by utilities as a renewable source of power. BR Fuel's GIS, satellite imagery and desk studies, suggest that there are over 259,000 ha of rubber trees in Liberia, 60-75% of which are currently non-producing.

BR Fuel works with rubber farmers, ranging from large concessionaires to smallholder farmers, to excavate and remove the non-producing trees from plantations and chip the rubber wood into woodchips used to produce renewable power. It uses heavy equipment to remove the trees and a combination of equipment and labor to clear the sites and prepare them for replanting, eliminating a significant cost for farmers and barrier to rejuvenation of the rubber industry.

Vattenfall, a leading European energy generator, and Swedfund, the Swedish state-owned risk capital fund recently partnered with BR Fuel. Vattenfall also finalized a long-term supply agreement with the company. It plans to co-fire BR Fuel's rubber woodchips in its coal-fired power plants as a means of reducing its fossil based carbon emissions and minimizing its impact on global climate change.

In order to fulfill this agreement, as well as other long-term supply agreements, BR Fuel aims to produce approximately 2,000,000 green metric tons (GMT) of biomass (rubber woodchips) on an annual basis by 2017 and into the future. This equates to the rehabilitation of an estimated 7,000-8,000 ha of rubber wood plantations per year, or approximately 3% of existing rubber plantations, which is below the annual sustainable cut for a tree species with a life cycle of approximately 30 years. The biomass produced will be exported to European utilities, as well as used locally for power generation in Liberia.

In order to reach these targets, BR Fuel will be expanding its business at a more rapid rate than originally anticipated and operating at a larger scale. While BR Fuel's basic project activities will not change significantly, it will be expanding to rubber plantations across Liberia at a faster rate. It will also be strengthening some of its facilities to support the expansion project. Woodchips will be shipped from the Port of Buchanan, and potentially other ports of Liberia as they are rehabilitated in the future. Ship loading will be through a system of conveyor belts.

BR Fuel's activities will be supported by its workshop and warehouse in Buchanan, as well as a small workshop facility that will likely be developed near the site of BR Power's power plant.

This expansion project has the potential to create approximately US $51 million in net present value for the Liberian rubber industry on an annual basis, as well as make a significant contribution to job creation, both directly through BR Fuel and indirectly through the rejuvenation of the rubber industry, and infrastructure development in Liberia. It will also provide a reliable, renewable, cost-effective, and local source of base load electricity in Liberia.

The objective of this ESIA is to ensure that the potential impacts from the biomass generation and related activities undertaken by BR Fuel and its sister companies are identified, their significance is assessed, and appropriate mitigation measures are proposed to minimize or eliminate such impacts during a fair and visible time frame with the consideration of the investment which has to be taken.

The ESIA was mainly prepared to assess the impacts and provide the mitigation measures for the following activities that are referred to as "Off-site" activities:

- Cutting down old rubber trees using excavators or feller bunchers and skidders;
- Sawing off the branches with chainsaws and chipping the trees in portable wood chippers or transporting the logs to a stationary chipper at the port (or power plant);
- Preparing the land and replanting;

- Rehabilitating some roads within and around plantations as required;
- Transporting the woodchips or logs (and some roots) in trucks to the port (or in future to the power plant);
- Maintaining the fleet of equipment;
- Loading and shipping the woodchips using loading conveyors, some shovels and some trucks; and
- Maintaining a nursery.

Furthermore, the ESIA provides mitigation measures for the impacts of the workshop facilities referred to as On-site/main site activities.

This document also presents a detailed and comprehensive environmental and social baseline data which will provide the environmental and social management process with key baseline information when identifying adverse impacts. The information contains data on Liberia's bio-physical environmental features such as its ecosystems, geology, hydrology in terms of ground and surface water resources, major and sensitive wetlands, flora and fauna. On social baselines the report discusses the main features of Liberia's demographics, public health features and poverty.

A number of legislations, policies and instruments available to support environmental management and the environmental impact assessment process in Liberia are reviewed in Section 3. The Environmental Protection and Management Law and other sectoral sections in other legislations are the key instruments that cover environmental management in all the sectors of development. The Environmental Impact Assessment Guidelines prescribe the process, procedures and practices for conducting an EIA and preparing the EIA reports. In addition to these instruments, there are sector specific policies and legislations that prescribe the conduct for managing the environment.

The EPA is the principle authority in Liberia for the management of the environment and coordinates, monitors, supervises and consult with relevant stakeholders on all activities in the protection of the environment and sustainable use of natural resources. In addition to being responsible for the provision of guidelines for the preparation of Environment Assessments and Audits, and the evaluation of environmental permits, the EPA is mandated to set environmental quality and ensure compliance for pollution control.

The main functions of the EPA are:

1. Co-ordinate, integrate, harmonize and monitor the implementation of environmental policy and decisions of the Policy Council by the Line Ministries,
2. Propose environmental policies and strategies to the Policy Council and ensure the integration of environmental concerns in overall national planning;
3. Collect, analyze and prepare basic scientific data and other information pertaining to pollution, degradation and on environmental quality, resource use and other environmental protection and conservation matters and undertake research and prepare and disseminate every two years a report on the state of the environment in Liberia;
4. Encourage the use of appropriate environmentally sound technologies and renewable sources of energy and natural resources;
5. Establish environmental criteria, guidelines, specifications and standards for production processes and the sustainable use of natural resources for the health and welfare of the present generation, and in order to prevent environmental degradation for the welfare of the future generations.

Impact Assessment

The typical elements that are affected by the project's activities whether on-site or off-site are classified into two categories: the social environment and the physical environment. The social environment includes social concerns such as human resources, services, human attitude and adaptation that could have influences on social characteristics of surrounding communities. The physical environment is concerned with potential contamination of surface and/or groundwater contamination, air emissions, noise, visual intrusions, biodiversity, traffic, waste management, and soil all of which could lead to alterations in the abiotic and biotic environment.

Potential impacts from the main activities of the proposed project have been described. Impacts are measured based on their type as they could be directly or indirectly affected by the whole project, nature reflects if the impact is positive or negative, duration emphasizes if the impact is permanent or temporary within the project time duration, and magnitude is the power of the impact on a certain component. The significance of impacts on each parameter is the result of the different assessed factor and is summarized in Table 1.

Table 1: Summary of Impacts.

Impact	*Type*	*Nature*	*Duration*	*Magnitude*	*Significance*
Air quality	Direct	Negative	Permanent	Moderate	Moderate
Water quality	Indirect	Negative	Temporary	Low	Low
Soil cover	Direct	Negative	Permanent	Moderate	Moderate
Biodiversity	Direct	Negative	Permanent	Moderate	Moderate
Noise	Direct	Negative	Temporary	Moderate	Low
Land-use	Indirect	Negative	Temporary	Low	Low
Socio-economic	Direct	Positive	Permanent	Moderate	Moderate
Health and safety	Direct	Negative	Permanent	Moderate	Moderate
Visual amenity	Direct	Negative	Permanent	Moderate	Moderate
Sanitation	Indirect	Negative	Permanent	Low	Low
Road network	Indirect	Negative	Permanent	Low	Low

Environmental Management Plan

This ESIA has been prepared for BR Fuel's expansion activities within Liberia. It covers activities on BR Fuel's workshop facilities referred to as "on-site" and harvesting activities taking place on rubber plantations within Liberia referred to as "off-site" activities.

The mitigation measures and monitoring plan recommended for the off-site activities are to serve as a general environmental and social management framework. All harvesting activities will require a separate, site-specific EMP. A site on which BR Fuel has already operated was used as a case study in order to set an example on the possible ways of implementing those mitigation measures and monitoring plans. This is located on Buchanan Highway and is called Johnson Farm.

The mitigation measures for the on-site operations are separated from those for off-site operations. The on-site mitigation measures are summarized in Table 2 whereas the off-site mitigation measures are summarized in Table 3.

Table 2: On-site mitigation measures.

Impact	*Recommended mitigation measures*
Air quality	• Watering of surfaces • Road surface grading • Maintain good housekeeping practices • Set speed limits of 10 km/hr on-site and off-site and cover trucks when necessary • Perform regular maintenance of vehicles • Ensure that vehicles are turned off when not in use • Ensure proper availability of firefighting system • Prohibit littering on-site • Prohibit any kind of smoke or fire on-site • Ensure that flammable chemicals are properly stored
Water quality	• Prevent oil spills and ensure proper containment • Divert oil/mixtures to sand/silt made channels • Ensure that the septic tank is emptied whenever full • Ensure that washing water from vehicles in drained in a sand/silt trap or in a constructed wetland for biological treatment • Ensure proper storage of oil and lubricants
Organic loading from rain action on wood piles at the port	• Prevent contact between rain and wood piles by building a high storage facility
Soil cover	• Ensure that mitigation measures for the preservation of water resources is properly done
Biodiversity	• Ensure proper management of solid and liquid wastes • Promote plantation of trees around the site • Prohibit any action that leads to the destruction of the ecological system

Impact	*Recommended mitigation measures*
	• Prevent any hunting activities
Solid waste management	• Ensure proper sorting and labeling of different waste materials according to their nature • Fence the site border to prevent any flying material to deposit in nature • Prohibit any open fires • Provide proper containment of stored liquids and avoid any leakages • Train and instruct workers on proper segregation and management of different waste materials
Noise	• Reduce noise emissions by enclosing any continuous source of noise e.g. generator • Perform periodic maintenance of equipment • Limit vehicle circulation near residents to daily working hours • Install suppression equipment
Occupational health and safety	• Avoid public access by proper fencing and guarding • Use adequate signs and safety barrier • Provide proper labeling of chemical storages • Provide personal with proper personal protection equipment • Train workers on emergency plans • Control leakages from equipment and storages • Provide appropriate lighting and ventilation in closed areas • Keep working spaces free from spills • Delineate spaces for loading and off-loading activities • Implement speed limits on-site
Landscape	• Promote trees plantation • Ensure proper management of solid and liquid waste
Socio-economic	• Promote jobs for local communities • Publicize data on environmental performances • Perform public consultations regarding new project
Traffic	• Provide drivers with a transport management plan (speed limits, traffic signs and directions of traffic routing, etc..)

Table 3: Off-site mitigation measures.

Potential negative impact	*Recommended mitigation measures*
Air Quality	
Gaseous emissions from transportation	• Ensure proper maintenance of engines and any machine used off-site • Set low speed limits for trucks • Do not exceed a tool's life expectancy
Dust emissions from cutting, sawing and chipping of wood	• Require workers to use personal protective equipment during operations • Introduce the use of a dust collector directly after operations take place
Increase in green house effect	• Introduce the plantation of windbreakers at the borders of the cleared areas • Replant rubber trees at ratio 1:1.

Potential negative impact	Recommended mitigation measures
Water Quality	
Sediment loading into downstream water bodies	• Build natural embankment at water bodies • Avoid littering or discharge of any debris into nearby water bodies
Water quality degradation by potential use of pesticides	• Raise farmer awareness on the application of biological fertilizers • Use chemical fertilizers in low doses and during dry periods
Water quality deterioration from chemical spills	• Store used oil in labeled containers • Provide preventative spill kits and absorbing material off-site
Disturbance to riparian zones	• Preserve any riparian zone detected off-site from any activities at a distance of 15 meters from both sides
Water consumption for the plantation of new trees	• Rely on rain water, rain water collection basins and regulation of water extraction
Water quality deterioration due to local sanitation	• Ensure that workers use provided lavatories off-site • Empty lavatories wastewater tanks in any close wastewater treatment system or introduce a build up treatment plant
Soil Cover	
Degradation of soil cover properties	• Even spreading of mulch and organic material • Plantation of fast growing vegetation and crops • Excavate shallow water channels that collect rain water • Construct water and sediment basins that control runoffs • Maintenance of landscape connectivity to decrease habitat fragmentation. (e.g. using tree corridors, and by leaving patches of ground cover) will allow species to move through the landscape to meet their habitat needs. • Harvest planning will ensure that harvest does not coincide with nesting or breeding seasons of local wildlife.
Deterioration of soil quality by potential use of pesticides	• Control and raise worker awareness of proper agricultural practices
Soil compaction due to vehicle circulation	• Turn the soil after clearing a land parcel
Biological environment	
Degradation of the biological environment	• Introduction of windbreakers at the borders of cleared areas • Introduction of vegetation plantation among the cleared areas • Preservation of riparian zones as ecological corridors • Preservation of wetlands

Potential negative impact	*Recommended mitigation measures*
Noise	
Increase in noise levels due to different vehicles and equipment used off-site	• Minimize cutting and sawing activities at early and late hours of the day at close residential areas • Purchase new equipment with sound suppression systems • Ensure that workers off-site employ personal sound proof devices
Disturbance to landuse	• Avoid extensive use of pesticides near agricultural lands • Avoid disturbance to any natural resource, public and cultural site
Socio-economic	• Integrate local residents in different phases of the project • Provide proper awareness on proper practices and working instructions • Prohibit employment of children
Health and safety	• Provide workers with personal protective equipment • Provide safety signs, labels and stripes to avoid hazards and accidents • Raise worker awareness of chemicals used, storage and disposal • Provide spill kits and train workers on their use • Provide first aid kit, fire extinguishers, alarm bells and emergency numbers • Provide transportation signs and speed limits • Train workers on routine check-ups and maintenance of equipment • Provide workers with health care and required vaccines • Delineate free spaces during cutting, sawing, loading and unloading of material • Train workers on proper sanitation and hygiene practices
Landscape degradation	• Promote trees planting and vegetation of cleared site
Sanitation services	• Avoid littering in the open fields • Educate workers on sorting waste • Label bins according to waste type • Raise worker awareness of hazardous waste and proper management • Provide lavatories off-site and discharge wastewater in a treatment system • Perform laboratory tests for any source of drinking water given to staff
Access to road network	• Set speed limits and cover trucks transporting material • Collect any waste material resulting after each activity performed off-site

Monitoring Plan

Two monitoring activities will be initiated by BR Fuel to ensure the environmental soundness of the project. The first is compliance monitoring, and the second is impact detection monitoring. Compliance monitoring provides for the control of BR Fuel's operation, while impact detection monitoring relates to detecting the impact of the operation on the environment. It is the responsibility of the environmental officer and the management of BR Fuel with appropriate help from third parties to ensure the implementation of the monitoring plan.

The proposed monitoring plan for BR Fuel must be implemented in its entirety in order to 1) properly assess the performance and effectiveness of the adopted mitigation measures, 2) identify the extent of environmental impacts predicted, 3) determine project compliance with regulatory requirements and to assist in adopting remedial action and further mitigation measures if found to be necessary.

The proposed monitoring plan for BR Fuel covers several elements including:

- Air quality and air emissions
- Noise levels
- Surface water quality
- Groundwater quality
- Waste generation
- Health and safety
- Biological environment
- Soil Quality
- Landscape and visual intrusion
- Socio-economic

The monitoring plan is based on the specific impact areas that are identified and includes a detailed description of the monitoring parameter(s), method (s), phases, location, frequency and cost. For certain parameters, sampling and analysis are necessary to assess the extent of the impact, while for other parameters surveys, visual inspection and photographic documentation by experienced personnel are required.

Monitoring efforts however, would be in vain in the absence of an organized record keeping practice. It is also the responsibility of the environmental officer and BR Fuel's management to ensure the development of a database that includes a systematic tabulation of process indicators, performed computations, maintenance schedule and logbook, and process control and performance monitoring outcomes.

Operational Phase Management

The proper operations of BR Fuel both on-site and off-site are highly dependent on the availability of competent personnel on site empowered with the appropriate educational and professional background. In addition, the suitability of the facility is highly dependent on having a comprehensive institutional support structure on the local and national authority level in order to adequately cover all aspects of the facility's operation and management.

Public Involvement

Public involvement and consultation are important components in any major agricultural and industrial projects as they aim to increase general environmental awareness among the public and various stakeholders on the proposed project thus addressing their concerns.

In accordance with the requirements of the Environmental Protection and Management Law and the EPA for public consultation on major development projects' related activities and disclosure of the findings of the ESIA report, Earthtime as well as BR Fuel's management have recognized the need for an effective public consultation and disclosure program. As such, consultation with relevant stakeholders commenced during the preparation of the ESIA report. The aim was to provide information on the findings of the conducted environmental survey in the area, expected impacts of the project, and the proposed mitigation measures and monitoring plan.

1 INTRODUCTION

Liberia has recently been making significant effort, through the Environmental Protection Agency (EPA) and other relevant stakeholders, towards sustainable development, and has placed more attention on environmental matters and the need to reduce the burden on the environment. The relatively young Environmental Protection Agency (EPA) has been able in the last few years to considerably improve its capabilities in protecting the environment from the various sources of pollution. Even though at the time of writing this report, it is still considered poorly financed and barely equipped with the appropriate human and technical resources, the EPA is seriously working on setting new environmental standards, building its staff capacity and informational database, and providing the framework to prevent future pollution to widespread in Liberia.

On the other hand, Liberia has abundant natural resources in terms of mining and agriculture. Agriculturally, rubber is one Liberia's main export cash crops and contributes to export earnings despite the fact many of Liberia's rubber plantations were destroyed during the 15 years Civil War. Several plantations were mismanaged, while a significant portion became redundant due to decline in productive lifespan and absence of sound replanting programs and given the fact of capacity and infrastructural constrains during the civil war period.

BR Fuel has introduced the concept of bio-fuels - a relatively new product/service- into the Liberian rubber industry, which is expected to add value to the rubber sector. BR Fuel seeks to rejuvenate existing rubber plantations in the country by entering into commercial agreements with small and large farm holders for the purchase of redundant rubber plantation. These agreements will allow BR Fuel to up-root non-productive rubber trees that will be processed into rubber chips for export and local use in the Buchanan Renewables Power power plant, and to replant the cultivated lands from which redundant rubber trees are harvested.

BR Fuel currently operates in Grand Bassa and Margibi Counties, Liberia. The present harvesting operations cover an area of more than 2000 acres in Liberian Agriculture Company, Big Joe Farm, Holt and Hunter's Plantations in Buchanan area and the Firestone Plantation on the outskirts of Kakata, whereas, the main administrative as well as the workshop and woodchip storage facilities and the nursery are located in Buchanan, Grand Bassa County. However, plans are underway for expansion in terms of harvesting into different parts of the country under the same program.

As a way of adding value to output from the rubber sector and minimizing waste from its operations, Buchanan Renewables Fuel and Buchanan Renewables Power are initializing plans to utilize the waste generated from uprooted rubber trees to produce bio-mass fuel and provide sustainable energy for the development of the country.

1.1 The Environmental & Social Impact Assessment

The objective of this ESIA is to ensure that the potential impacts from the biomass generation and related activities undertaken by BR Fuel and its sister companies are identified, their significance is assessed, and appropriate mitigation measures are proposed to minimize or eliminate such impacts during a fair and visible time frame with the consideration of the investment which has to be taken.

The Environmental & Social Impact Assessment is a live document and should always reflect the varying needs and environmental baseline conditions of each site given the fact that BR Fuel's operations will not be restricted to a single site; however, the operational activities and methods followed will more or less remain the same from one location to another. Accordingly, the worst case scenario was approached in order to ensure the maximum potential impacts are predicted and understood and their relative mitigation measures are set. The ESIA was mainly prepared to assess the impacts and provide the mitigation measures for the following activities that are referred to as "Off-site" activities:

- Cutting down rubber trees using excavators or feller bunchers and skidders;
- Sawing off the branches with chainsaws and chipping the trees in portable wood chippers or transporting the logs to a stationary chipper at the port (or power plant);
- Preparing the land and replanting;
- Rehabilitating some roads within and around plantations as required;
- Transporting the woodchips or logs (and some roots) in trucks to the port (or in future to the power plant);
- Maintaining the fleet of equipment;
- Loading and shipping the woodchips using loading conveyors, some shovels and some trucks; and
- Managing a nursery.

Furthermore, the ESIA provides mitigation measures for the impacts of the workshop facilities referred to as On-site/main site activities.

1.2 Scope of Work

Besides the introductory section, the scope of work implemented in the preparation of the ESIA report includes the following:

- Definition of the legislative and institution framework (Section 2);
- Description of the environment (Section 3);
- Description of the proposed project (Section 4);
- Identification and analysis of potential environmental and social impact (Section 5);
- Analysis of potential alternatives (Section 6);
- Proposed mitigation measures (Section 7);
- Proposed Monitoring Plan (Section 8);

- Operational Phase Management (Section 9)
- Public Consultation (Section10)

2 LEGISLATIVE AND INSTITUTIONAL FRAMEWORK

2.1 LEGISLATIVE FRAMEWORK

Article 7 of the 1986 Constitution of the Republic of Liberia sets the fundamental basis for the constitutional, legislative, and institutional frameworks for the protection and management of the environment. It also encourages public participation in the protection and management of the environment and the natural resources in Liberia.

The EPA of Liberia was created by the Legislative Act of November 26, 2002 and published on April 30, 2003. The establishment of the EPA marks a significant step forward in the protection and management of the environment in Liberia.

Part II, Section 5 of the Act designated the EPA as the principal Liberian authority for environmental management which shall co-ordinate, monitor, supervise, and consult with relevant stakeholders on all activities for environmental protection and the sustainable use of natural resources. Section 6 (b) of the Act stipulates that the EPA should propose environmental policies and strategies to the Policy Council and ensure the integration of environmental concerns in the overall national planning.

Meanwhile, Section 1 of The EPML gives the responsibilities of sustainable development, protection and environmental management to the EPA in partnership with regulated Ministries and organizations and in a close relationship with the people of Liberia. The EPA should also provide high quality information and advice on the state of the environment and for matters connected therewith. This article indicates that environmental protection by the EPA should be accomplished taking into consideration public health and welfare of the Liberian societies. In addition, Section 15 of the EPML states that business investors should present an environmental mitigation plan to the EPA, which should include the following sections:

- Objectives.
- Description of activities to be carried out by the project to mitigate any adverse effects on the environment.
- Period within which the mitigation measures shall be implemented.
- Proven efficacy of the mitigation measures of indicating their experimental nature.

Moreover, Section 12 of the same law requires environmental review for project or activities that may have significant impact on the environment. The project proponent shall submit to the EPA their plans for improving environmental performance including:

- Identification of the major environmental effects; and
- A comprehensive mitigation plan in accordance with section 15 of this Law

In addition, Section 6 of The Environmental Protection and Management Law which requires an Environmental Impact Assessment license or permit for the commencement of such projects, and Section 13 requires the preparation of an environmental impact study for such a project. Moreover, the Agency (EPA) is empowered to carry out among others, the following aspects of environmental protection and management in Liberia:

- Establish environmental criteria, guidelines, specifications, and standards for production processes and the sustainable use of natural resources for the health and welfare of the present generation, and in order to prevent environmental degradation for the welfare of the future generations;
- Identify projects, activities, and programs for which environmental impact assessment must be conducted under this Act.
- Review and approve environmental impact statements and environmental impact assessment submitted in accordance with this Act;
- Monitor and assess projects, programs, and policies including activities being carried out by relevant ministries and bodies to ensure that the environment

is not degraded by such activities and that environmental management objectives are adhered to and adequate early warning and monitoring on impending environmental emergencies is given;

- Review sectoral environmental laws and regulations and recommend for amendments and to initiate proposals for the enactment of environmental legislations in accordance with this Act or any other Act;
- Encourage the use of appropriate environmentally sound technologies and renewable sources of energy and natural resources;
- Function as the national clearinghouse for all activities relating to regional and international environment-related conventions, treaties and agreements, and as national liaison with the secretariat for all such regional and international instruments.

Table 2-1 describes the main categories of legislation in Liberia. Table 2-2 shows international conventions that are signed and ratified by the Liberian Government. In terms of environmental legislation, Table 2-3 represents a list of all issued legislation.

Table 2-1: Categories of Legislations in Liberia.

Law	Laws are passed by the National Legislature of Liberia comprising of the Senate and the House of Representatives. Any citizen or group of citizens, Cabinet Ministers, Managing Directors of public corporations or agencies can propose a bill to the National Legislature for enactment. The draft bill is first passed over to the appropriate Steering Committee of the Legislature. In case of environmental bill, this committee is generally the Committee on Natural Resources and the Environment. The Committee reviews, assesses and presents the bill to the Legislative Plenary with appropriate amendments for debate, public hearing and subsequent enactment by the Legislature.
Executive Order	The Executive Branch of government headed by the President can issue Executive Order without the approval of the National Legislature. The Executive orders have the power of a law provided that they do not contravene the existing law. The power of such orders has a limited time of existence.
Regulations	The national Legislature has empowered Cabinet Ministers and Managing Directors of public corporations and agencies to issue regulations for their respective functionaries without legislative approval or supervision, provided that such regulations are not inconsistent with the statutory Laws and the Constitution of Liberia.

Table 2-2: International Environmental Conventions Signed/Ratified by the Government of Liberia.

Convention	Status	Year
African Convention on Conservation of Nature and Natural Resources	Ratified	NA
Convention of International Trade in Endangered Species of Wild Fauna and Flora (CITES)	Ratified	1981
Convention Concerning the Protection of the World Cultural and Natural Heritage	Signed	2002
Framework Convention on Climate Change and the Kyoto Protocol	Signed	2002
Stockholm Convention on Persistent Organic Pollutants (POP)	Signed	2002
Ramsar Convention on Wetlands of International Importance	Signed	2003
Convention on Biodiversity	Ratified	2000
Bio-Safety Protocol	Ratified	2003
Convention on Desertification	Signed	1998
Vienna Convention for the Protection of the Ozone Layer	Signed	1996
Montréal Protocol on Substances that Deplete the Ozone Layer	Signed	1996
International Convention for the Safety of Life at Sea (SOLAS)		1980
Protocol to the International Convention on the Establishment of an International Fund of Compensation for Oil Pollution Damage		1994
Protocol to the International Convention on Civil Liability for Oil Pollution Damage		1981
Convention on Limitation of Liability for Maritime Claims		1986
International Convention for the Prevention of Pollution from Ships as modified by the Protocol of 1978		1983
Protocol relating to the International Convention for the Safety of Life at Sea (SOLAS Prot.) 1981		
International Convention for the Prevention of Pollution from Ships, (MARPOL) - Annex III (Optional): Hazardous substances carried in packaged form		1973
International Convention for the Prevention of Pollution from Ships (MARPOL) - Annex V (Optional) =Garbage		1995
Protocol relating to Intervention on the High Seas in Cases of Pollution by Substances other than Oil		1983
Annex VI to MARPOL 73/78 on the prevention of air pollution from ships		2003

Table 2-3: Relevant Environmental Legislations.

Legislation (act)	Date	Title/ description
Law	1953	Conservation of the Forests of the Republic of Liberia. This Law provided the framework for the use of forest and wildlife resources and allowed for the creation of government reserves, native authority reserves, commercial forests, national parks and wildlife refuges.

Legislation (act)	Date	Title/ description
Law	1957	Supplementary Act for the Conservation of Forests. This Supplementary Law also provided the framework for the use of forest and wildlife resources and allowed for the creation of government reserves, native authority reserves, commercial forests, national parks and wildlife refuges.
Law	1976	The Act that created the Forestry Development Authority (FDA). The Act established and defined the responsibilities of the FDA, outlined forest offences and penalties; made provision for an Advisory Conservation Committee and specified powers of forest officers with regard to trees in reserve areas.
Law	1976	Public Health Act. It contains provision for the protection of drinking water resources and the inspection of potential sources of pollution.
Law	1979	The Natural Resources Law of Liberia. This Law includes chapters on forests, fish, and wildlife, soil, water, and minerals.
Law	1988	Wildlife and National Parks Act. The Act identifies a number of protected areas; specifies policies and objectives regarding wildlife and conservation in the country.
Law	03/04/ 2000	The New Minerals and Mining Law. The Law and its resulting policy call for restoration of land to its previous state as much as possible after mining activities. All medium to large-scale mining activities are to submit Environmental Impact statements. Environmental audits and periodic assessments will be undertaken to ensure compliance.
Law	26/11/ 2002	The Environment Protection Agency (EPA) Act. The Act provides the Agency with the authority of government for the protection and management of the environment in Liberia. It provides for an Environmental Administrative Court to hear from aggrieved parties. It requires that an Environmental Impact Assessment (EIA) be carried out for all activities and projects likely to have an adverse impact on the environment.
Law	26/11/2002	The Environment Protection and Management Law. The Act enables the Environment Protection Agency to protect the environment through the implementation of the Law. It arranges the rules, regulations, and procedures for the conduct of EIA. It establishes regulations for environmental quality standards, pollution control and licensing, among others.
Law	26/11/2002	The National Environmental Policy Act. It defines policies, goals, objectives, and principles of sustainable development and improvement of the physical environment, quality of life of the people and ensures coordination between economic development and growth with sustainable management of

Legislation (act)	Date	Title/ description
		natural resources.
Law	2006	National New Forestry Reform Law. The administration of this Act provides for the Forestry Development Authority to exercise the power under the Law to assure sustainable management of the Republic's forestland, conservation of the forest resources, protection of the environment, sustainable economic development with the participation of and for the benefit of all Liberians and to contribute to poverty alleviation in the country.

2.2 NATIONAL ENERGY POLICY

In February 2007, the Government of Liberia (GOL), through the Ministry of Lands, Mines and Energy (MLME), with the support of the United States Agency for International Development (USAID) published the National Energy Policy.

The principal objective of the National Energy Policy is to ensure universal access to modern energy services in an affordable, sustainable and environmentally-friendly manner in order to foster the economic, political, and social development of Liberia.

The NEP recognizes the fact that energy is essential towards GOL Poverty Reduction Strategy (PRS) and the achievement of the Millennium Development Goals (MDGs).

The NEP assumes the implementation of proposed energy sector reforms founded on three essential features: (1) demonstrating the Government's resolve for good governance and ensuring financial transparency in all sector transactions; (2) overcoming the significant obstacles to private sector investment in energy supply; and (3) creating the requisite institutional and legal framework and an independent regulatory regime. In undertaking energy sector reform, the Government will also be addressing a key component of Liberia's commitment to the World Bank and other donors for debt relief under the program for Highly Indebted Poor Countries.

2.2.1 Key Policy Issues

The NEP addresses the following strategic issues that are implied in the principal policy objective – access, quality, cost, and institutional framework. These issues refer to the need for the various technologies and delivery options for energy products and services to be available, acceptable, affordable, and adequate.

2.3 Environmental Quality Standards

Several environmental quality standards are under preparation by EPA. Some of these environmental quality standards shall include: 1) Air Quality Standards; 2) Noise Level Standards; 3) Combustion Conditions and Emission Standards for Municipal and Hospital Wastes Incineration; and 4) Selected Standards for Discharge into surface waters.

2.4 Institutional Framework

At a regional cooperation level, Liberia is a member of a number of organizations that play an important role in the protection and management of the environment. These organizations include the Economic community of West Africa (ECOWAS), The Mano River Union (MRU), The West African Rice Development Association (WARDA), and the African Union (AU).

In addition to the EPA, other organizations play a vital role in environmental protection and management, particularly the Forestry Development Authority (FDA), Ministries of Lands, Mines and Energy (MLM&E), Ministry of Planning and Economic Affairs (MPEA), Ministry of Justice (MOJ), Ministry of Public Works (MPW), and Ministry of Health and Social Welfare (MHSW), Ministry of Agriculture (MOA), Ministry of Commerce (MOC), and the Liberia Water and Sewer Corporation (LWSC).

However, EPA is the main agency and principal authority in Liberia for environmental management and shall co-ordinate, monitor, supervise and consult with relevant stakeholders when needed.

The main functions of the EPA are:

6. Co-ordinate, integrate, harmonize and monitor the implementation of environmental policy and decisions of the Policy Council by the Line Ministries,
7. Propose environmental policies and strategies to the Policy Council and ensure the integration of environmental concerns in overall national planning;
8. Collect, analyze and prepare basic scientific data and other information pertaining to pollution, degradation and on environmental quality, resource use and other environmental protection and conservation matters and undertake research and prepare and disseminate every two years a report on the state of the environment in Liberia;
9. Encourage the use of appropriate environmentally sound technologies and renewable sources of energy and natural resources;
10. Establish environmental criteria, guidelines, specifications and standards for production processes and the sustainable use of natural resources for the health and welfare of the present generation, and in order to prevent environmental degradation for the welfare of the future generations.

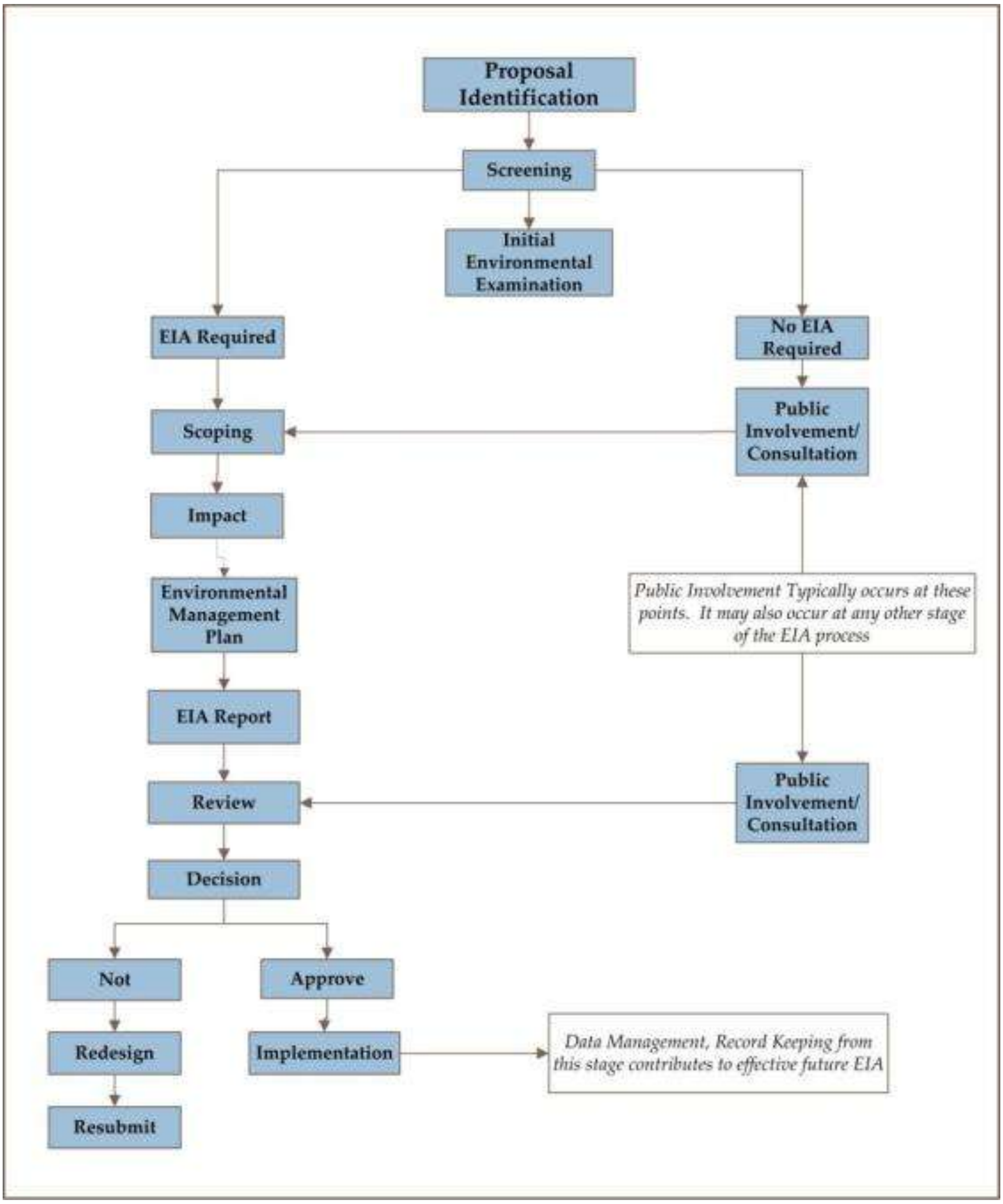


Figure 2-1: EIA process in Liberia.

3 DESCRIPTION OF ENVIRONMENT

3.1 GENERAL DESCRIPTION AND LOCATION

The quadrangle of Liberia is located on the western side of the African Continent and southwest corner of the West Coast of Africa. It is positioned on the Atlantic coastline of Africa, and has a surface area of 111,370 km^2, and the dry land extent is 96,160 km^2. It lies between the longitudes of 7°30′ and 11°30′ west and latitudes 4°18′ and 8°30′ north. It is bordered by Guinea from the north, Sierra Leone from the west and Côte d'Ivoire from the east (Figure 3-1). The border with Guinea is approximately 563 km, with Sierra Leone approximately 306km, and with Cote d'Ivoire approximately 716 km. Liberia has a studded coastline approximately 560 km long. It is characterized by unbroken sand strips, and is dominated by lagoons and marshes. Generally, Liberia has low relief topography. However, the hinterland is made up of ill-defined and dissected plateaus and low relief mountains few rising abruptly above the surface to an elevation of 400m above sea level (asl). The highest mountain (Mount Wutivi) is located in the northeast (Yekepa) and rises to an elevation of approximately 1,380m asl.

Liberia has virgin rain forests that are primarily located inland and in mountainous areas. The rest of the land is occupied by small farms. Liberia has four types of vegetation cover. Those are distributed according to the following: brush, grassland, cultivated and tree crops dominate the central and coastline areas; swamps are present as patches along the coastline mainly near river mouths; broadleaf evergreen forests are present in the southeastern part of the country; and broadleaf deciduous and evergreen forests dominate the northern parts and are present in the central parts.

Liberia has six major rivers that divide the country into several quadrants. The rivers are Cavalla, Cestos, St. Paul, St. John, Lofa, and Mano. The longest and largest is the Cavalla River.

Figure 3-1: Liberia bordered by Ivory Coast, Guinea and Sierra Leone.

3.2 METEOROLOGICAL SETTING

The climate of Liberia is determined by the equatorial position and the distribution of low and high-pressure belts along the African continent and Atlantic Ocean. A fairly warm temperature throughout the year with very high humidity is common because of the moderating influence of the ocean and the equatorial position (UNDP, 2006).

3.2.1 Precipitation

Liberia has two seasons: rainy and dry seasons. The dry season lasts from November to April and the rainy season is from May to October. Average annual rainfall along the coastal belt is over 4000 mm and declines to 1300 mm at the forest-savannah boundary in the north (Bongers et. al. 1999). The months of heavy rainfall vary from one part of the country to another, but are normally June, July and September (Table 3-1). The driest part of the country is along a strip of the eastward flowing Cavalla River, but even there, the land receives over 1778 mm of rain a year. Monrovia receives almost 4572 mm, about twice the estimate of rain annually. Observations concerning the diurnal distribution of rainfall prove that two-thirds of the rain along the coast, particularly in Monrovia and its environs fall during the night between 18:00 and 07:00 hours. Most of the rest of the rain usually falls during the morning while only a minimum of rain is recorded between mid-day and early afternoon.

Table 3-1: Average monthly rainfall data for various stations (Liberia Hydrological Service, 1981).

Location	Period	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
National Iron Ore Company	1959-1980	14.2	40.4	64.8	177.0	269.6	356.5	422.8	528.2	548.5	379.1	195.1	48.7
Voinjama	1952-1973	12.7	38.4	108.4	163.2	212.0	296.4	349.2	426.6	353.8	261.6	168.1	53.0
Goodrich	1956-1980	22.6	41.0	76.6	146.7	225.0	385.2	561.3	660.2	634.5	369.9	137.2	38.2
Bomi Hills	1952-1977	18.4	53.3	117.0	172.0	272.9	391.3	434.8	551.4	589.1	337.9	161.1	61.8
Bong Mines	1961-1980	14.7	53.0	90.6	180.2	260.3	307.7	304.8	414.0	494.7	285.9	149.1	33.0
Monrovia	1951-1973	36.8	57.3	121.5	154.6	386.1	889.3	887.8	583.7	702.5	625.3	229.8	121.8
Firestone Harbel	1936-1980	34.0	55.3	119.6	160.5	258.1	391.5	431.6	584.6	575.6	363.7	165.6	68.6
Robersfield	1949-1980	30.9	53.8	93.8	137.0	291.9	570.0	654.6	586.9	679.1	409.0	172.5	60.9
Salala Rubber Corporation	1961-1980	15.8	52.7	112.3	189.8	242.7	306.6	272.0	392.4	418.1	293.2	137.9	40.9
Cocopa	1950-1979	21.0	56.7	116.7	164.9	180.6	276.8	218.0	261.5	385.8	246.1	89.2	35.2
LAMCO Buchanan	1959-1980	27.0	60.8	100.3	174.4	333.2	596.2	592.5	478.0	771.0	535.4	288.7	101.3
Ganta	1934-1973	20.2	56.4	129.9	150.3	219.4	280.6	250.8	300.5	397.5	250.8	135.0	34.8
LAC	1961-1979	27.5	57.4	118.4	200.2	273.9	359.3	281.8	376.7	489.5	374.0	182.5	54.1
Tapeta	1952-1973	18.1	58.4	107.3	155.7	231.9	278.9	207.1	172.2	324.8	237.2	99.3	22.9
Firestone Cavalla	1928-1981	80.4	112.8	163.1	180.6	340.8	403.3	137.5	119.1	294.9	308.1	229.5	199.9
Zwedru	1952-1973	21.2	62.7	118.2	183.3	203.5	271.2	186.2	160.2	349.0	281.8	125.5	60.3
Pyne Town	1952-1973	59.6	118.3	216.9	240.0	284.6	342.6	192.0	194.3	396.4	359.2	183.6	99.8
Greenville	1952-1973	93.9	115.1	153.1	212.5	433.8	758.0	365.5	271.5	626.8	622.1	559.0	231.0
Robertsports	1952-1973	23.8	33.7	76.5	143.8	352.9	796.1	990.8	687.2	761.3	458.3	175.9	80.3
Ziah Town	1952-1961	40.8	86.1	154.3	209.7	280.4	277.9	126.1	111.1	321.1	288.0	140.4	100.1

3.2.2 Temperature and Sunshine

The Atlantic Ocean has an additional ameliorating effect on the temperature along the coast with maximum annual and daily variations (UNDP, 2006). Generally, temperature remains warm throughout the county and there is little change between seasons. The temperature over the country ranges from 27-32 °C during the day and from 21-24 °C at night. The average annual temperature along the coast ranges from 24-30 °C. In the interior it is between 27-32 °C. The highest temperature occurs between January and March and the lowest is between August and September.

The sun is overhead at noon throughout the year, giving rise to intense insolation in all parts of the country, thus resulting in high temperatures with little monthly variations (UNDP, 2006). Temperature would have been much higher had it not been for the effect of the degree of the cloud cover, air, humidity and rainfall, which are influenced by the vegetation cover of the country. The days with longest hours of sunshine (average of six hours a day) fall between December and March. Daily sunshine hours are at a minimum during July, August and September.

3.2.3 Wind

The seasons in Liberia mainly result from the movement of two air masses:

1. The Inter-Tropical Convergence Zone (ITCZ) from the northern hemisphere; and
2. Cool air masses over the South Atlantic Ocean from the southern hemisphere.

Pressure shifts between the air masses force the dry continental air mass and the moist south-equatorial maritime air mass to replace each other every six months (UNDP, 2006).

3.2.3.1 Wind Direction (Robertsfield, 2000-2006)

Monthly mean wind direction shows southeast as first dominant direction and south as second dominant direction (Figure 3-2). According to frequency chart, wind direction slightly changes, for example, southeast in January, southeast to south in

February to July, south to southwest in August, south to southeast in September to November and southeast in December (JICA, 2009).

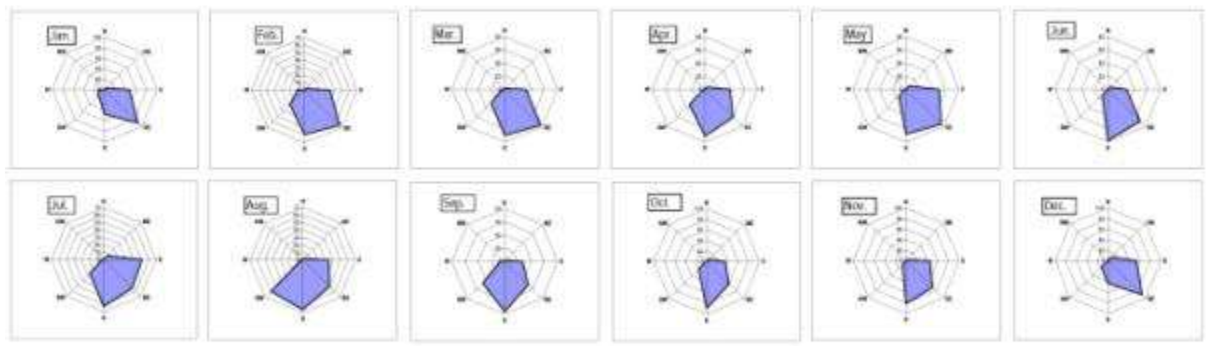


Figure 3-2: Monthly Frequency of Wind Direction of Robertsfield in 2000-2006.

3.2.3.2 Wind Speed (Robertsfield, 2000-2006)

Monthly mean wind speed shows maximum 10.3 km/hrs in August, minimum 7.1 km/hrs in January and average 9.3 km/hrs (JICA, 2009).

3.2.4 Relative Humidity

Relative humidity is generally high throughout the year. Along the coast belt it does not drop below 80% and on the average is above 90% (UNEP 2004). There is a wider variation in the interior and may fall below 20% during the Harmattan period. A relative humidity of 90% to 100% is common during the rainy season. In general, during the dry Season it decreases to as low as 65%.

In Monrovia, the relative humidity shows a relationship with the existing air temperature and its variation depends on the prevailing season and the hour of the day. During the dry season it decreases to 80-85%. In March and February the driest period of the year, relative air humidity may be as low as 65%. Regardless of the season, the relative humidity at night and in the early morning is usually in the range of 90-100 percent. Data from other weather stations such as Bomi Hills, Harbel and Greenville show similar results. Only the zone, north of the Inter-Tropical Front, where the continental air masses prevail from mid-December to end of January show arid conditions. At times due to the extreme dryness of the Harmattan, the humidity may drop to below 50% (Schulze, W. 1975).

3.3 GEOLOGICAL SETTING

Liberia is underlain by the Guinean Shield of West Africa and is composed mainly of Precambrian igneous and metamorphic rocks. Other rocks occur locally and are chiefly Paleozoic sandstone, Jurassic diabase dikes Cretaceous sandstones and Quaternary unconsolidated deposits. Rock outcrops are sparse in Liberia owing to tropical weathering that has produced a thick laterite and saprolite cover, which supports a dense rain forest. The rocks forming this crystalline shield consist of an older series of granulitic and migmatitic gneisses and amphibolites with subordinate granitoids. Remnants of slightly younger supercrustal rocks or sedimentary and volcanic origin are aligned predominantly in a SW-NE direction. Phanerozoic sediments are only exposed along a narrow coastal strip.

3.3.1 Stratigraphy

Approximately 90% of Liberia is underlain by Archean and Peleoproterozoic granitic rocks. The basement rocks can be divided into three major units on the basis of their radiometric age. The Archean rocks were affected by the earlier Leonian (3,500-2,900 Ma) and the younger Liberian (2,900-2,500 Ma) Orogenies. SW-NE trending greenstone belts of Birrimian age (2,100 Ma) have been reported from the southern central part of the country. The third unit comprises the Pan-African age province, which was metamorphosed and intruded about 550Ma ago. The Archean and Pan-African provinces are separated by a series of WNW-ESE trending faults comprising the Todi Shear Zone. Gneisses of the Archean and part of the Pan-African age provinces are metamorphosed to amphibolites grade. Granulite facies rock, however, are restricted to the Pan-African age province, but are probably derived from Archean rocks.

Two small outliers of classic sedimentary rocks, the Gibi Mountain Formation, form heavily forested hills 32 km northeast of the Todi shear Zone. They lie disconformably on Archean gneisses and are overlain by klippen of Precambrian itabirite-bearing quartzite.

Isolated diabas or gabbro dykes (400 – 180 Ma) are intrusive to the Precambrian rocks. Unmetamorphosed laminated sandstones, arkoses, siltstones and conglomerates of possible Cretaceous age occur in narrow section (<5 km) along the coast.

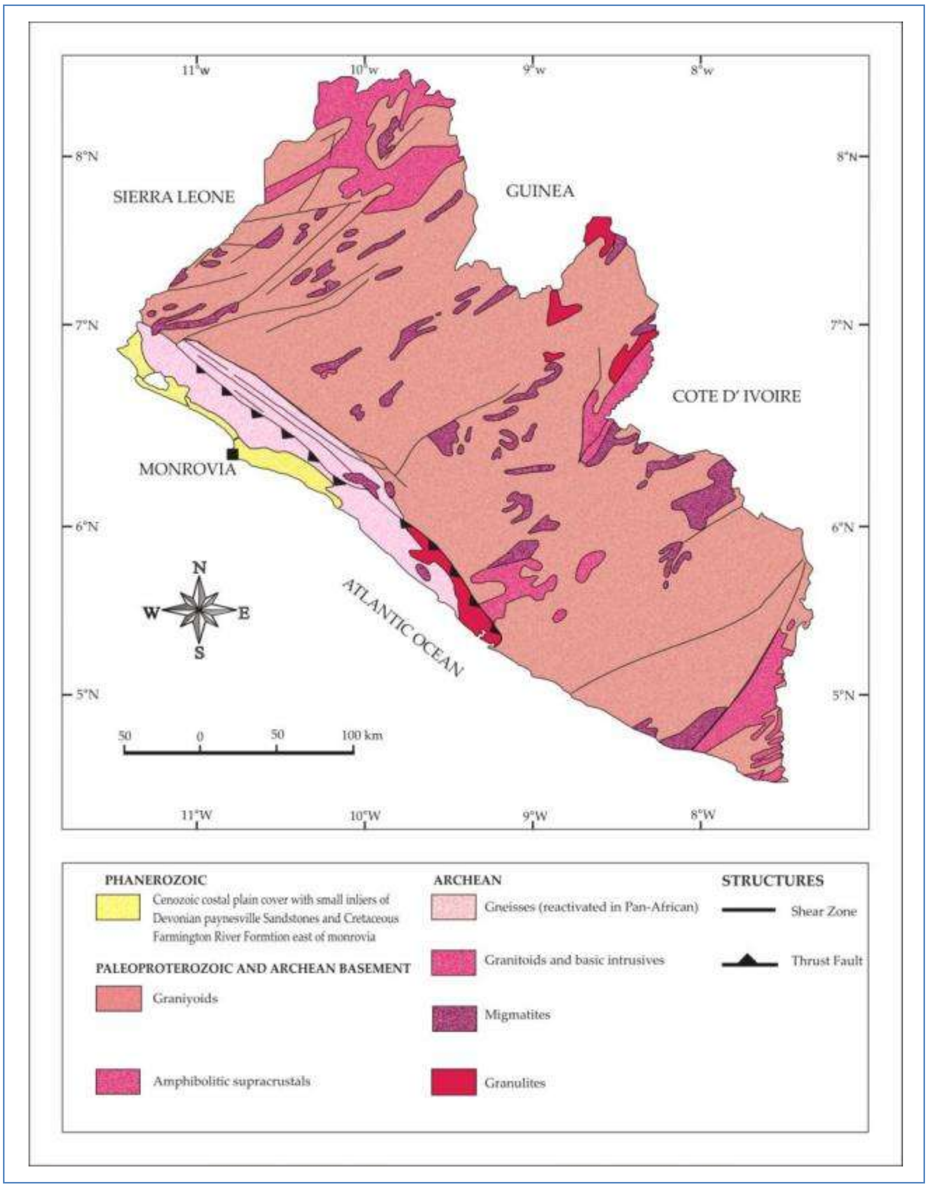


Figure 3-3: Geological overview of Liberia.

3.4 SOIL

The climate tends to become the dominant soil-forming factor in Liberia, reinforced by the associated effects of the abundant and dense vegetation. The warm and humid climate conditions cause intensive mechanical and chemical weathering of the parent rock and leaching of the soil profile. As a result, Liberian soils share many important features, even though some minor variations reflect the more local influence of relief and geology. The bedrocks from which the rocks have formed are mainly of crystalline, igneous and metamorphic origin, consisting of granites, gneisses, gneissic sandstone and schists and shales. The three major groups of soil in Liberia can be identified: latosols, lithosols and regosols.

The latosols are lateritic soils occupying about 75% of the total area, and occurring on undulating and rolling land. They are heavily leached, and silica, nutrients and humus are mostly washed out. Iron and aluminum minerals have accumulated as permanent residual materials, forming hardpans and cemented layers within the subsoil, while on the surface hard and rounded iron oxides can be observed. This process which is called laterization has a pronounced binding effect, making the soils impermeable and increasing the hazards of run-off and erosion. The prevalence of the iron oxides gives the laterites the characteristic brown and red color.

In sharp contrast to the latosols are azonal soils, classified as lithosol. The striking characteristic of these soils is that profile development is very slow and often subject to erosion. The lithosol represent about 17% of the total area on mostly hilly and rugged land. They are mostly very shallow and frequently show outcrops of decomposing rocks because of their elevated position. The percentage of the gravel is also very high and therefore nutrient and moisture storage capacity of the soil is greatly reduced.

Regosols are sandy soils which occur within the narrow coastal belt and also in small patches farther inland. Along the coast they are mainly marine sediments consisting of more than 70% of fine to coarse sand and silt. These sands are heavily leached and bleached to an almost white color, and the percentage of clay and organic matter is very small. Where the drainage is poor, swamps develop.

Alongside the stream and river beds rich alluvial soils are encountered. They contain a high amount of the necessary plant nutrients and are best for agricultural production. However, they represent only between 2 to 3% of the total area.

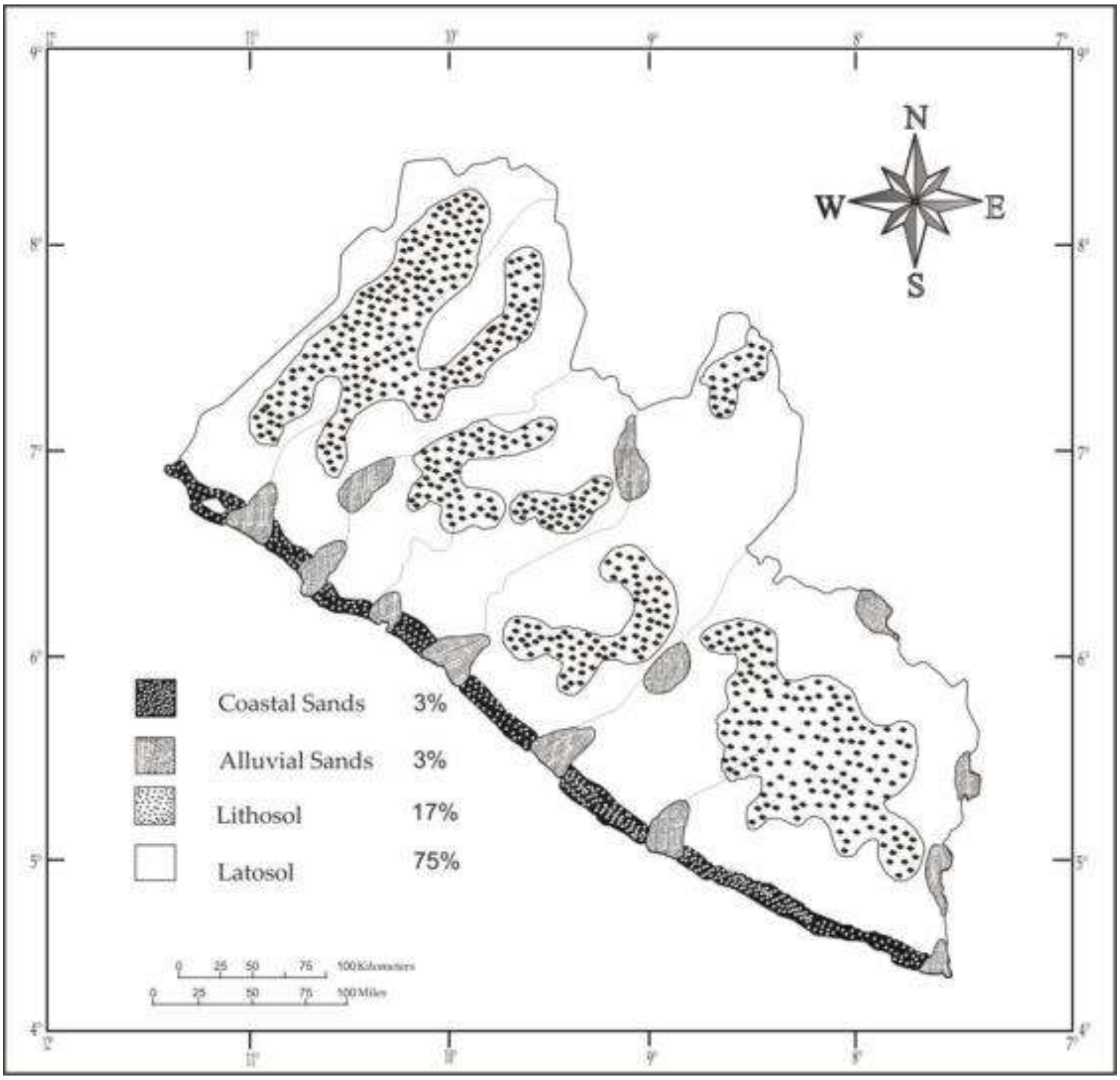


Figure 3-4: Soil type distribution in Liberia.

3.5 HYDROLOGY

There are six major rivers which drain Liberia's territory in a general northeast-southwest direction. With the great number of their tributaries they have developed a dense system with a dendritic pattern. The six major rivers are: Mano, Lofa, St. John, Cestos, Cavalla and St, Paul (Table 3-2). These rivers have many tributaries which include but not limited to the Po, Du, Timbo, the Farmington and Sinoe River.

The hydrological system is influenced by the geological structure as well as the general slope of the relief of the country. The system generally follows the direction of the mountain ranges from north-east to south-west and perpendicular to the coast (Figure 3-5), with the exception of the Cavalla and its tributary, the Duobe which flow for some distance due east before they ultimately turn to the sea. As a matter of fact, the Cavalla River and its tributary is the largest and longest river with a flow rate of 2550 m^3/sec. They water an approximate area of 30,225 km^2, and bordered by an irregular divide formed by the Pulu and Tsenpo Ranges. The other rivers are roughly parallel to each other and spaced at fairly regular intervals across the county. All the six rivers are not navigable and therefore do not support water transport and industrial fishing. Many rocks, waterfalls, rapids and sandbanks reduce navigation of these rivers very far inland; bedrock frequently outcrops in the riverbeds. Valleys and flood plains are not well developed, the gradients are fairly steep and irregular, and the basins are mostly narrow.

Closer to the coast, the river grade becomes less, and tidal current prevent the rivers from removing sand bars and accumulations. However, most streams overflow their banks regularly, and during the rainy seasons there is often severe flooding along the coastal plains. All major river basins in Liberia originate from Guinea. Moreover, the six major rivers drain 80% of the country; whereas, small water courses such as Po, Du, Timbo, Mesurado, Farmington, Seinken and Sineo Rivers drain 20% of the county.

Seasonal precipitation causes considerable fluctuations of the river levels. Although all of the main rivers carry a great volume of water all year round, the upper courses are usually shallow because of the fast run-off especially during the dry season. During the rainy season most of the streams overflow their banks after heavy downpours. The six major rivers have varying potentials for the development of mini hydro-electric facilities.

Table 3-2: Major Rivers in Liberia. (Liberia Hydrological Services, 1988)

Basin	*Area(Km²)*	*Annual Flow (m³/sec)*	*Sediment Load (metric ton/annum)*	*Highest Elevation (m above sea level)*
Mano	6,604	251	580	750
St. Paul	12,820	512.3	1,920	n/a
St. John	14,726	N/A	15,108	1,000
Cavalla	13,726	380	988	1,500
Cestos	10,000	60.3	850	1,500
Lofa	9,194	N/A	11,200	1,200

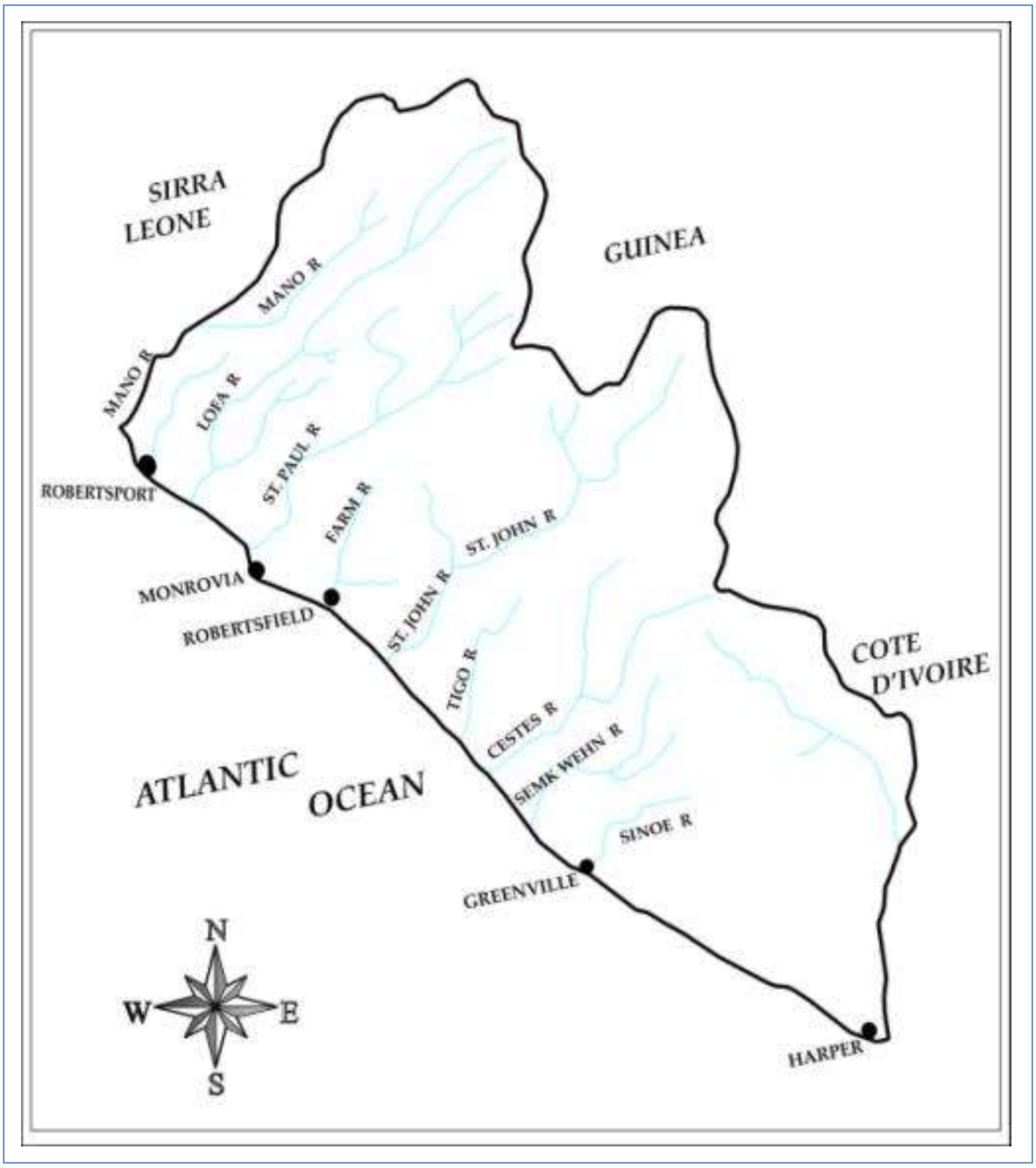


Figure 3-5: Locations of Coastal Rivers.

3.6 VEGETATION

The tropical rain forest belt in West Africa extends from Sierra Leone to Ghana and comprises in Liberia most of the country except a very narrow strip along the coast where mangrove vegetation alters with coastal savannahs. The climatic conditions in the whole country allow the vegetation to develop into a tropical high forest and most probably the entire land area was once covered with it. Nowadays the total area of tropical high forest and old secondary forest consists only of about one-third of the country, while the remaining 65% is composed of forested areas such as young secondary forest and intermediate forest and further non-forested areas such as farmlands, savannas, towns, swamps, etc. The far northwest of the country and small parts of Nimba County are grass-woodlands. Although the general climatic conditions are nearly equal throughout the country, the amount of rainfall and humidity, which influence the vegetation in a large measure, decreases toward the interior. Consequently three vegetational zones can be distinguished: the coastal savannah, the high forest belt, and the northern savannah.

The coastal savannah extends some 15 to 25 km from the coast into the country and was in earlier times covered with high forest as forest relics indicate. The actual vegetation consists mainly of grass with scattered, often malformed trees. There are also scattered oil palms and mango indicating former human occupation. Along the rivers in the coastal zone dense thickets of mangrove vegetation may have developed. Landward beyond the tide, another type of vegetation has developed with species such as Pandanus and Raphia palms.

The high forest belt in Liberia can be divided into the evergreen rain forest zone and the moist Semi-deciduous forest zone. The transition zone between these two belts lies in western Liberia about 70 km from the coast and in the eastern part of the country up to 140km inland.

The evergreen rainforest receives an annual rainfall of 2000 mm or more, and it consists of species which do not have a well marked period to leaf fall. The taller trees frequently reach over 60 m. Because of the mixed character of this forest it is called mixed evergreen rainforest. Infrequent counting of tree species per acre show more than 40 species; sometimes patches of the forest may be dominated by only one or two species and this type of forest is called single dominant forest. Together with young trees of the dominant species many other species occupy the lower level of the canopy and may form one complete continuous layer of leaves preventing the light from reaching the soil. The shrub layer is not, however, normally very thick and is easy to enter.

A forest type normally separated from the evergreen forest is the wet coastal rainfall which is found in the south-eastern part of Liberia between River Cess and Greenville and which reaches 65 to 83 km into the country. The vegetation is specially characterized by the occurrence of many dominant stands.

North of the belt of mixed evergreen forest is encountered the moist semi-deciduous forest which has many trees in common with the first type mentioned, but also many other species particular to this vegetation type. It may be that species are much more frequent in the mixed evergreen rain forest than in the moist semi-deciduous forest and vice versa. The climate condition in the north-western part of the country are characterized by an annual rainfall of 2030 to 2790mm and in the south-eastern Parts 1780 to 2030 mm. The long dry season (4.5 to 5.5 months) force many species to drop their leave during part of this period to minimize their evaporation. The semi-deciduous forest is a transition to the deciduous forest type found in Ivory Coast but not in Liberia.

The three above mentioned type of high forest are most closely linked, but various kings of transition occur, which are mostly influenced by topography and soil conditions of the country. The influence of shifting cultivation on the vegetation has been immense, and most of the high forests have at time been converted into farm land. After the farms are abandoned the vegetation replaces itself again and gradually the high forest reappears. Several development stages can be recognized such as recent farmland, old farmland, and intermediate forest. This process of regeneration from farmland to secondary high forest takes approximately 100 to 130 years.

The northern savannah comprise the grass-woodland in the far north-western parts of the country and a small part of the Nimba Country and is a type of manmade savannah continuous burning and clearing for agriculture purpose prevent the original vegetation from establishing itself again. The so-called elephant grass which grows to a height of 3 m is the typical grass species and only here and there small forested areas are present.

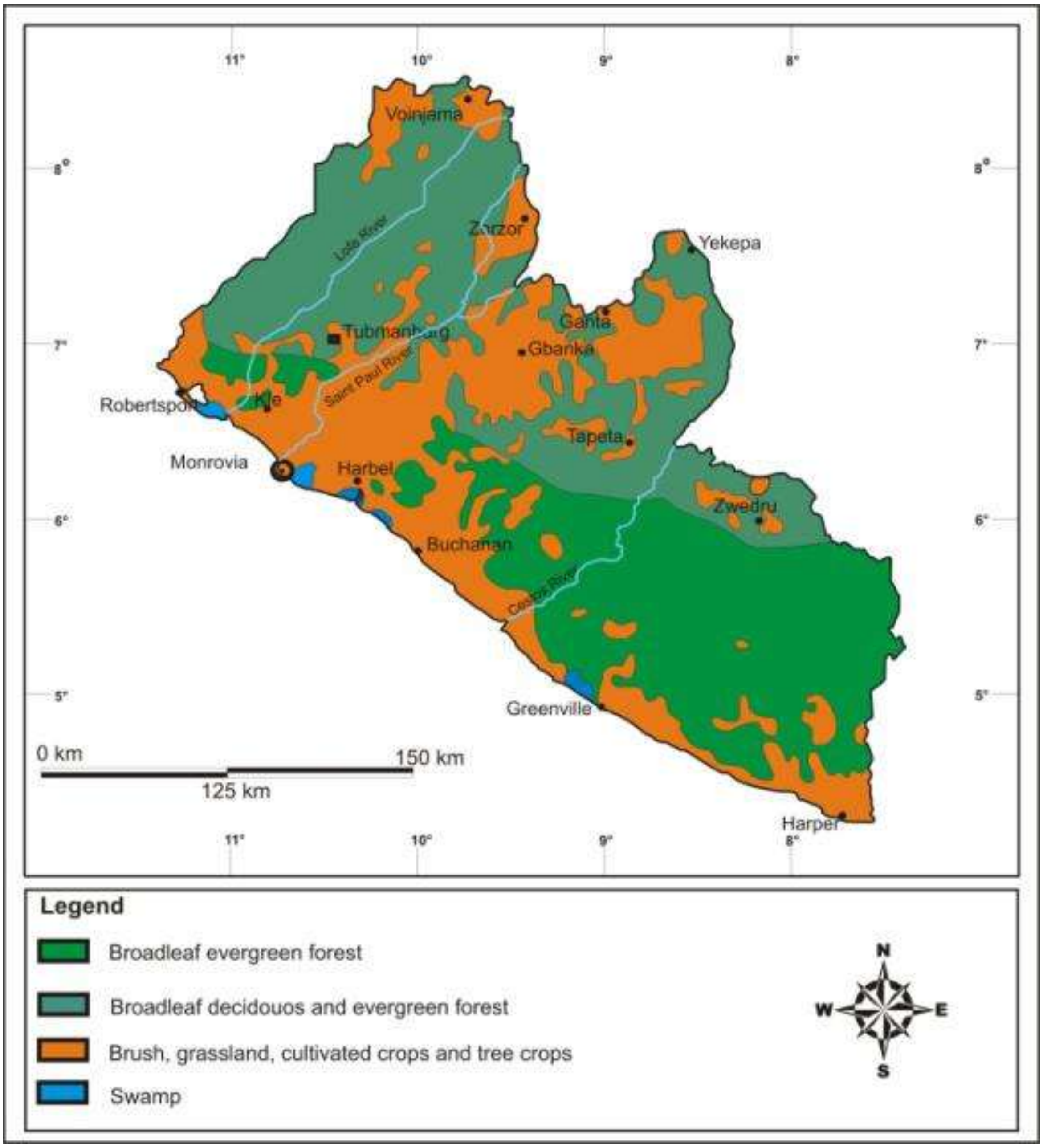


Figure 3-6: Vegetation cover in Liberia.

3.7 WETLANDS: LAGOONS, ESTUARIES, SWAMPS AND MANGROVES

3.7.1 Overview

Liberia is endowed with wetlands that provide both subsistence and economic benefits to its many inhabitants. Like wetlands all over the world, they have become over burdened by human induced activities. There are four (4) wetlands types: Inland Riverine, Inland swamp, coastal and coastal lacustrine. Eight (8) wetlands have been identified, three (3) of which have been proposed for conservation status (Table 3-3).

The wetlands of Liberia are dominated by mangroves that cover a large area along the coast from Cape Mount to Cape Palmus. Mangroves are mainly found at the edges of lagoons, river banks and estuaries and also in widespread areas of swamps. Mangroves cover about 0.5% of the total land surface of Liberia. This is equivalent to a 500 km-wide belt extending along the total length of the coastline. The mangroves form vital coastal ecosystems: they provide habitat for fish invertebrates and epiphytic plants, and are considered more efficient photo synthesizer than most plants. Besides, mangrove forests provide:

- Spawning grounds for many fish species, crabs, shrimps, mollusks and other forms of sea life;
- Habitats for many endangered species of manatees, crocodiles, turtles, migratory birds;
- Flood regulation and protection from violent storms;
- Protection of shore line from erosion; and
- Water recharge and improve quality.

The most common mangrove species is Rhizophora racemosa, but six (6) other species occur in the Country. Mature mangrove trees, reaching heights up to 50 meters, were found in the Marshall Wetlands and along the lower Sehnkwehn River in Sinoe County.

Mangrove species such as Rhizophora harrisonnii, Rhizophora mangle and Avicennia africana occur together with impressive tracts of pandanus. Except for few places in the central part of Liberia, primary mangrove forest has been replaced by secondary stands of mangroves. Much of the destruction appears to be concentrated along the edges of creeks, river estuaries, lagoons and particularly more widespread destruction around the major coastal towns and cities, such as Monrovia, Buchanan, Greenville, Robertsport and Harper.

Table 3-3: Wetlands of Liberia (EPA/GEF/UNDP, 2004)

Wetland	Type	Size (acres)	Conservation status
Lake Piso	Coastal Lacustine	76,091	Proposed Nature Reserve, RAMSAR Wetland
Marshall	Coastal Lacustine	38,500	Proposed Nature Reserve, RAMSAR Wetland
Mesurado	Coastal	22.000	RAMSAR Wetland
Bafu Bay	Coastal	11.900	None
Lake Shepherd	Coastal	18.000	None
Cestos-Senkwehn	Inland Riverine	15,000	Proposed Nature Reserve
Gbedin	Inland Riverine	11,200	RAMSAR Wetland
Kpatawee	Inland Riverine	8,800	RAMSAR Wetland

The national environmental policy of Liberia explains that the importance of wetlands are not fully understood, and that wetlands are threatened with degradation due to factors such as: pressure from fire wood gatherers and charcoal producers, uncontrolled solid and liquid wastes, unregulated settlements near wetlands, agriculture production and industrial expansion and other constructions. Some strategic actions recommended by the National Environmental Policy (2003) include:

- Establishment of full protection status for wetlands of biodiversity significance
- Development of wetlands policy and management plans
- Inventory of wetlands

Part VI, sections 74 and 75 of the Environment Protection and Management Law of Liberia deal with management and protection of wetlands. The Law provides for a penalty of US$5,000.00 (five thousand United State Dollars) or imprisonment for a period not exceeding two years for violators.

3.7.2 Lake Piso Wetlands

Lake Piso Wetland is characterized by a vast expanse of wetlands and lowland forest vegetation. Lake Piso wetland is one of six proposed protected areas in Liberia. It is situated in Robertsport, Grand Cape Mount County, and it contains migrating birds, sea turtles, reptiles, mammal and fisheries. Lake Piso Wetlands is situated in southwestern part of Liberia coastline and it is an important habitat for West African manatees (Trichechus seneglis).

3.8 BIODIVERSITY

Liberia is among the nine different West African Countries straddled in the Upper Guinean Forest belt (L. Poorter, et al. 2004). That stretches from western Togo to eastern Sierra Leone. This forest belt is considered as one of the highest global conservation priorities due to its high levels of endemism, species rarity and the extreme and immediate threat facing its survival.

The rich biodiversity of the country is currently threatened by two major factors (D. Wiles, 2007):

1. Loss and fragmentation of habitat caused by deforestation;
2. Wildlife remains a critical source of protein to rural Liberians, as well as source of cash income.

The Mount Nimba, Cestos-Senkwehn rivershed, Lofa-Mano and Sapo National Park areas contains many endemic species.

3.8.1 Fauna and Flora

Liberia is home to approximately 150 mammals species, 590 birds species, 15 reptiles and amphibians species and over 1,000 insect species.

Forest areas in Liberia were once known to host a wide range of animals including elephant, pygmy hippopotamus, buffalo, large primates and large hornbills; these species have largely disappeared due to hunting, farming and logging activities. Several antelope species that prefer patchy forest and regenerating forest/bush fallow areas, are commonly reported in abundance in the interior. These include rare species such as Zebra and Jentik's duiker. Primates such as chimpanzees, three species of colobus monkeys, Diana monkey, various guenons and manabies are reported to be abundant in the mature secondary and primary forest. Wild pigs and porcupines exist in sparsely settled areas, and several members of the leopard group are also found.

The Leatherback turtles (Demochely Coriacoa) are critically endangered and along with the olive ridley (Lepitochely olivacea), Green turtle (Chelonia mydas), Loggerhead turtle (Caretta Caretta) and Hawksbull turtle (Eretmochelys imbricate) are found on Liberia's beaches. The sea turtles are widely hunted while nesting and are occasionally caught in artisanal fishermen's net.

There are over 2000 flowering plant species, with 59 of them endemic to the country and one endemic genus. Among the plant species, 240 timber species are known to inhabit Liberia's forest.

3.8.2 Protected Areas

3.8.2.1 Nationally Protected Areas

Nationally protected areas of Liberia are shown in Figure 3-7. There are currently no protected areas on the coastline or offshore. However, two proposed protected areas are located on the coastline (Figure 3-8):

1. Cape Mount Nature Reserve - The proposed Nature Reserve of Cape Mount lies on the coast of Liberia northwest of Monrovia. It includes a spit of land which separates Lake Piso from the Atlantic. The town of Robertsport lies at the tip of this spit. The site includes part of the lagoon, mangroves, rocky and sandy shorelines together with a small area of lowland forest (BirdLife International. 2009).

2. Cestos-Sankwen National Park - This site lies on the coast between the towns of Buchanan to the north-west and Greenville to the south-east and stretches inland northwards from the coast approximately 70 km. It includes part of the lower reaches of the scenic Cestos and Senkwen rivers, as well as the estuary

of the latter. The proposed park includes evergreen lowland rainforest, 1,200 ha of mangroves and undisturbed coastal vegetation including some of the last examples of littoral forest in West Africa. Part of the area overlaps the Krahn Bassa National Forest. Deforestation and a large influx of people, and associated development of settlements and agriculture threaten the conservation value of the area (BirdLife International. 2009).

3.8.2.2 Ramsar Wetlands of International Importance

There are five designated Ramsar Wetlands of International Importance in Liberia. Three of these are located on or adjacent to the coastline (Figure 3-9). They include (http://www.ramsar.org):

1. Lake Piso Wetlands – the largest inlet on the Liberian coast, the area is surrounded by forested hillsides (including one of the rarest tropical rainforests in the region) and fed by a number of creeks and rivers that drain a series of swamps above the lagoon, the lower ones of which are tidal and support mangroves. Additional mangrove swamps occur behind the dune ridge on the west side of the lake mouth and at creek mouths. A series of small lakes with swampy margins occurs on the sandy forested spit that separates the lake from the sea. This area coincides with the proposed Cape Mount Nature Reserve.

2. Masurado Wetlands - Located in the capital city Monrovia and Montserrado County, the site is important for the protection of three mangrove species (Rhizophora harrisonii, R. mangle and Avicennia africana), which are threatened by intense charcoal burning and fuel wood collection. It provides a favorable habitat and feeding ground for several species of birds including the African spoonbill (Platalea alba), common pratincole (Glareola pratincola) and Eurasian curlew (Numenius arquata). It also hosts the vulnerable African dwarf crocodile (Osteolaemus tetraspis), the Nile crocodile (Crocodylus

niloticus) and the African sharp-nosed crocodile (Crocodylus cataphractus) and plays an important role in shoreline stabilization and sediment trapping.

3. Marshall Wetlands – Comprising three small rivers, the area has sandy and rocky shores, and further inland is a population of secondary forests and savannah woodland. The wetland is chiefly a mangrove type with mature trees reaching up to 30m. In addition to the red colobus monkey (Piliocolobus sp.), a number of bird species listed by the Convention on Migratory Species appear in the area, such as the glossy ibis (Plegadis falcinellus), lesser kestrel (Falco naumanni) and common pratincole (Glareola pratincola). The site provides control against flooding and underground water recharge and is a sediment trap. The very large stands of mangroves, fish population and wildlife are valuable resources for inhabitants in the area. The three rivers are navigable by small boats and are used for transport from one village to another. Research on chimpanzees for human vaccines against hepatitis A, B and C is also being carried out at the site, with the animals released on islets in the mangroves afterwards.

3.8.2.3 Key Biodiversity Areas

In addition to national protection, Liberia remains an international priority area for conservation (Figure 3-8). For example, in December 1999 the Global Environmental facility (GEF) funded the West African Conservation priority-setting exercise for the Upper Guinea Ecosystem. The project identified Liberia as a top priority country in West Africa for conservation purposes since 41% of its area is designated as being of exceptionally high biological importance. In September 2002, the West African chimpanzee conservation identified the southeastern Liberia forest block as one of the highest or top priority rainforest sites for chimpanzees.

In 2007, the International Union for Conservation of Nature (IUCN) identified Key Biodiversity Areas in Liberia (Langhammer, P.F, et. al., 2007). These areas are not legally protected, but are designated based on quantitative criteria based on manageable land units defined by local experts using global standards. Criteria include: presence of globally threatened species; significant populations of restricted range species; a representative sample of biome-restricted species; and, important congregations of species. This methodology was pioneered by Birdlife International, which also identified nine important bird areas in Liberia: Cape Mount, Cestos-Sankwen, Grebo, Lofa-Gola- Mano Complex, Nimba Mountains, Sapo National Park, Wologizi Mountains, Wonegizi Mountains, and Zwendru. Two of the identified important bird areas, Cape Mount and Cestos-Sankwen, are located on the coastline (Section 3.8.2.1).

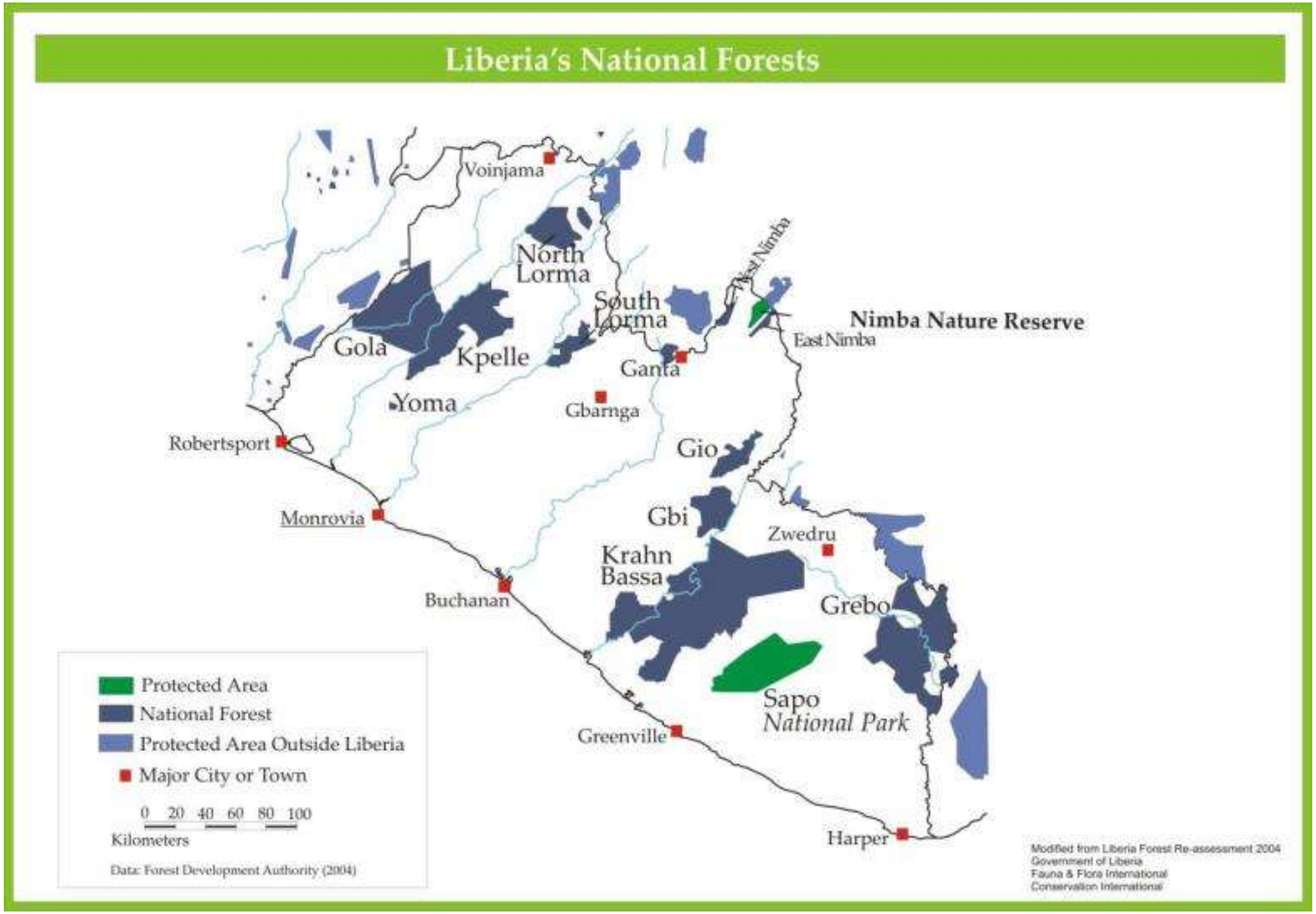


Figure 3-7: Protected areas, nature reserves, and protected areas of Liberia (modified from Conservation International, Liberia Forest Re-assessment, 2004).

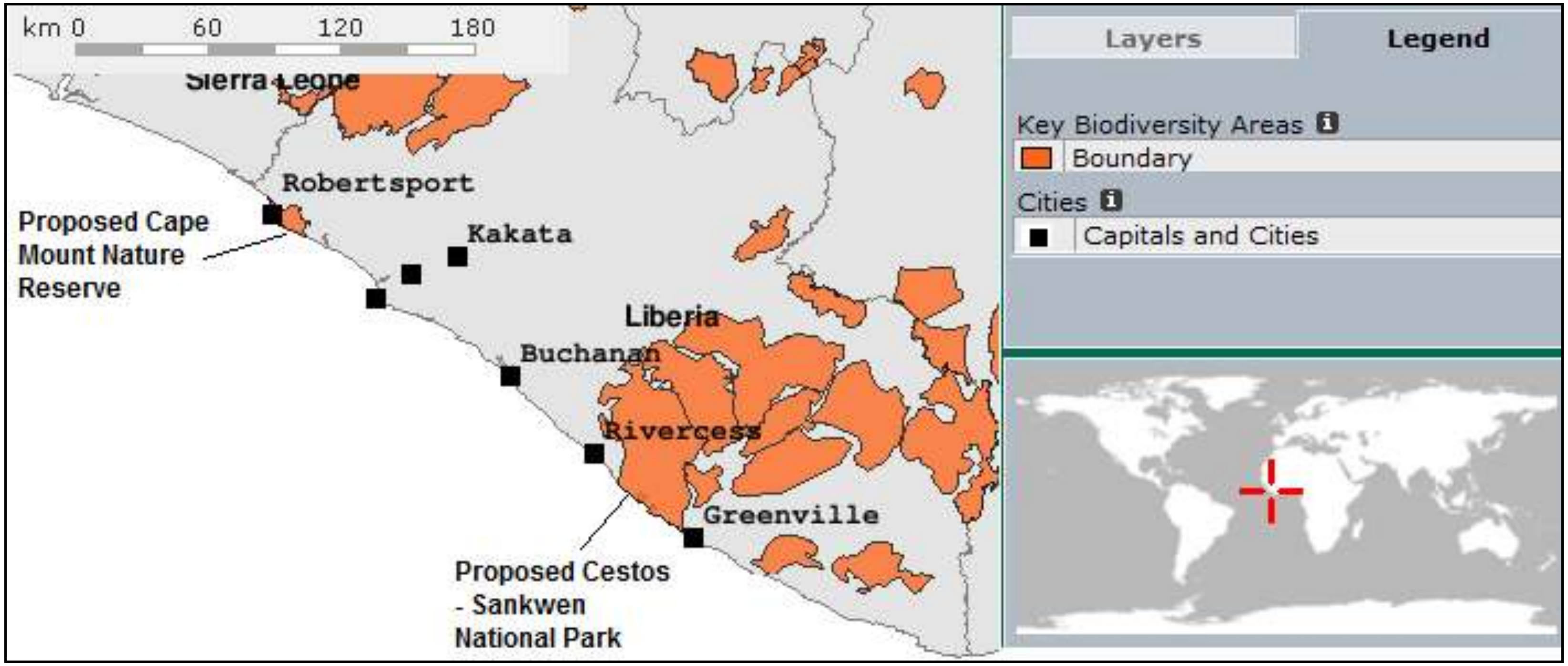


Figure 3-8: Proposed National Parks and Key Biodiversity Areas (Source: Birdlife International, Conservation International, IUCN, UNEP and WCMC . 2008. Integrated Biodiversity Assessment Tool).

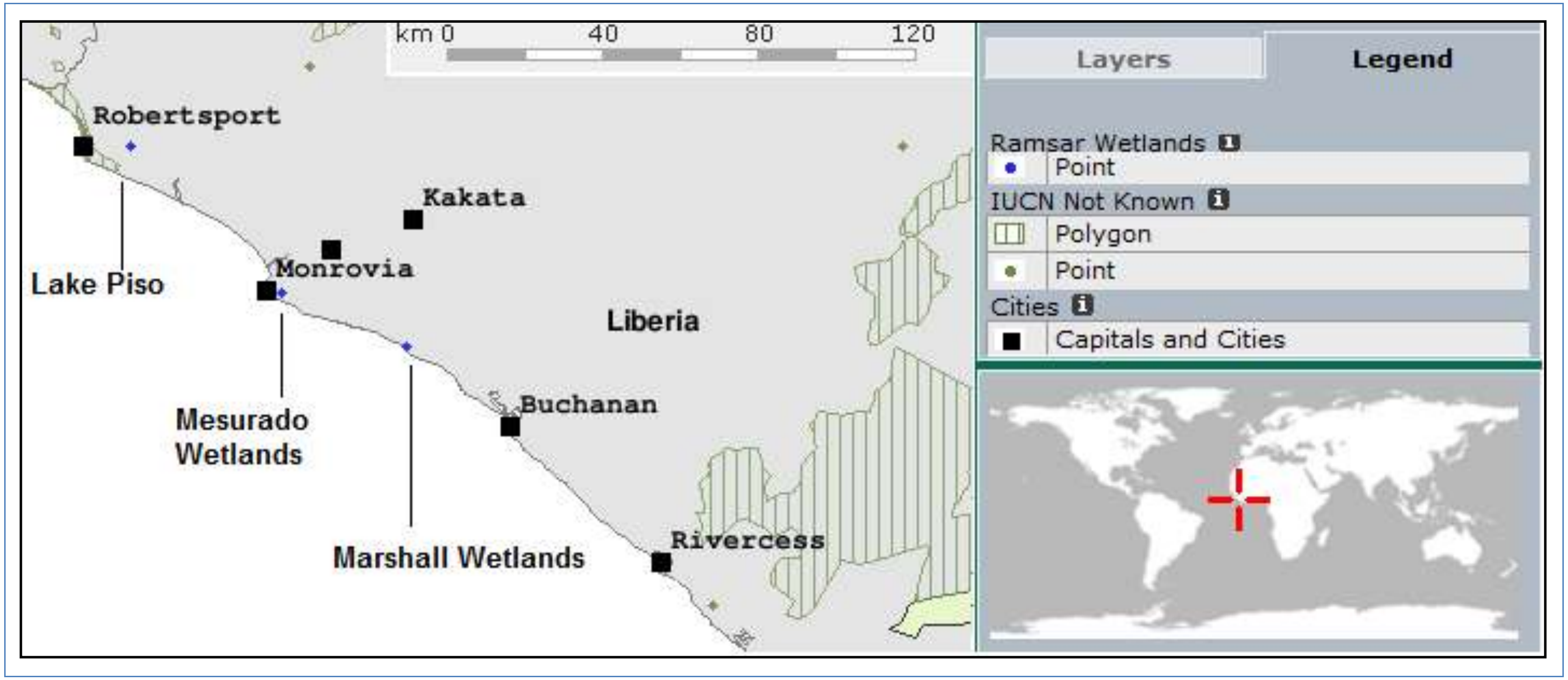


Figure 3-9: Ramsar Wetlands of International Importance Located on the Liberian Coast (Source: Birdlife International, Conservation International, IUCN, UNEP and WCMC . 2008. Integrated Biodiversity Assessment Tool).

3.9 AGRICULTURAL RESOURCES

Liberia has immense agricultural potential with an estimated 3.7 million hectares of arable land (38% of the total land area), of which about 6% is currently cultivated (FRM 2004). About 60% of the country, situated in the moist belt along the coast of West Africa, is covered by forest and woodland. The rain forest soils, while well drained, are highly leached, making Liberia better adapted to tree crop agriculture than to annual field crop production (NREL, 2009).

The climate and terrain conditions in Liberia are very favorable for agricultural development. Due to abundant water resources in the country, irrigation infrastructure is virtually non-existent. The rainy season lasts from April to October with a very high annual rainfall, ranging from 1,600 mm inland to 4,600 mm on the coast. The terrain is mostly made up of flat to rolling coastal plains, running into some interior plateaus and low mountains in the northeast. The country is divided into four agro-ecological zones: coastal plains (up to 100 m above sea level), interior hills (100–300 m), interior plateaus (300-600 m), and mountainous areas (in excess of 600 m) (NREL, 2009).

Agriculture is the backbone of Liberia's economy, providing informal employment for more than 70% of the workforce (mostly in rural areas) and contributing an estimated 53% to the gross domestic product (GDP) in 2006 (MOA 2007). The agricultural sector was left in ruin after Liberia's 14-year civil war (which ended in 2003), and it is slowly starting to revive itself. The damage to the agricultural sector is manifested in low productivity of agricultural systems; disruption of production due to the displacement of farming communities; erosion of marketing systems due to road, transport, and processing infrastructure degradation; physical insecurity; lack of farming opportunities (including seeds and tools) in the areas of displacement; and socio-economic dislocation (FAO 2006).

The Ministry of Agriculture defines three agricultural production systems, differentiated by the scale of production (MOA 2007):

- *Large plantations* (between 800 and 40,000 ha) produce export crops from perennials such as rubber, oil palm, and to a lesser degree, coffee and cacao. This system can be sub-divided into the large commercial plantations that are owned and managed by the private sector (found particularly in the rubber and palm oil sectors) and the state-owned plantations run by the Liberian Palm Products Corporation and the Liberian Cocoa and Coffee Corporation. Production in this second group is limited, although they remain in existence.
- *Domestically owned*, medium-sized commercial farms (between 5 and 200 ha) produce industrial crops for export and the local market (although these farms are extremely small in number).
- *Small household farms* (average size of 1.2 ha), the livelihood of the rural population, make up the majority of all farming. They use traditional production techniques with extremely limited use of modern inputs. Household farms are based on family labor and concentrate on growing food crops like rice and cassava, with some growing cash crops like rubber, coffee, cacao, and oil palm.

3.9.1 Rubber

Rubber has been Liberia's principle cash crop since the 1920s. The country ranks third in Africa's production of natural latex after Nigeria and Ivory Coast, with about 117,000 tons in 2005 (FAOSTAT). Below is a list of the large-scale rubber plantations established in Liberia over the years and Figure 3-10 illustrates their locations:

- Firestone near Harbel, Margibi County
- Liberia Agricultural Company (LAC) near Buchanan, Grand Bassa County
- Guthrie (also known as Goodrich plantation) near Baha, Bomi County

- Liberia Company (LIBCO) near Cocopa, Nimba County
- Salala Rubber Corporation near Nienka, Margibi County
- Cavalla (initially part of the Firestone concession) near Harper, Maryland County
- Sinoe Rubber Corporation (SRC) near Greenville, Sinoe County

Figure 3-10: Rubber Plantations in Liberia. Source: UN 2006

Some of these plantations were abandoned or taken over by rebel forces during the civil war. As a result, many suffered years of poor or indifferent management and would need significant investment to put them back in production. During this time, few plantations changed hands, such as Firestone, which sold its interests to the Japanese-owned Bridgestone in 1988, or ceased operation (the government suspended the agreement with LIBCO in December 2007, citing poor management). The two largest plantations, Firestone and LAC, remained in good condition after the war, and are currently producing significant quantities of rubber. As of July 2007, the Firestone factory was producing 3,000-4,000 tons of rubber per month, while LAC was producing about 2,000 tons per month. Two other plantations, Guthrie and Cavalla, reported production of about 4,000 tons each in 2006 (MOA 2007). Because of these companies' operation, many household farmers in Liberia note that rubber is currently their most important cash crop. They sell raw rubber to the companies, making the industry a big employment generator as well as a major income earner for the country (FAO 2006).

It is estimated that large-scale rubber plantations in Liberia today cover an area of approximately 58,000 hectares (NREL, 2009), while small and medium sized farms make up the balance of the rubber acreage. These plantations generate considerable amounts of wood residues from pruning and replanting activities. UNEP and BR Fuel data indicate they have reached or are nearing the end of their productive lifespan due to slaughter tapping or neglect during Liberia's civil conflict. The rotation period, when the trees are cut down for replanting, is 25-30 years. Tree trunks and branches become available during replanting. Tree trunks and branches may be left on the ground to rot, burned in the fields, or on a small scale, used as a local source of timber or in charcoal production. Rubber trees are deciduous—they shed their leaves during the dry season, resulting in another source of nutrients and biomass.

3.10 ENERGY & ELECTRICITY RESOURCES

Energy is an essential sector in Liberia because it cuts across all the other sectors and serves as a catalyst for social, economic, and political growth and development. Furthermore, energy contributes to employment, trade, fiscal revenues, food security, and regional and sub-regional development, besides its share of about 0.8% (Table 3-4) (CBL, 2008) of the overall gross domestic product (GDP) of Liberia as a sector.

The current energy market in Liberia is dominated by petroleum products that are imported in refined forms, and woody traditional biomass consumed primarily for cooking and heating as in nearly all of Sub-Sahara African countries. The market for petroleum is formal in nature while that of woody biomass is informal.

Table 3-4: Relevant Energy Sector Indicators.

Indicator	Value	Source, Year
% of energy sector share of national GDP	0.8	CBL, 2008
2008 petroleum product consumption (US gallons)	65,279,917	LPRC, 2008
Current power generation capacity (national grid)	9.6 MW	LEC, 2008
% of urban population with access to electricity	10	NEP, 2008
Current electricity tariff	US$ 0.43/kWh	LEC, 2008
% of rural areas electrified by national grid	0	LEC, 2008
% of rural population with access to electricity (private)	<2	NEP, 2009
% of rural population with access to national grid (LEC)	0	LEC, 2008
Charcoal consumption in 2005	~36,500 tons	NACUL, 2005
Fire wood consumption in 2005	~10.8 million m^3	CSET, 2004

Prior to the 14 year civil crisis it was estimated that the total installed electricity generation capacity was 412MW. Overall 52 % of pre-war capacity was heavy fuel (bunker) oil (HFO) thermal, 31 % light oil thermal and 17 % hydro (CBL, 2000). The 17 % or 68 MW were the total generation capacity of two main hydropower stations. These were the Mount Coffee hydro power plant (64 MW) and Firestone hydro-power plant, Harbel plant (4MW). A community micro-hydro power station of 30 KW was also located at Yandohun in Lofa County. The Mount Coffee and Yandohun plants were destroyed during the war where the Harbel plant is still operation. The remaining fossil based power plants were owned by the Liberia Electricity Corporation (LEC) and private concessionaires.

Fuel storage infrastructure facilities have also been damaged as a result of the conflict. Thus, fuel storage and handling is poor across the country with little or no safeguards to contain surface spilling.

As a result, unreliable supplies of electricity, lead to the use of generators as an alternative. In 2004, UNEP reported that approximately 45,000 generators were used in Monrovia.

One of the most critical impacts from the lack of electricity has been the increase in demand for alternative sources of energy given the abundance of Liberia forests. Fuel wood and charcoal became the principal energy sources and consumption skyrocketed both during and after the war (UNEP 2004). In 2004, UNDP reported that 99.5 percent of the population relied on biomass (fire wood, charcoal and Palm oil) for the energy needs; a trend passing threat to biodiversity and forests, due to the unsustainable manner in which the production of their tradition fuel is handled. In 2000, the Central Bank of Liberia estimated that 960.00 trees are cut down annually to produce charcoal for the Monrovia area alone. Annual consumption of woody biomass was estimated at about 10.8 million m^3 (CSET, 2004) for fire wood, and 36,500 tons (NACUL, 2005) for charcoal (Table 3-4).

Moreover, prior to the war, the electricity supply system in Liberia, operated by LEC, was based on a central Monrovia city system with radial lines extending into the country and independent isolated grid; the national electricity grid had a total of installed capacity of 191 MW of power by 1989 (NEP, 2008). However emergency power program (EPP) was launched in 2006 following the inauguration of president Ellen Johnson Sirleaf, the EPP was designed to re-establish the public power supply as part of the Government Political Stabilization and Economic Reconstruction program. The LEC now has a system with 9.6 MW diesel generators, 80 km of transmission and distribution network, and over 2500 customers in Monrovia (NEP, 2009).

(a)

(b)

(c)

(d)

Figure 3-11: (a-b) Damaged LEC facilities; (c-d) fuel storage problems in Free Port of Monrovia: leaking oil storage tanks posing threats to groundwater.

There has been a lack of policy and regulation for the energy sector of Liberia, thus making the sector fragmented with no coordination mechanism. As a remedy to this problem, the Government, through the Ministry of Lands, Mines and Energy formulated a National Energy Policy (NEP) in 2008 to detail the actions required to enable the country's energy sector to play its strategic supporting role. The NEP calls for universal and sustainable access to affordable and reliable energy supplies in order to foster the economic, political, and social development of Liberia. One of the key pieces of the NEP related to rural energy is the creation of a Rural and Renewable Energy Agency (RREA) whose long-term goal is to facilitate the economic transformation of rural Liberia by accelerating the commercial development of modern and renewable energy services in rural areas. The Government of Liberia states the following targets in the NEP using 2009 as the base year:

- Reducing greenhouse gas emissions by 10% by the energy sector in 2015.
- Improving energy efficiency by 20% by 2015.
- Raising the share of renewable energy from the current level of 10% to 30% of electricity production in 2015.
- Increasing the level of biofuels in transport fuel to 5% by 2015.
- Implementing a long-term strategy to make Liberia a carbon neutral country, and eventually less carbon dependent by 2050.

There have been the following developments in Liberia's energy sector since the election of the new Government into office in 2006:

- Emergency Power: with the assistance of multilateral co-operation (Ghana, EU, USAID) diesel units of 9.6 MW total across four sub-stations have been installed; in order to provide street lighting and a limited number of connections (<2500), small portion of the distribution network in Monrovia has been rehabilitated.
- Monrovia Management Contract: IFC has been contracted by the Government of Liberia to attract the private sector into a management contract to provide power services in Monrovia, which will be funded by the Norwegian Government. IFC undertook the due diligence analysis and proposed strategic options to the Government of Liberia. Manitoba Hydro has been selected for the Management Contract and began operations on July 1, 2010.

Another option under consideration is to supply Monrovia and Buchanan through Côte d'Ivoire. This would require the construction of a transmission line, part of the future West Africa Power Pool (WAPP), connecting Côte d'Ivoire, Liberia, Guinea, and Sierra Leone (CSLG). The World Bank is preparing a project for the financing of this CSLG transmission interconnector.

3.11 Socio-Economics

3.11.1 Demographics

The population of Liberia as reported by Liberia Institute of Statistics and Geo-Information Services (LISGIS) in 2008 is 3,489,072. This population size is relatively small in comparison with other countries around the region despite the fact that the yearly rate of growth of the nation is slightly over two percent (2.1%) (LISGIS, 2008). It is also estimated that the total population of Liberia would double in 34 years as of 2008 (i.e. by 2024) if the observed annual growth rate of 2.1 percent persists into the future. Out of the total population, 1,764,555 are males, and 1,724,517 are females (LISGIS, 2008) (Table 3-5).

Table 3-5: Population Distribution and Sex Ratio (LISGIS, 2008).

County	*Male*	*Female*	*Total*
Bomi	41,807	40,229	***82,036***
Bong	161,928	166,991	***328,919***
Gbarpolu	44,376	39,382	***83,758***
Grand Bassa	111,861	112,978	***224,839***
Grand Cape Mount	66,922	62,133	***129,055***
Grand Gedeh	65,062	61,084	***126,146***
Grand kru	29,330	27,776	***57,106***
Lofa	130,143	139,971	***270,114***
Margibi	99,900	99,789	***199,689***
Maryland	70,725	65,679	***136,404***
Montsserado	585,833	558,973	***1,144,806***
Nimba	232,700	235,388	***468,088***
Rivercess	33,860	32,002	***65,862***
Rivergee	35,360	31,958	***67,318***
Sinoe	54,748	50,184	***104,932***
Total	**1,764,555**	**1,724,517**	**3,489,072**

Liberia is presently divided into 15 major counties; Bomi , Margibi, Maryland, Montserrado, Sinoe, Nimba, Grand Gedeh, Grand Bassa, Grand Cape Mount, Lofa, Bong, Gbarpolu, Grand kru, River Cess, and River Gee. Each of these subdivisions is headed by a superintendent who serves as the vice juror to the President of Liberia.

The total national population is seen to be unevenly distributed among the counties. The population distribution favors Montserrado, Nimba, Lofa, Grand Bassa, and Margibi Counties in descending order of magnitude. Montserrado, Nimba and Bong Counties hold exactly 56 percent of the population (LISGIS, 2008).

On the other hand, Grand Kru, River Cess, River Gee, Bomi and Gbarpolu counties hold the least population totals. They together have 10 percent of the national count and each of them contributes less than 2.5 percent (LISGIS, 2008).

In 2008, the population density of Liberia was 93 persons per square miles, with Montserrado County being the most densely packed where the population density is over 1,500 persons per square mile and can be much higher in Monrovia and its environs. As a matter of fact, Monrovia has a population of 1,010,970 people and alone is more than five times greater than the combined population of all county headquarter. It has a total population over 32 percent of the national population (LISGIS, 2008).

Counties of Margibi, Maryland, Bomi and Nimba are classified as dense population concentrations with densities falling between 100-199 persons per square mile. The counties that hold moderate population concentration (55-99 persons per square miles) include Bong, Lofa, Grand Bassa and Cape Mount. The rest of the counties comprising Gbarpolu, Grand Gedeh, Grand Kru, River Cess, River Gee and Sinoe Counties are sparsely populated; they typically have distribution between 22 and 38 persons per square mile.

3.11.2 Household Characteristics

Liberian households consist of an average of 5.0 persons. Almost one-third (31 percent) of households are headed by a woman (LDHS, 2007).

Housing conditions vary greatly based on residence. Only 3 percent of households have electricity. Electricity is almost non-existent in rural areas, while 7 percent of urban households have power. Only 10 percent of households nationwide have an improved (and not shared) toilet facility. About one-third have an non-improved facility, while 55 percent have no toilet facility at all (LDHS, 2007).

Half of Liberian households have a radio, while only 7 percent have a television. Almost three in ten households have a mobile phone, while only 2 percent have a refrigerator. Even the most common households goods are not universal in Liberia- only 60 percent of households have a table or chairs (LDHS, 2007).

More than two in five Liberian women 15-49 have had little or no education. Only 8 percent of women and 19 percent of men age 15-49 have completed secondary school or beyond. Urban residents are more educated than rural residents; more than half of women and almost one-quarter of men in rural areas have received no education at all compared to only one-quarter of women and 8 percent of men in urban areas. Education is particularly low in North Western and North Central regions, among both women and men (LDHS, 2007).

3.11.3 Land Use Pattern

Agriculture plays an important role in the country's economy. During the pre-war years about 70 percent of the population lived in rural areas and depended on agriculture (crop and livestock production) for their livelihood. About 46 percent of the total land area of 9.8 million hectares is available for agriculture (FAO, 2005). Most agriculture is carried out on small holdings, many of which are still cultivated in the traditional ways of bush following shifting cultivation. These are also large individual and commercial plantations that produce rubber, coffee, cocoa, palm kernel, and other export crops. Land use patterns vary around the country; forested areas accounts for 46% of the land use, pastures about 20% and others 34%.

3.11.4 Economics

Agriculture and mining form the backbone of the Liberian economy. Timber and rubber are the main export items earning more than $100 million and $70 million annually respectively. Alluvial diamond and gold mining activities also account for some economic activity.

3.11.5 Health Care Delivery

The health infrastructure in the country is in very poor condition with about 70% of public health care facilities in a non-functional state. Access to basic health services is extremely low, which accounts for high infant and child mortality rates. Malaria, diarrhea, acute respiratory infections, neonatal tetanus, measles, and malnutrition are the major causes of morbidity.

The 2007 Liberia Health and Demographic Survey (LDHS) included HIV testing of almost 12,000 men and women. Eighty-seven percent of eligible women aged 15-49 and 80 percent of men 15-49 were tested for HIV. The LDHS results indicate that 1.5 percent of adults age 15-49 are HIV-positive. Women are slightly more likely to be infected than men, and those living in urban areas are at higher risk of infection than those living in rural areas. HIV prevalence is highest among women and men living in Monrovia, and lowest in North Central.

For women, prevalence hits its peak at age 35-39 (2.5 percent), while for men, prevalence is at its highest at ages 25-34 and 45-49 (1.7 percent). HIV prevalence is slightly higher among women and men who are widowed or divorced/separated than those who are currently married or who have never been married.

3.11.6 Infrastructure

Liberia's infrastructure was severely damaged by the war. Most Liberians have no access to electricity, improved water and sanitation facilities, acceptable housing, or decent roads. Weak infrastructure undermines income earning opportunities, limits access to health and education facilities, raises the price of goods and services, and weakens food security. Women and children bear a large burden as a result of poor infrastructure, as they must spend more time carrying water and other goods; are more vulnerable to crime; and have less access to health facilities, raising the risk of child and maternal mortality. Persons with disabilities are also disproportionately disadvantaged.

Perhaps the most critical infrastructure problem is roads, which Liberians across the country consistently placed at the top of their priorities during PRS consultations. Currently there is only around 700 km of paved road surface, almost all of which is damaged, and 1600 km of unpaved roads, which are mostly in need of repair. Farm-to-market access is of paramount concern, and parts of the country remain cut off during the rainy season. It takes at least an hour for most rural dwellers to access a food market or the nearest potential transport option. Roads are central to reducing poverty, as they open up income-earning opportunities for the poor, improve access to health and education facilities, reduce transport costs and commodity prices, and help strengthen local governance.

Other transportation infrastructure is equally weak. Many bridges have been damaged and need rebuilding or repair. The limited railway network has not been operational for nearly 20 years. Civil aviation is limited to Monrovia with only UN flights operating upcountry. The Port of Monrovia is operational, but badly damaged and in need of urgent repairs.

Most Liberians use palm oil, kerosene and candles for light. While significant progress has been made since the end of the war, still only 25 percent of Liberians have access to safe drinking water and just 15 percent have access to human waste collection and disposal facilities. Most residents do not treat or boil their water, which has grave implications for the health and nutritional status of the population. Garbage collection is minimal with the availability of one open dump site located at the outskirts of Monrovia, Whein Town.

Many Liberians live in sub-standard housing. The war sparked massive internal displacements, with Monrovia hosting the majority of the Internally Displaced Peoples. There is a huge mismatch between the number of urban dwellers and available social services, leading to overcrowding, deteriorating living conditions, and the growth of slums and illegal home occupation. Over a third of the population cannot afford to honor their rent payments, contributing to a high incidence of squatting.

4 PROJECT DESCRIPTION

The Buchanan Renewables (BR) Group invests in projects that are intrinsically social and environmentally responsible. BR believes that its greatest contribution to social responsibility is through job creation and economic development catalyzed by its business activities. Similarly, it aims to promote environmental responsibility by developing a renewable energy and resource business.

BR has two core businesses in Liberia: Buchanan Renewables Fuel (BR Fuel) and Buchanan Renewables Power (BR Power). Buchanan Renewables Fuel (BR Fuel) is a biomass generation company that converts rubber trees that are no longer producing latex at economically viable rates into woodchips. BR Fuel is currently exporting these woodchips to European utilities, which use them to reduce their fossil based emissions. In the future, the rubber wood will also be used to fuel the 36 MW power plant that BR Power is building near Kakata to bring affordable, reliable and sustainable base load power to Liberia.

BR Fuel believes that Liberian rubber wood is an ideal source of biomass, as it is an existing agricultural byproduct, available in high concentrations and currently with few alternative uses, at least at a significant scale. Furthermore, the use of Liberian rubber wood is not threatening to food security. In fact, thoughtful replanting strategies involving cover crops and intercropping could support the development of markets for Liberian produce, both internally and externally.

BR Fuel's GIS, satellite imagery and desk studies, suggest that there are over 259,000 ha of rubber trees in Liberia, 60-75% of which are currently non-producing. This is as a result of the civil conflict in Liberia during which rubber trees were often "slaughter tapped", a process that accelerates the flow of rubber from trees, leaving them unable to sustain themselves, or simply neglected and left to age. The normal productive life of a rubber tree is about 26 years and it starts producing latex after 5-

7 years. The backlog of non-producing rubber trees in Liberia is estimated to equate to approximately 60 million tons of biomass.

BR Fuel works with rubber farmers, ranging from large concessionaires to smallholder farmers, to excavate and remove the non-producing trees from plantations and chip the rubber wood into woodchips used to produce renewable power. It uses heavy equipment to remove the trees and a combination of equipment and labor to clear the sites and prepare them for replanting, eliminating a significant cost for farmers and barrier to rejuvenation of the rubber industry.

BR Fuel's relationship with farmers is defined in a clear written contract. BR Fuel pays rubber farmers for the tonnage of chipped rubber wood extracted from their farms and either replants the farms or supports the replanting through provision of materials and advice, unlocking future income from latex sales for the farmers. BR Fuel has committed to ensuring that at least one tree is replanted for every tree removed to maintain the sustainability of the project and achieve relative carbon neutrality. In general, BR Fuel plants between one and two trees for every tree removed.

BR Fuel is also exploring partnerships with rubber concessionaires, NGOs and IGOs, aid organizations and financing institutions to comprehensively support the rejuvenation of the rubber industry and other income generating activities for smallholder farmers. It currently manages a nursery in the Buchanan area, which it uses to source the seedlings for replanting smallholder farms.

Vattenfall, a leading European energy generator, and Swedfund, the Swedish state-owned risk capital fund recently partnered with BR Fuel. Vattenfall also finalized a long-term supply agreement with the company. It plans to co-fire BR Fuel's rubber woodchips in its coal-fired power plants as a means of reducing its fossil based carbon emissions and minimizing its impact on global climate change.

In order to fulfill this agreement, BR Fuel aims to produce approximately 2,000,000 green metric tons (GMT) of biomass (rubber woodchips) on an annual basis by 2017 and into the future. This equates to the rehabilitation of an estimated 7,000-8,000 ha of rubber wood plantations per year, or approximately 3% of existing rubber plantations, which is below the annual sustainable cut for a tree species with a life cycle of approximately 30 years. The biomass produced will be exported to European utilities, as well as used locally for power generation in Liberia.

In order to reach these targets, BR Fuel will be expanding its business at a more rapid rate than originally anticipated and operating at a larger scale. While BR Fuel's basic project activities will not change significantly, it will be expanding to rubber plantations across Liberia at a faster rate. It will also be strengthening some of its facilities to support the expansion project. BR Fuel views this expansion project as a development opportunity, one that will expedite the rejuvenation of the rubber industry, the associated job creation, and infrastructure development in Liberia. BR Fuel will be converting rubber trees into woodchips both through the use of mobile chippers, and, in future, by trucking rubber wood logs and roots to stationary chippers/grinders at its port facility in Buchanan and BR Power's power plant site near Kakata. Thus, BR Fuel will be transporting large volumes of woodchips or logs from rubber plantations to one of the two sites mentioned above. In order to facilitate movement of the woodchips, logs and roots, BR Fuel will undertake road development and improvement activities on plantations and road improvement activities on public roads in the area in which it is working.

Woodchips will be shipped from the Port of Buchanan, and potentially other ports of Liberia as they are rehabilitated in the future. Ship loading will be through a system of conveyor belts. As part of its expansion project, BR Fuel intends to develop a materials handling and ship loading facility to accept and store logs, chip the logs, and then store and convey the chips to the commercial quay in the Port of Buchanan where they will be loaded directly from the stockpile.

Once BR Power's power plant is operational, logs and roots will be chipped or ground on the power plant site and used in the biomass-fueled boilers to generate power. It is important to highlight, that as part of BR Fuel's long-term supply agreement with Vattenfall, supply of biomass to BR Power's power plant is to be prioritized above generation of biomass for export to Vattenfall, thus ensuring sufficient supply for local use in the plant.

BR Fuel's activities will be supported by its workshop and warehouse in Buchanan, as well as a small workshop facility that will likely be developed near the site of BR Power's power plant.

This expansion project has the potential to create approximately US $51 million in net present value for the Liberian rubber industry on an annual basis, as well as make a significant contribution to job creation, both directly through BR Fuel and indirectly through the rejuvenation of the rubber industry, and infrastructure development in Liberia. It will also provide a reliable, renewable, cost-effective, and local source of base load electricity in Liberia.

4.1 Project Location

BR Fuel's corporate headquarters are located in Monrovia, Montserrado County, and its main operational site (workshop, warehouse, fuel station, equipment yard, offices), woodchip handling facility, and nursery are located in Buchanan, Grand Bassa County. BR Fuel's production sites (rubber farms) are mobile and are located in different counties. Its current operations focus on smallholder farms in the Buchanan area, the Liberian Agriculture Corporation and the Firestone Natural Rubber Company. As BR Fuel expands, however, it aims to operate on rubber plantations throughout Liberia. It is currently developing strategies to facilitate the transport of rubber wood from various regions of Liberia in line with the country's infrastructure development plans.

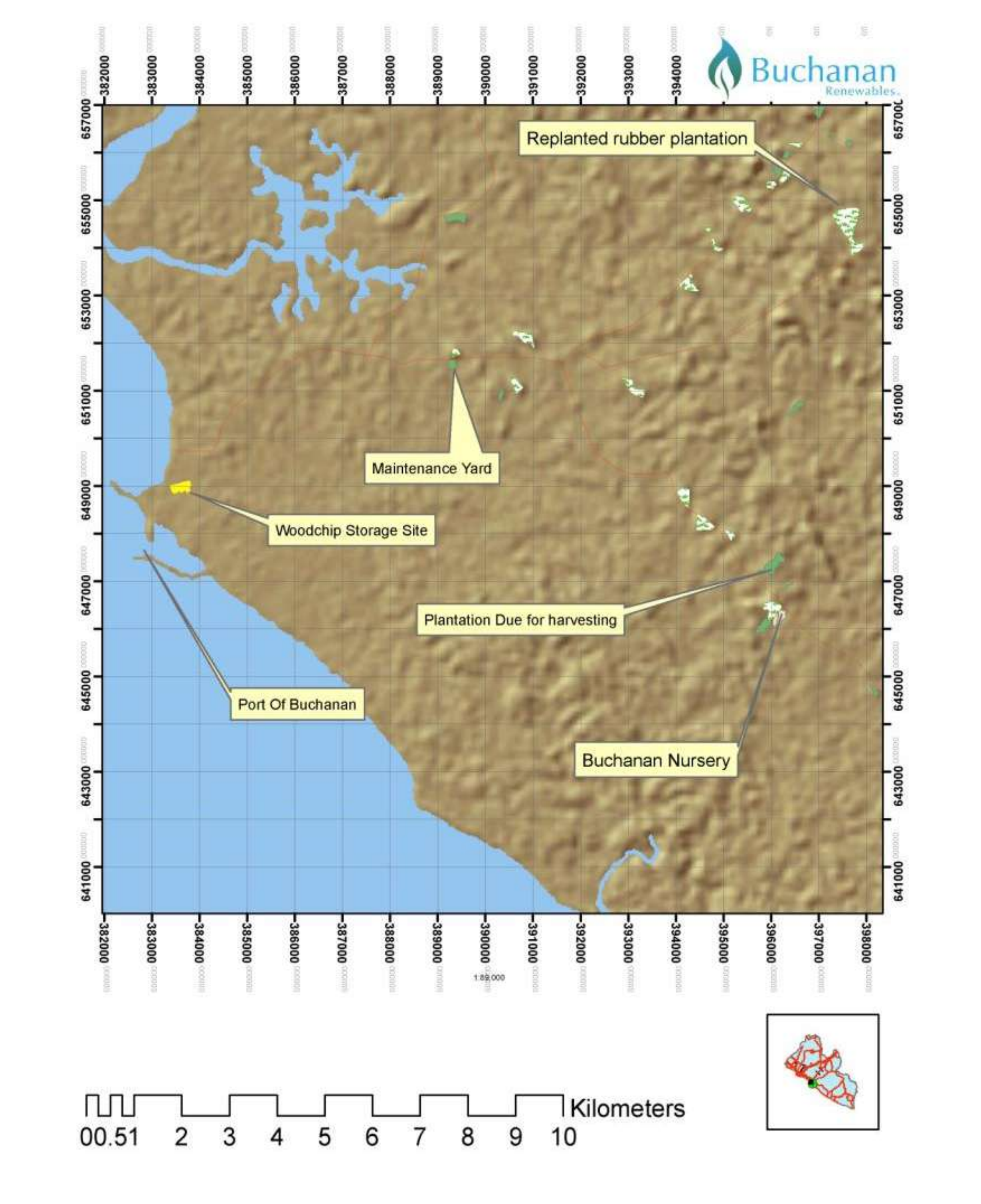


Figure 4-1: Project Location Map. ***Source:*** **Buchanan Renewables Fuel.**

4.2 Harvesting Plan

BR Fuel aims to produce approximately 2,000,000 green metric tons (GMT) of biomass (rubber woodchips) on an annual basis by 2017 and into the future. This equates to the rehabilitation of an estimated 7,000-8,000 ha of rubber wood plantations per year, approximately 3% of existing rubber plantations. Given the estimated 30 year lifecycle of a rubber tree, this is less than the sustainable cut of the estimated 259,000 ha of rubber trees. BR Fuel plans to expand its business gradually, scaling up to the production of approximately 540,000 GMT in 2011 with gradual annual increments up until 2017, when it aims to be producing approximately 2 million GMT per year.

In order to achieve these targets, BR Fuel will source short and medium term biomass feedstock primarily from rubber farms and plantations throughout the country containing a significant backlog of old, non-producing rubber trees. In the longer-term, biomass feedstock will come from the harvest of replanted rubber farms as rubber trees move through their 30 year lifecycle. Future biomass may also come from feedstock developed by Buchanan Renewables Fuel.

Combining information from multiple sources[1] along with results from the company's surveying and GIS initiative, BR Fuel has been able to create a reasonable planning estimate of the locations of the country's rubber wood feedstock. This initial supply assessment forms the basis of the company's harvesting and operations strategy. The key areas that BR Fuel will target in the initial term are highlighted in dark green in Figure 4-2. These are areas with high concentrations of redundant rubber trees. Initially BR Fuel will focus on rubber farms, large and small, closest to the Port of Buchanan and the power plant site near Kakata (LAC, Firestone, smallholders in the Buchanan Area, Bright and Morris farms near Kakata, and Todee smallholder farms near Kakata). As Liberia's infrastructure improves, BR Fuel will expand into other areas of the country, prioritizing areas with high concentrations of non-producing rubber farms (see map below). Once the backlog has been cleared, BR Fuel will focus on areas with high concentrations of rubber farms and strong links to its port facility.

[1] Including LISGIS Census Data, industry reports, and consultations with industry experts.

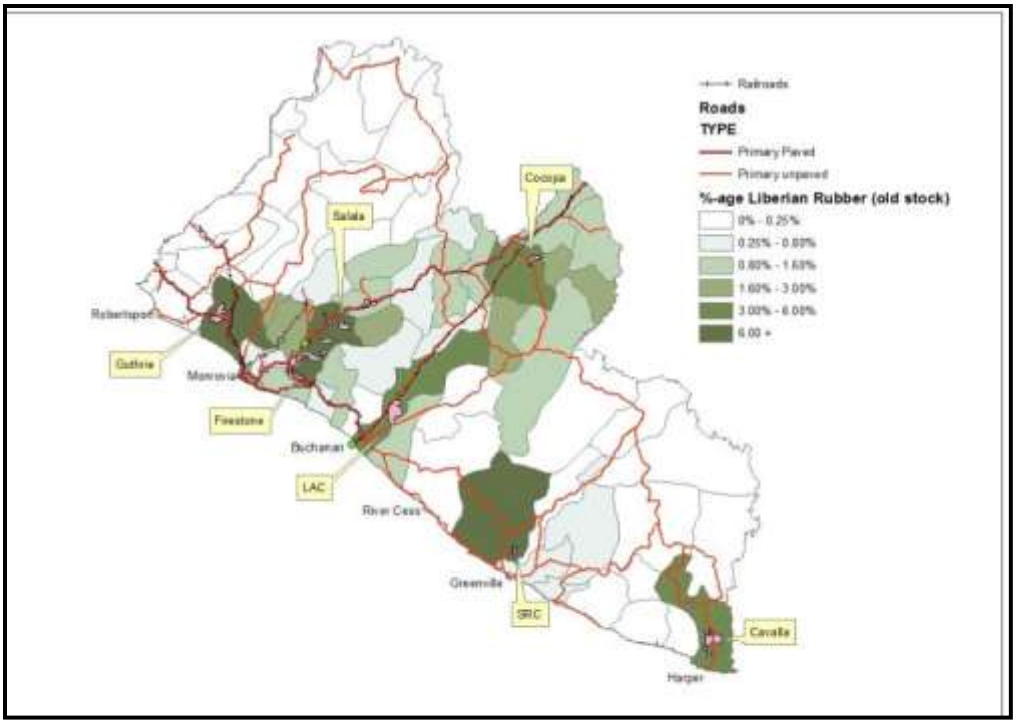


Figure 4-2: Approximate Location of Old Rubber Stock. Source: Source: Buchanan Renewables (July 2009) and LISGIS Census Data (2008).

Buchanan Renewables Fuel will harvest rubber wood on land falling under three principal ownership classifications: concessions, commercial plantations, and smallholders.

4.2.1 Corporate Concessions

- There are seven rubber concessions in Liberia comprising a total planted acreage around 80,000 hectares.[2] The concessions were destroyed to varying degrees during Liberia's fifteen year civil war. Replanting programs were interrupted and, in some cases, rebel groups occupied the plantations during and in the period immediately after the war ended.[3] BR Fuel estimates around half of the total planted area on the seven concessions consists of old or damaged trees.

[2] The total area under concession management is much larger than then are planted with rubber trees. A recent study estimates just 18% of the total concession area is presently under rubber production.

[3] For example, on Guthries 120,000 hectare concession in Bomi county, LURD militia "slaughter tapped" and maimed the rubber trees, greatly impacting future production of latex.

- Restarting concession-based rubber production has been a major focus of the Liberia's rebuilding efforts.[4] In 2006, President Johnson-Sirleaf established a Rubber Plantation Task Force jointly with UNMIL Forces to advise on legal, management, and political issues involved in resuming plantation activity.[5]
- Rubber concessions have been prioritized in international development assistance programs targeting private sector growth. Three concessionaires – LAC, Salala, and Guthries – have received financing from the International Finance Corporation (IFC) to replant rubber and rebuild or expand processing capacity.
- All but one of the seven concessionaires had a processing facility for natural rubber exports (mostly Technically Specified Rubber but also latex concentrate) before the war. Processors source rubber partially from their own corporate plantation and partially from independent farmers and smallholders in the regions proximate or contained within the concession.[6] Concessionaires have buying stations throughout the country as well as field agents who purchase coagulum at the farm gate.
- The concessions best preserved during the war have their own harvest management programs in which rubber trees are cleared and replanted, in most cases on a thirty-two year rotation[7].

4.2.2 Independent Commercial Plantations

There are approximately twenty large Liberian-owned rubber plantations. Liberian-owned plantations range from around 400 hectares up to 4,000 hectares. BR Fuel

[4] See UNMIL Report: Joint Government of Liberia – United Nations Rubber Plantation Task Force, 23 May 2006.
[5] As of May 2007, it is generally recognized that all of the major concessions have been returned to their rightful owners after many were occupied by squatters. (Comprehensive Assessment of the Agricultural Sector (CAAS), World Bank and Liberian Ministry of Agriculture (MOA), 2007)
[6] Rubber exporters in operation today include Firestone, LAC, Salala, and MARCO; facilities at Guthries, Cavalla and Cocopa were destroyed during the war. Re-milling factories not yet in production include the Liberian Rubber Corporation and T.H. Lee.
[7] The average rotation for rubber trees in Liberia is 32 years, consisting of 7 years from planting to maturity, plus 25 years of natural rubber production, after which the tree's productivity is greatly diminished.

estimates that independent plantations account for 25-30% of the productive rubber are in the country today, as well as much of the unproductive rubber.

4.2.3 Smallholder Rubber Farms

- Smallholders entered the Liberian rubber market more recently before the civil war. Today BR Fuel estimates that about a third of the productive rubber acreage in the country is owned by farms with less than 400 hectares of land. The average smallholder farm size is three hectares and employs three to five rubber-tappers, though the company has surveyed several farms in the 100 to 400 hectare range that BR Fuel groups with smallholders for planning purposes.
- Smallholders in general are poor and weakly integrated with domestic, let alone international, markets. They have little to no access to banks and the savings and insurance instruments common in more developed countries. Many farmers planted rubber (of unimproved varieties) to provide for future generations or as a way to secure a title to their land according to the country's customary land rights system.
- In most areas of the country, smallholder farms were completely abandoned during the war. BR Fuel estimates 40 percent of old rubber trees in Liberia sit on smallholder land. Many farmers today lack the resources to redevelop their farms. In Liberia, the cost of developing a typical three hectare farm requires an outlay of $3,840, including labor inputs,[8] more than seven times Liberia's per-capita income.
- The economic constraints of smallholder farmers are perhaps best illustrated by the marketing and pricing of rubber coagulate within Liberia. Liberian

[8] International Institute of Tropical Agriculture, 2008.

rubber farmers receive as low as 50 to 60 percent of the export price of rubber.[9]

- Of the three ownership categories, the company's development impact will be highest with smallholder farmers. The company is currently working with several partners to support the creation of a farmer association to secure and manage the supply of biomass from the Todee District, containing 121 farmers with 3,600 hectares of old rubber. BR Fuel estimates the Todee District could supply several millions of tons of biomass over a seven year period, provide over US$600,000 per year in community income, generate 5,000 plantation jobs, and make possible a present value of over US$18 million in community agricultural investments.

4.3 Mechanisms for Farmer Engagement

BR Fuel has defined two key mechanisms for engaging rubber farmers; however, it continues to explore alternatives for farmer engagement. In all cases the relationship between BR Fuel and the farmer will be defined by a written contract:

- **"Phased removal" for small, medium and large plantations** – The company assess the value of rubber wood on the land and provides a tree removal schedule. BR Fuel will then harvest biomass gradually over time, pay-as-you-go as trees are removed. The farmer can use the payments to invest in upkeep of sections removed in prior seasons. The farmer will replant the farm with BR Fuel's support.
- **"Farmer Associations" for smallholders** – The Company assesses the value of rubber wood on each farm and provides a tree removal schedule which groups several farms in an association. BR Fuel then harvests biomass

[9] There are several factors to blame for this situation, but one important aspect is the high transportation costs combined with cash constraints faced by the farmer, which create an opportunity for middle-men agents to absorb a large share of the value. Instead of waiting for an opportunity to sell to the multinationals, and receive a weigh bill in USD for future payment, smallholders often turn to village-level entrepreneurs who pay cash for the rubber at the farmgate in LD and then deliver the coagulate at the remote buying stations. CAAS, World Bank / MOA, 2007.

gradually over time, pay-as-you-go to association as trees are removed (similar to the "phased removal"). Each farmer gets a share of payments proportional to his or her share of overall association biomass. This scheme will include incentives to encourage self-monitoring and adequate selection within the association, similar to those employed in the micro-finance industry. The company also partners with sustainable agriculture-focused NGO to help farmers institute cover crop and intercropping schemes and provide training and facilitation in association development and agricultural practices. The NGO provides agricultural services (such as planting) or facilitates association nursery development.

4.4 Site-Specific Harvesting Plans

BR Fuel currently works according to 4 monthly harvesting plans. As the company's long-term contracts come on line, it will develop harvesting plans for and extended time period.

Prior to harvesting each site, BR Fuel conducts site-specific harvesting plans as follows:

- GIS mapping of site with roadways, water bodies and relevant cultural or conservation areas;
- Tree counting;
- Impact assessment and harvesting management plan, including mapping of Riparian Management zones and other buffer zones, as well as any other site-specific environmental and social management practices; and
- Monitoring activities and time frames

4.5 Harvesting Operation

The current harvesting method uses a set of mobile equipment called the chipper-set capable of producing approximately 240,000 GMT of woodchips and up to 60,000 tons of roots per year. It consists of tree felling machines, yarding machines and an industrial mobile chipper machine.

At each site, a small, flat area is delineated for the chipper. The tracked excavators fell the trees, the chainsaw team cuts off the roots and branches, and skidders gather the trunks and roots and stack them in front of the chipper. The chipper feeds itself with the trunks and the processed chips are blown straight into the back of a haul trailer. The full trailer is shunted to a staging area where a haul truck drops an empty trailer and collects the full trailer destined to the Port of Buchanan. Roots, which are a by-product of chip production, are either stacked with branches and left for local charcoal producers or loaded onto root transport trucks for delivery to the port, where they can be ground and used for mulch. Any further clearing of large debris required on harvesting sites is completed with a dozer; however, use of the machine is limited as far as possible. Wood dust and waste from the chipper, as well as debris from cleared vegetation is left scattered on site to maintain soil quality and stability.

In the future, when the power plant is operational, the trunks and roots will also be transported to the power plant site to be chipped/ground to generate local power. A portion of the roots and branches will continue to be left for use by charcoal producers and villagers.

Figure 4-3: Stages of chipping operations. ***Source:*** **Buchanan Renewables Fuel.**

In order to increase efficiency and minimize the number of trucks required, control traffic flow at the port and power station, and ensure production at the chipper sites are not inhibited by lack of trucks, haul trucks will operate 24 hours per day and will "drop and swap" laden and empty trailers to and from the port facility and production sites or trailer depots. In the case of sites that are far from the Port of Buchanan, trailer depots will be set up at points that are easily accessible for trucks. Depot sites will be selected to service multiple harvesting sites. The aim is to ensure the chipper will have a flow 25 trucks per shift.

The method described above represents an expansion of the current practice. In the future, as the company expands, it will modify its harvesting methodology, decoupling the logistic chain into 5 different sections that can be operated more independently, enabling the company to operate more cost-effectively on both small and large farms. This methodology will enable the company to work with a greater proportion of smallholder farms, thus unlocking the long-term income potential for those farmers.

The new methodology will involve two large stationary chippers at the Port of Buchanan, powered by diesel at first, but eventually powered by electricity from woodchips or root grindings, as well as similar chipping and/or grinding plant at the power plant site. The basic methodology will be as follows:

- Defining a relatively flat loading area on each site
- Felling rubber trees using feller-bunchers and skidding them to the road side loading area, leaving the roots in the ground
- Stacking and loading logs on site with a knuckle boom track loader and transporting them to Buchanan log storage (current woodchip storage or new site if required in the future)
- Feeding the stationary chipper in the port from the log storage and blowing chips directly onto the stacker conveyer
- Removing the roots from the ground using excavators and skidders, loading them onto trucks and transporting them to the port facility or power plant for grinding
- Clearing the land for replanting
- Leaving piles of branches and excess roots on site for use by local charcoal producers and villagers

The parts of the rubber tree not used for biomass generation will be piled near the side of the road for use by charcoal producers and by local community members as firewood. Initially this will constitute approximately 0.25 tons of biomass per tree. As the harvesting methodology changes and more of the roots are used in the biomass generation process, this figure will decrease slightly.

Replanting will be undertaken on all cleared farms. Large concessionaires and largeholders will carry out their own replanting and care for the land according to their standard practices. On smallholder farms, replanting capacity is limited. Thus, in order to ensure the replanting cycle is continued, the company will provide the resources (stumps, fertilizer, cover crops) and technical support to the farmers to replant their farms. If the farmers have not replanted their farms by mid way through the replanting season following the clearing of their land, BR Fuel's replanting team will undertake the replanting activities.

- Each replanting team consists of surveyors, weeders, hole-diggers and planters.
- When stumps (bud grafted seedlings) are planted, rock phosphate is used in the holes to fertilize the young tree (120g per tree).
- Cover crops, generally leguminous plants, but also grasses are planted for soil stability. BR Fuel is investigating other options for the use of nitrogen fixing cash crops and intercropping through its partnership initative for smallholder farm development.
- One team is currently capable of planting 1,200 trees or 2 ha per day.
- Stumps for replanting are grown and prepared in the company's nursery. Stumps do not contain genetically modified organisms (GMOs).

The nursery is currently 20 ha and can produce approximately 300,000 stumps per year. As the company develops, it will need to expand the nursery. In principle, however, BR Fuel, aims to partner with smallholder associations and others to develop nursery sites on a more regional basis. The nursery was developed on land that was covered in shrubs, elephant grass and a small area of secondary vegetation. It was traditionally used predominantly for cattle grazing and is located adjacent to a rubber plantation near BR Fuel's main site compound. The nursery staffs have undergone training courses in bud grafting. They plant and bud graft seedlings in the open fields and in polybags. The seedlings in polybags are used to replace planted trees that die in the first couple of years.

Low doses of fertilizer (NPK 15 15 15, Urea, TSP) and, as required, herbicides (Glyfos), insecticides (Plan Dec 25) and fungicides (Mancozeb 80wp) are used in the nursery to ensure the health and viability of the seedlings. Rainwater is used to irrigate the land throughout most of the year; however, in the height of the dry season, water from the nearby river is used. The nursery is operated according to the same principles on harvesting sites.

Figure 4-4: Field activities.

4.6 Woodchip Handling and Ship Loading

Woodchips and logs are transported via truck to BR Fuel's woodchip handling facility near the Port of Buchanan, weighed on the weigh bridge, and stacked into cones. The quality control team located at the woodchip handling facility tests the stock regularly for moisture content, bark content, size and other characteristics. The woodchip handling facility is located on a fenced in concrete pad near the main site compound. It was a former wood factory, equipped with a water reservoir. It is also the home base of BR Fuel's 24 hour fire service.

As BR Fuel modifies its operations to use stationary chippers, the woodchip handling facility will have to be reconfigured to accommodate the woodchippers, log and woodchips storage areas, and the increased number of trucks as the biomass generation targets increase. The required storage area for woodchips will decrease in size with the continuous export of woodchips once the long-term supply agreements come into effect, thus creating more room for the other facilities.

The storage area for logs and roots at the power plant is being designed in cooperation with BR Power.

When a ship is due to arrive in the Port of Buchanan, woodchips are transported to the Port of Buchanan via truck and loaded onto the ship using wheel loaders and two semi fixed conveyors. The company can currently load approximately 8,000 tons per day. BR Fuel has launched a project to develop material handling options to increase loading efficiency. This project contemplates an integrated roofed storage and loading facility to allow control of moisture content and a first in, first out stock management process. The stockpile will feed a reclaiming conveyor system that will lead to an overhead ship loading system.

BR Fuel intends to use the commercial quay of the Prot of Buchanan for ship loading. The Port, which was constructed in 1965, is capable of accepting large bulk ships. The commercial quay, which has very little traffic, currently provides a 10bm draught. The length of the quay is 320 m and can accommodate vessels with length of 240 m. As BR Fuel expands, it will load up to 7 vessels per month, each with a two day laytime. BR Fuel also has an option agreement to develop its own bulk handling and loading facility within the Port Buchanan

4.7 SIGNIFICANT SOCIAL BENEFITS

- Despite widespread destruction and the halt of replanting in rubber plantations during the war, rubber is one of Liberia's most important industries today, employing over 40,000 Liberians directly plus 5,000 additional Liberians in related industries.[10] Rubber sales make up 90 percent of the country's export revenues.[11] As a labor-intensive industry in which Liberia has proven its global competitiveness, rubber is one of Liberia's best available options for generating wide scale sustainable employment and poverty alleviation.

[10] International Institute of Tropical Agriculture, 2008.
[11] 92 percent in 2007, according to the Rubber Planters Association of Liberia, 2009.

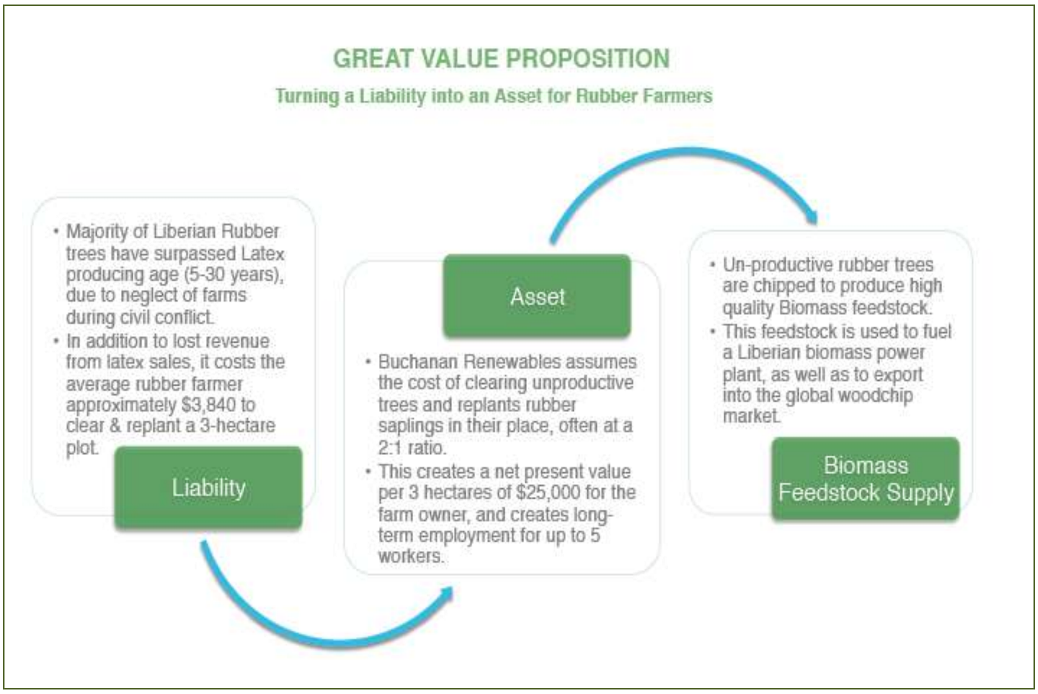
- The Liberian government and donor institutions have prioritized growth of the rubber sector in the country's overall development strategy. The Rubber Planters Association of Liberia (RPAL), supported by the Sustainable Tree Crops Program (USAID funded through the International Institute for Tropical Agriculture) developed a rubber master plan to replant 200,000 hectares, of which approximately 100,000 will be on smallholder farms. The ultimate aim of the government-industry-farmer alliance is to increase the total land under rubber production to 250,000 hectares by 2020 so Liberia may capture 2 percent of the world market for rubber.[12]
- BR Fuel's business comprises an integral part of the country's overall development strategy for the rubber sector. Eighty percent of RPAL's planting program will be on existing rubber plantations which will require the felling and removal of the mature tree stock.
- By removing unproductive trees, the company unlocks the income and employment-generating potential of the land possessed by otherwise capital-starved smallholder farmers. In Liberia, the cost of developing a typical three-hectare plot smallholder farm requires an outlay of US$3,840, including labor inputs.[13] This cost, more than seven times Liberia's per-capita income, prohibits the majority of small farmers, as well as several medium to large sized independent plantations, from developing new farms.
- Yet that same three-hectare smallholder farm has the potential to employ three to five workers and generates US$1,250 in income per month. On a net present value basis, investing in a rubber farm of this size may be worth US$25,000, including planting and maintenance costs (through year seven

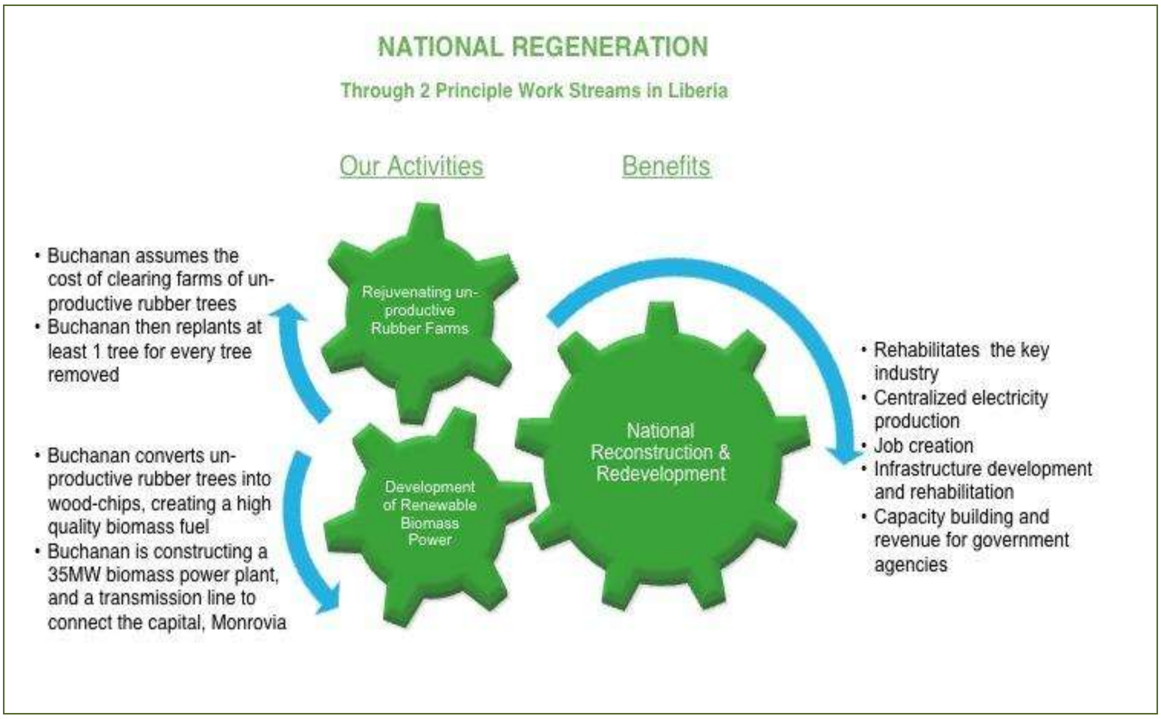
[12] See Annex 3 of Sustainable Tree Crops Program, A Program to Support the Smallholder Sector of the Rubber Industry, May 2008. The projections assume 150,000 hectares of the existing land will remain in rubber production. Liberia currently supplies 1.15 percent of the world market for natural rubber.
[13] International Institute of Tropical Agriculture, 2008.

after planting), and latex sales and harvesting costs during the plantation's productive life (years seven to thirty-two after planting).[14]

- BR Fuel accelerates the farm rejuvenation cycle by removing unproductive rubber trees, turning a liability into an asset for farmers. The company clears and replants the land, and pays the farmer for biomass on a per-ton basis. The company's total harvesting investment off-sets the costs of developing a rubber farm by as much as half. The company's forecasted biomass production would generate 5,000 plantation jobs per year by 2015 and, over the period 2010 to 2023, would unlock agricultural investments for just smallholders of approximately US$18 million in present value terms.
- The nature of the company's production activities helps accelerate the rebuilding of the roads and the ports creating access to markets and has positive externalities. So far the company has invested approximately US$480,000 in building road and other infrastructure to access rubber farms. Over the thirteen year forecast period, the company has budgeted US$13 million for rehabilitation of roads and other infrastructure and US$22.5 million for port redevelopment, with immense public spillover benefits.
- The high cost of electricity, and lack of access to electricity in many areas in the country, is frequently cited as the major constraint to industrial development of Liberia. Current per KWh electricity prices are more than US$0.45/KWh. By way of the BR Power 36 MW power plant, Liberia will have its first direct source of sustainable local electrical power, which is a critical initial step in alleviating the country's poverty. Currently, Liberia has availability of approximately 9.0 MW of electricity (primarily through diesel generators). Prior to the outbreak the civil war, there was a total of 250 MW for the entire country.

[14] International Institute of Tropical Agriculture, 2008, and Buchanan Renewables analysis.





4.8 SIGNIFICANT ENVIRONMENTAL BENEFITS

- Rubber trees were traditionally considered agricultural waste, mostly burned in open fields or left to rot, thus generating CO_2 and/or methane emissions. On a small scale, rubber wood has also been used for charcoal and local timber.

- BR uses rubber wood as a sustainable, renewable source of fuel low in fossil based Carbon emissions. It is considered relatively Carbon neutral because BR replants at least one tree (often 2) for every tree removed.
- BR will generate approximately 170,000 tons of carbon offsets per year by replacing diesel-fuelled generators with its 36MW biomass-fuelled power plant. It will further reduce fossil based carbon emissions through its export market by substituting biomass for coal and other fossil fuels. Coal replacement can lead to an 18 times reduction in fossil based carbon emissions.
- BR will promote best farming practices to encourage sustainable plantation management in Liberia.
- Liberia's biomass-fuelled economy will set an example for other countries and companies around the world.

5 ENVIRONMENTAL IMPACT ASSESSMENT AND ANALYSIS

This chapter examines the potential environmental impacts associated with the proposed activities of BR Fuel at the main site and off-site. The typical elements that are affected by the project's activities whether on-site or off-site are classified into two categories: the social environment and the physical environment (Figure 5-1). The social environment includes social concerns such as human resources, services, human attitude and adaptation that could have influences on social characteristics of surrounding communities. The physical environment is concerned with potential contamination of surface and/or groundwater contamination, air emissions, noise, visual intrusions, biodiversity, traffic, waste management, and soil all of which could lead to alterations in the abiotic and biotic environment.

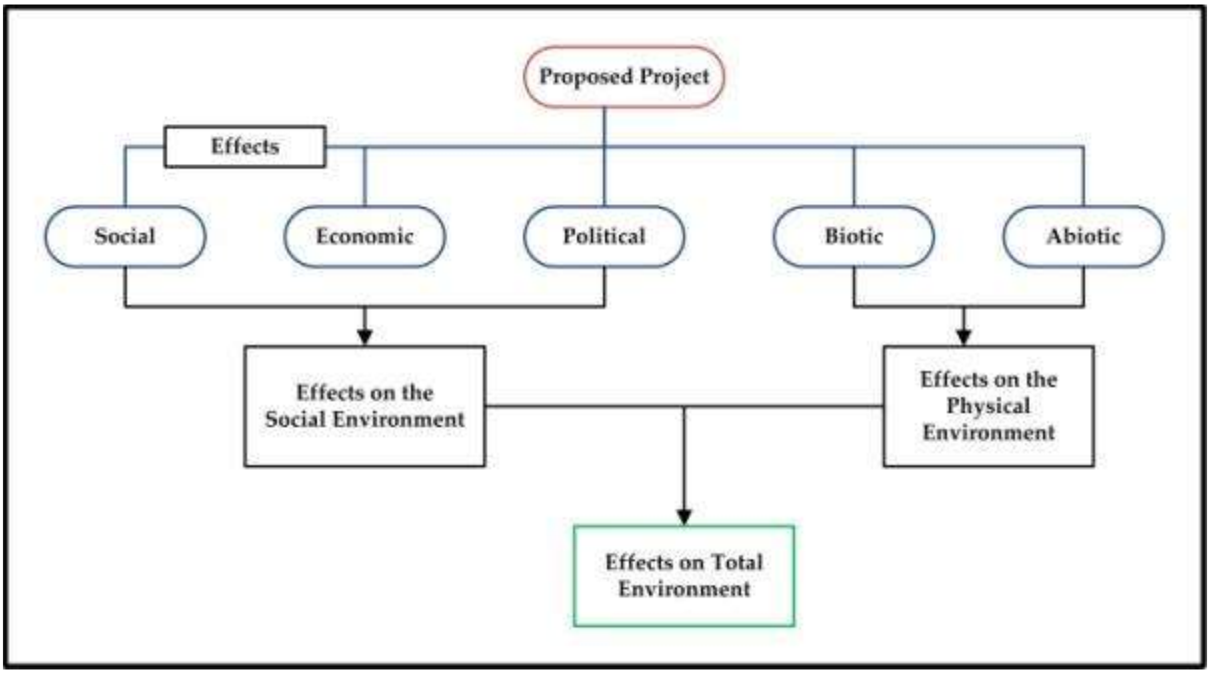


Figure 5-1: Typical elements that are affected by the project.

5.1 IMPACT IDENTIFICATION

Impact identification involves documenting all possible events that could lead to hazardous incidents. It is a systematic process listing potential causes and consequences. Reference is also made to proposed operational and organizational safeguards (and their basis) that would prevent any possible hazardous events from occurring, or should they occur, that would mitigate the impact on the plant, its equipment, people and the surrounding environment. This process enables the establishment, at least in principle, of the adequacy and relevancy of proposed safeguards.

The aim of the impact identification is to highlight all possible residual risks associated with the interaction of the facility (as a whole) with the surrounding environment, so as to identify the worst case scenario. Whereas some impacts could be of short term significance, others could be of long term due to the cumulative impact of the projects operations over several years and across several hectares.

Table 5-1 presents a summary of the main activities and the potential receptors affected by the project. The described impacts are potential impacts from the main activities starting from cutting of the trees, woodchip or log loading and transporting, land preparation as well as activities occurring on the main site with focus on those of the workshop facilities. The likely significance and type of these impacts has been indicated based on professional judgment as well as experience from similar facilities abroad as reported in the literature. In the following sections, a more detailed analysis of these impacts is conducted to show their characteristics.

Table 5-1: Project activities and impacts identification

Activity	Duration	Receptor
Felling trees with excavators or feller bunchers and transporting them with skidders Sawing off branches with chainsaws and chipping the trees either at offsite locations or the port/power plant facility	Short-term[15]	– Air quality – Soil quality – Biodiversity – Water quality – Health and safety – Noise – Socio-economic – Visual amenity
Land preparation and cultivation	Long-term[16]	– Air quality – Soil quality – Water quality – Socio-economic – Noise – Health and safety
Wood chip or log transportation to the port Rehabilitation of some internal roads and roads leading to the site Maintaining the fleet of equipment Loading and shipping the wood chips	Short-term	– Air quality – Road access – traffic – Socio-economic – Noise
Workshop site (workshop, repair and spare parts, fuel storage, parts storage, clinic, administration)	Long-term	– Air quality – Water quality – Soil cover – Health and safety – Sanitation

5.1.1 Impact on Air Quality

Air quality is concerned with two main receptors: the working personnel implementing the project and the receiving environment. Air emissions are generated within the implementation phase and are mainly related to vehicles and machinery in use. Vehicles, machinery and generators working on sites to cut trees, saw branches, chip wood, transport woodchips or logs to the port/power plant, load woodchips onto vessels and circulate within the site to replant the fields are sources of air emissions. Gaseous emissions related to those activities include: particulate matter (PM), NOx, SOx, CO and VOCs. These impacts are of long-term duration and occur during the different phases of the project especially during the clearing of

[15] Short-term:~6 month
[16] Long-term: longer than 2 years

rubber trees and the transportation of chips and logs, although such activities occur within a specific time frame. Further activities such as emergency repairs and welding off-site have minor impacts on the air quality and are more limited. Fossil fuel based atmospheric emissions occur from the exhaust of ships transporting the woodchips to their final destinations abroad.

Another significant issue regarding air emissions is the dust particles or PM emissions due to the cutting of trees, sawing of branches and chipping of wood whereas those activities will result in the emission of dust particles. Dust particles will eventually deposit on surrounding vegetation, ground surface as well as nearby residential areas if present. Emitted dust particles could also be transported by strong winds and have an impact on a larger area other than the original source. The deposition of dust particles will also form a coating on the surrounding vegetation and on the flora thus leading to possible damage to the leaves and thus to photosynthesis, respiration and transpirations processes of plants. Furthermore, dust particles also influence the increase in pH levels when deposited on water bodies surface or soil cover. Increased dust may also be generated from the transport of woodchips and logs along laterite roads during the dry season, potentially affecting communities along the roads. While this impact is minimal for one truck, it may be more significant as the number of trucks carrying logs and woodchips increases along the roads. The impact will, however, be mitigated as Liberia's road infrastructure is developed into the future.

Adverse health effects of PM especially on workers range between respiratory and cardiac illnesses, skin irritation and eyes irritation (Table 5-2). Although dust emissions are temporal and mainly attributed to mobile vehicles, this problem can represent a significant health issue for the workers if not addressed properly.

Another concern from the proposed project is related to climate change, where the cutting of trees accounts for the degradation of an environmental buffer element. Trees are considered as major players in the carbon sequestration process, which is essential for limiting climate change. In other words, the cut rubber trees play a role in reducing the carbon dioxide and pollutants in the atmosphere. However, the increase in carbon due to the cutting and burning (in power plants) of rubber trees will be for a limited time especially given that the cut trees are redundant and old and could start emitting carbon instead of absorbing. Moreover, young rubber trees tend to absorb carbon as they grow much more quickly than older trees.

Moreover, unplanned fertilization at the newly cultivated site might lead to high levels of nitrogen leaking from the soil back into the atmosphere mainly in the form of Nitrogen dioxide. The main sources of these emissions are microbial nitrification and de-nitrification. Nitrogen dioxide is considered a primary criteria pollutant, which once introduced to the atmosphere will result in acid rain in the presence of water and oxygen and the formation of tropospheric ozone in the presence sunlight and Volatile Organic Compounds (VOCs) (Cooper et.al., 2002). Although the agricultural sector is not considered the major source of nitrogen oxides as compared to the industrial and transport sectors, this issue is worth mentioning. In addition, acid rain and tropospheric ozone formation are classified as global air pollution problems, thus they might not have a direct impact on the plantation or its neighborhood. Nevertheless, the impacts of these pollution problems have direct effect on fauna and flora in addition to the damage it can produce to physical structures and structures of cultural importance (Cooper et.al., 2002).

Transport trucks, machineries and the combustion engines used on-site and to transport chips and logs between sites are associated with the possible gaseous emissions from the combustion of fossil fuel. Typical air pollutants that are expected to be emitted include CO, PM, SO2, NO2, along with HC. Each of the mentioned pollutants has significant adverse effects whenever present in the atmosphere in high concentrations (Table 5-2). The gaseous emissions are carried by the winds and have impact on the close surroundings. Emission levels from company operations are likely to increase significantly as the number of trucks transporting woodchips and logs, and the distances between sites, increase to accommodate annual targets for biomass generation. BR Fuel is currently considering options for the use of biofuels in order to reduce potential emissions from transport vehicles; however, such options must be carefully considered in order to ensure a positive net impact.

The impact on the air quality from the presence of an incinerator on the main site is insignificant given its small size and the fact that medical waste is now burned in the incinerator at the LAC Hospital. However, incinerators in general, have impacts on air quality especially if the combustion process is not controlled.

Risks of wildfires are possible to occur under certain natural conditions depending on natural conditions related to weather conditions, humidity, sun exposure, and wind speed. Some human activities can contribute to igniting fires such as improper functioning conditions of equipment, smoking and any fires set by workers on-site.

Table 5-2: List of Pollutants Generated as a Result of Fuel Combustion and the Related Health Impact (Cooper et. al, 2002; USEPA, 2008).

Name of Pollutant	*Type of Pollutant*	*Health Impact*
Nitrogen oxides (NO_x)	Primary Criteria Pollutant	▪ Eye and nose irritation; ▪ Pulmonary edema; ▪ Bronchitis; ▪ Pneumonia; ▪ Pulmonary fibrosis; ▪ Emphysema; and ▪ Increases the frequency of lower respiratory tract illness in children.
Sulfur dioxide (SO_2)	Primary Criteria Pollutant	▪ Bronchoconstriction; ▪ Eye, nose and throat irritation; ▪ Stimulates mucus secretion; and ▪ Chronic bronchitis
Carbon monoxide (CO)	Primary Criteria Pollutant	▪ Fatigue; ▪ Headaches; and ▪ Intoxication
Particulate matter (PM)	Primary Criteria Pollutant	▪ Bronchitis; ▪ Asthma; ▪ Emphysema; ▪ Pneumonia; and ▪ Cardiac disease
Carbon dioxide (CO_2)	Greenhouse Gas	▪ Adverse effects due to exposure to extreme temperature variations (i.e.: Prolongation of the disease transmission seasons, dehydration,
Methane (CH_4)	Greenhouse Gas	

Name of Pollutant	*Type of Pollutant*	*Health Impact*
		etc…); ▪ Reappearance of climate sensitive diseases (i.e.: malaria, dengue fever, yellow fever, and encephalitis, and cholera, etc…)
Volatile organic compounds (VOCs)	Lead to Ground-level Ozone formation in presence of NO_x	Formation of ozone might lead to: o Severe eye and nose irritation; o Reductions in lung functions; and o Lung aging

5.1.2 Impact on Water Resources

Water resources located within or nearby the activities areas are prone to deterioration unless good management practices are adopted. Water resources include surface water such as streams, springs, rivers, wetlands, and lakes, and groundwater including aquifers and wells. Such water bodies are of main importance as they are habitat for several fauna and flora species, sources of water supply, irrigation and drinking water.

The proposed activities of cutting, sawing and wood chipping have impacts on sites close to water bodies. The resulting wood dust or PM and debris could alter the water quality if transported and deposited in a water body by increasing water turbidity and/or depleting oxygen levels which could increase the content of organic substances. Such changes can disturb the natural balance and threaten the sustainability of affected ecosystem. Settling of dust particles suspended sediments resulting from soil erosion will affect the storage and flow capacities of streams, lakes and reservoirs which will adversely affect water supplies and lead to increased flooding potential in wet seasons and clogging of waterways in dry seasons. Moreover, the resulting debris is mainly light weight and could form a cover on the surface of the water thus blocking of sunlight infiltration and the exchange of oxygen. The impact of wood dust on the various sites is likely to be reduced significantly as chipping operations are centralized at the port facility and the power plant site. Centralizing such impacts will make it easier for BR Fuel to mitigate the impacts on water quality.

The clearance of old trees to be replaced by new ones will make the soil cover prone to erosion by rainfall and wind. The resulting runoff will carry the soil material and any chemicals/fertilizers/pesticide applied during the replanting phase. This will threaten the water quality and increase the sediment load in the natural watercourses which will affect the flow capacities of streams, lakes and reservoirs, and also affect water supplies and increasing flood potential. The significance of this impact increases as operations become more concentrated and larger-scale. Water quality could also be degraded from gaseous emissions and particulates that are deposit on the water surface.

The activities related to land preparation, replanting and further care could have impacts on surface and ground waters. Water resources are mainly affected by pesticides (if used), herbicides, insecticides and other agricultural chemicals, and depend on their dose and frequency of application. Excess in pesticide application could lead to groundwater contamination and further contamination of drinking water resources. Such activities could have direct impacts on human health. The seepage of such liquids to surface waters results in negative impacts on the aquatic system by inducing eutrophication. Environmental issues associated with eutrophication can be summarized by the following:

- Disturbance in the aquatic food chain due to changes in the species composition of algal communities;
- Increased fish mortality caused by deoxygenating water (resulting from algae and weeds decomposition);
- Impairment of the amenity value of water due to surface algal bloom; and
- Production of toxins in the water by some algal species.

Excessive use of pesticides combined with soil erosion, will lead to a relatively significant contamination of the water bodies close to the sites of operation.

Impacts on water quality are also anticipated to be high at the port site where the wood chips are piled up without preventive covers allowing rainwater to percolate through. Heavy rains will drain some fine particles of wood and contribute to organic loads into the nearby water bodies (Figure 5-2).

Figure 5-2: (a-d) storm water from piles of wood chips discharging into a nearby creek at the port of Buchanan

The impacts on surface and groundwater from operations on the main site can be significant in case of accidental fuel leakage or spillage or any mismanagement of other fuel used on the main site or off-site. These elements are transported into the nearby agricultural fields and water resources through direct run-off or through seepage into the groundwater (Figure 5-3). Oil spills on the ground of the site's facilities including the workshop and the fuel storage area get flushed by strong rains and transported to surrounding fields (Figure 5-3).

(a)

(b)

(c)

(d)

Figure 5-3: (a-d) Oil Trace in Drainages. (d) Nearby Farm.

The direct discharge of such liquids has negative impacts on the aquatic species. Such impacts can be summarized as: 1) oxygen depletion in the water; 2) increased levels of chemical pollutants; 3) increased turbidity inhibiting the sunlight infiltration; and 4) increased sedimentation leading to reduced storage and flow capacities of streams, lakes and reservoirs leading to limited water supplies and increased flood potential. Groundwater aquifers are also expected to deteriorate, especially where the water table is high, mainly due to the leaking of harmful chemicals used or openly dumped during work. Once contaminated, groundwater is much more difficult to treat.

Domestic wastewater from administrative offices and workers facilities including the toilets and kitchens is a potential source of water pollution if not properly collected and treated. Other minor impacts may result from vehicles transporting waste, oil and lubricant generated from equipment maintenance workshop on-site, washing waters of vehicles and buildings, as well as drainage water collected from waste collection site.

Wastewater that will be produced at the main site consists of sewage waste, equipment cleaning effluent, runoff from material staging areas, and miscellaneous activities including wastewater from laboratories, equipment maintenance workshop, etc.

Spillage of either woodchips or machine oil into the sea during ship loading could have an impact on the ecosystem in the Port of Buchanan. The impact of woodchip spillage from one loading one ship would likely be quite limited due to the size of the water body; however, the impact of spillage from several ships would be more significant. This impact is likely to be limited due to the use of a new conveyor system by BR Fuel, as well as careful servicing of equipment used during ship loading.

The woodchips entering the water would form an organic load that decreases oxygen saturation in the water due to aerobic decay, negatively impacting aquatic fauna in the area.

5.1.3 Impact on Soil

Tropical soils are more prone to human interferences and are usually more difficult to restore as compared to temperate region soils (Lal, 1990; Zhang, 2005). Severe deterioration of the soil quality in these regions is anticipated, especially when poor management practices are observed. At this level, it is very important to understand and identify the negative environmental impacts generated by BR Fuel in order to reverse degradation.

The action of cutting trees and clearing parcels of land has an impact on soil quality degradation and aridity, namely loss of organic matter and nutrients, soil acidification, as well as compaction of surface soil, especially if coupled with poor management and intensive farming practices. This could be worse if analyses indicate highly weathered and acidic soil, having low organic content and low nutrient storage capacity. The intensity and frequency of precipitation, the soil texture and land slope also play a major role in the impact on soil conditions. For example, light rainfall doesn't have negative impacts on soil as the water will percolate through the soil and rather enrich the underlying aquifer; whereas, strong rains could result in a rapid filling of the groundwater and an increase in the water level on the top surface and the formation runoff along soil cover. The clearing process will also cause the soil to be susceptible to erosion by rain and wind.

The development of a rubber plantation would be interrupted by soil erosion, where the related detrimental impacts include the accelerated loss of organic matter/nutrients and biocides. Soil erosion can also have detrimental effects on nearby water bodies (Merrington et. Al., 2002). Erosion is intimately linked to the cultivation practices. The magnitude of soil erosion is directly related to weather conditions (i.e.: rainfalls, storms, etc.), geological conditions, and topographical features (i.e.: land sloping), and it might contribute to subsequent sedimentation of surface water bodies (Merrington et. Al., 2002). More details on the soil erosion problem are included in the impact on water resources analysis.

The soil texture also has an impact on making the soil cover more susceptible to erosion. This depends on the soil composition variation of silt, sand, clay and gravel. Most laterite soils are porous and claylike. Regosols are known to be shallow medium to fine textured soils. Swamp soils are rich in minerals and drain very slowly. Soil erosion is mainly enhanced by the presence of slope within the various soil covers.

Soil compaction is another problem resulting from various activities off-site that include cutting, sawing and chipping will mainly depend on machinery and constant movement of vehicles (Figure 5-4). The impact of compaction will be reduces as BR Fuel changes its methodology to trucking logs to a stationary chipper site at its port facility or the power plant. The new methodology of using feller bunchers to harvest the trees reduces the number of machines required on a single site.

Among the offsite activities that will deplete soil nutrients will be the replanting of rubber trees, which will also be tapped in the future. Increased tapping frequency is the leading cause behind soil nutrient depletion. In fact, Hevea trees convert nutrients from the soil, and carbon dioxide from the atmosphere, into organic carbohydrates known as rubber latex. Over-tapping speeds up the uptake of nutrients to replace those already lost throughout the process. Unless nutrients are replenished through fertilizer application, this procedure will only lead to soil quality deterioration (Zhang, 2005). On the other hand, planting density is also considered an issue when it comes to nutrient preservation. Planting density should not exceed 500 trees/ha if soil quality is to be preserved (IRRDB). It is worth mentioning that the replanting of trees and cover crops will eventually minimize erosion thus preventing leaching of soil nutrients. Moreover, BR Fuel will use the ash left over from burning trees in the power plant as fertilizers.

The traditional cycle of replanting rubber trees often involved trees being left to rot or burned on the ground, allowing the nutrients from the trees to be reabsorbed into the soil. Thus, using the majority of the harvested trees for biomass generation may result in reduced soil nutrients, particularly in the long-term. This may require greater use of fertilizers during replanting and in the first few years of a rubber trees life in order to replace the nutrients required for the development of a viable plantation.

Different types of fertilizers are expected to be used at the plantation as an attempt to overcome the soil quality degradation problem and increase in productivity, since Hevea is relatively intensive to soil-type, and higher yields and disease resistance can be expected if it is grown on highly fertile soils. Insecticides, herbicides and fungicides that are to be used on to fight insects and disease have an impact on soil quality. These actions could deteriorate soil properties and make it unsuitable for future agricultural activities. The following fertilizers are expected to be used by BR Fuel:

- Rock phosphate and NPK 15 15 15
- Urea
- TSP (Triple Super Phosphate)
- Herbicide: glyfos
- Insecticide: Plan Dec 25
- Fungicides (Agrithane (Mancozeb 80wp)
- Organic material: mulch resulting from plant roots and natural debris
- Nitrogen fixing cover crops

In an attempt to control soil erosion, natural debris from trees leaves and some of the roots are mulched and spread as land cover. This action will help in reducing soil erosion and will help in returning organic matter and nutrients that are enriching to soil. As much as these initiatives are important to control soil erosion and enrich soil quality, if not coupled with additional conservation measures they will not deliver the expected outcome. In fact, adopting efficient preventative measures will not only enhance the soil quality and protect environmental resources, but it will also play an important role in enhancing productivity and reducing cost incurred during application of agrochemicals.

Last but not least, although acidification is a natural process, it can be triggered by rubber farming especially in high rainfall regions. This process is induced by unbalanced nitrogen cycling. In other terms, during periods of rainfall, nitrogen is washed down in the soil where it is converted into nitrate by soil microorganisms. In this form, nitrate ions are available for plant uptake. However, excess nitrate ions in soil, as a result of inappropriate fertilization, will either leach down below the root zone leading to acidification of the subsoil or run-off to nearby water bodies leading to eutrophication (Merrington, 2002). Unless this issue is given enough attention, acidification of topsoil, and more seriously, subsoil will eventually lead to:

- Increased nitrate leaching into water aquifers;
- Increased contamination of surface water bodies, leading to eutrophication;
- Reduced productivity of the plantation;
- Reduced options for intercropping (as only acid-tolerant plants can grow well in these conditions);
- Reduced vegetative cover, leading to accelerated run-off and erosion;
- Declining pH of streams; and
- Decreased land values.

Oil spills and improper containment of fuels and chemicals at the workshop site could pose a threat to the soil cover when discharged. Fuels and chemicals are carried by runoffs and mixed with the soil and the ground cover if not prevented.

(a)

(b)

(c)

(d)

Figure 5-4: (a) land cover clearing; (b) mud and pond formation; (c) wood collected for mulching; (d) mulch to be spread on cleared surfaces.

5.1.4 Impact on Biodiversity

The cutting of rubber trees and clearing of land parcels of different sizes have adverse impacts on the biodiversity. Trees play an important role in maintaining a balance in levels of CO_2. The loss and use of trees enhances the CO_2 level in the atmosphere and contributes to climate change. However, if the cut trees are replanted, there is no net contribution to climate change especially given that BR Fuel replants at least, but usually more than one tree for every tree removed

Removal of blocks of rubber trees could lead to a discontinuity of habitat which would have an impact on various species existing in the area. The plantation could also be habitat to migrating birds, which would have to alter their passages, particularly as the scale of the operation increases. Animals relying on the land cover as habitat will have to be displaced due to the potential damages and noises released. In cases where the site is surrounded by swamps or other water bodies, adverse impacts of the activities are also anticipated. Swamps are classified "among the most productive ecosystems in the world" (US EPA, 2006). They appear to host a large variety of living organisms namely some microbes' species, plants, insects, amphibians, reptiles, birds, fish, and mammals. The complex relationship established between these different organisms is defined by food webs (US EPA, 2006). Any disturbance of this natural balance will eventually lead to a serious distortion of these life cycles. The cleared area could include other vegetation that is popularly growing in this area. Although rubber plantations tend not to be biodiversity rich, it could be habitat to endemic species of plants, herbs or flowers that could be damaged due to the activities of circulating machineries. Dust depositing on surrounding vegetation will also form a layer that reduces photosynthesis until it gets washed by the rains. It should be noted that BR Fuel does not cut down natural forest, but harvests rubber trees, which are classified as agricultural resources, on existing plantations.

In addition, riparian zones will be affected if areas that are going to be cleared are within or adjacent to those zones. These areas provide shelter to different species and play a role in preventing runoff material and pollutants to reach water bodies. The removal of tress within those zones makes them more susceptible to destruction. This will lead to deteriorating the water quality, decreasing the abundance of vegetation and any special flowers and eliminate the habitat of animals of different trophic levels of the aquatic and terrestrial ecosystems. The disturbance of such zones will also result in a lower filtering of sediments and non-point source pollutants such as agrochemical products.

Furthermore, clone rubber farming is known to require intensive use of chemical inputs (Gouyon, 2003). Even though BR Fuel is not expected to employ the intensive use of agrochemical, different types of agrochemicals are anticipated to be used by rubber farmers, some of which are known to have significant impact on the ecosystem. Table 5-3 will summarize the impact of these chemicals on biodiversity.

Table 5-3: List of some of the agrochemicals used that have an adverse impact on biodiversity.

Name of Agrochemical	*Ecotoxicity*	*Reference*
Glyphosate (Kalach)	▪ Destruction of habitats and food sources for some birds and amphibians leading to population reductions	Pesticides News, 1996
Mancozeb	▪ Toxicity to aquatic organisms	PAN Pesticide Database, 2008
2,4-D	▪ Slightly toxic to small mammals on	USEPA, 2005

Name of Agrochemical	*Ecotoxicity*	*Reference*
	an acute oral basis ▪ Toxic to terrestrial plants (it is more toxic to dicots than to monocots)	
Chlorothalonil	▪ Very ecotoxic in the aquatic environment ▪ Ecotoxic in the soil environment ▪ Ecotoxic to terrestrial vertebrates	FAO, 2005
Carbendazim	▪ Highly toxic to aquatic life ▪ Ecotoxic in the soil environment ▪ Low acute toxicity for birds	Pesticides News, 2002
Nitric Acid	▪ Slightly toxic to aquatic ecosystems	PAN Pesticide Database
Sulfuric Acid	▪ Slightly toxic to Crustaceans and fishes	PAN Pesticide Database

On the other hand, the rubber trees planned to be cut are mainly clones from Hevea brasiliensis and cover most of the farms. These trees are mainly older than 25 years and are not in vigorous conditions. These trees have suffered from pests, termites, and disease spread by fungi and insects. The production of latex is at its minimal stage. The removal of those trees and proper harvest planning will help to enhance the ecological conditions of the local farms and their surrounding habitat.

Nearby agriculture could be negatively affected from released dust and gaseous emissions which will deteriorate the productivity of crops.

5.1.5 Sanitation (solid and liquid wastes)

Solid waste produced on-site is mainly of a domestic type. Other wastes resulting from oil, fats, fuel, empty containers from agrochemical products are expected. Generated waste could have negative impacts on the soil and receiving water bodies if littered or dumped openly in nature.

Spare parts are mainly recycled in Buchanan by BR Technical Services. Materials that are not recyclable are stored as scrap for export and recycling abroad. Used tires are mainly being reused locally, which is a safe way of making use of those tires. Used lead acid batteries are collected by a local dealer. Domestic waste is mainly collected and disposed of by an EPA certified waste disposal company. Hazardous materials on-site are composed of used oil and lubricants and are managed based on the Material Data Safety Sheet.

Other wastes generated at the workshop site include domestic and medical waste from the clinic. Medical waste is currently sent to an EPA certified incinerator at the Liberia Agriculture Company hospital.

Liquid waste is mainly concerned with domestic wastewater produced from workers on-site. Wastewater effluent has a direct impact on the receiving soil cover and underground aquifer if not properly managed. Wastewater discharged from administrative buildings is discharged in septic tanks. The tank has a liner and is emptied every three months. Another concern with liquid waste is the grey water generated from washing vehicles and its direct discharge in nature. This water has a negative on impact receiving water bodies and soil top cover.

(a) **(b)** **(c)** **(d)**

Figure 5-5: (a-b) Solid waste collection bins at main site; (c) septic tank at main site; (d) incinerator at main site that is not used anymore.

5.1.6 Impact of Noise

Offsite operations can be significant sources of noise pollution with potential impacts on workers and nearby residents. The noise emissions are functions of the circulation of the vehicles, use of generators for energy supply, excavators, skidders, power saws used to cut trees and tree branches, wood chippers to produce the chips, mulching machine, the loading and transportation of chips to the port site. Noise that may be generated from the transport of raw material is negligible and is not anticipated to significantly affect human amenity especially if adequate noise reduction/suppression measures are undertaken.

However, potential impacts on residential communities from noise generated off-site by power saws, excavators, chippers and mulching machine is expected to be high if agglomerates exist in close proximity. Such activities will cause noise nuisance and annoyance to the surroundings when exceeding the permissible limits and when occurring at early and late hours of the day. The impact of noise from chipping is expected to decrease significantly as BR Fuel changes to a system of stationary chippers at their port facility, which is isolated from nearby communities.

Noise emissions when exceeding the average acceptable limit cause damage to the human ear. According to OSHA, occupational exposure to sound levels higher than 85 dBA within 16 working hours poses a threat to the working staff and 85 dBA along 8 hours according to NIOSH. This could have irreversible damages to human ears and create health problems and increase stress on human behavior.

Noise impact is mainly dependant of the size of machine in operation; the level of noise produced either by one machine or more at a simultaneous time and the duration of the exposure to the emitted noises was measured. Table 5-4 shows the average noise level from various tools/machinery used by BR Fuel.

Table 5-4: Noise measurement of most point-sources

Location	Monitoring Duration (Min)	Recorded Number	Maximum Value (dBA)	Minimum value (dBA)	Leq (dBA)	Average[17] value
Excavator 330	5	60	93.2	72.6	81.7	80.87
Power Saw	5	12	101.8	75.0	96.3	95.23
Peterson 5000H (Chipper)	5	60	105.2	73.5	96.6	97.41
CAT Generator 100KVA	5	60	94.5	79.9	81.4	81.01
Cat 322 Grabber	5	60	87.5	74.8	81.6	81.08
Grinder	5	60	100.8	76.1	92.8	94.13
Conveyor McClosky	5	60	88.3	68.0	76.0	75.61

Noise impact will be reduced after clearing the land and will be limited to vehicles working on rehabilitating the land and cultivating new trees.

5.1.7 Impact of Human Health & Occupational Safety

Safety issues associated with BR Fuel's activities involve improper handling, storing and disposing of fuels, oils, lubricants and some agricultural chemicals as well as accidents occurring with the operation of moving equipment. A significant amount of pollutants can be subsequently introduced to the environment. While the magnitude of this impact is difficult to quantify, they can be divided into two categories, those confined with on-site and off-site workers, as occupational hazards, and those expanding to affect the general population, as a consequence of environmental pollution. On the other hand, occupational health hazards can vary from site to site according to the technologies and adopted methods. However, the project activities could prove harmful to human health with the lack of proper measures. Workers on-site could be affected from different activities:

[17] Average value was obtained by calculating the average of noise level readings at each location.

- Health impacts and sickness related to dust emissions: respiratory problems, skin irritation and eyes itching.
- Health stress impacts from workers exposure to daily noise emissions from different machines used on-site.
- Health hazards related to cutting activities, improper electrical supply, improper ways of displacing cut trees and chopped woods from one place to another.
- Improper use of the different machinery and the mismanagement of proper spacing of different tools and fuels on-site cause a threat on workers safety.
- The presence of any unstable land prone to slides, erosion and slippery or a deep swale is also a potential threat to human safety.
- During the process of cutting of the trees, the areas beneath if not cleared cause risks of injuries of the workers and any damages to the machinery.
- The trucks and equipment used to perform the proposed activities could cause a hazard when extensively used without proper maintenance and check-ups.
- Workers' health could be at risk if proper safety and protective gear is not employed against gaseous and particulate air emissions, noise, and rain, and if proper hygiene is not maintained throughout the worksite.
- Workers' health could posed at risk if medical precautions and necessary vaccines are not taken.
- Lack of proper controls and signage around potentially hazardous areas.

Deterioration of the environmental quality is directly reflected in adverse health outcomes. Each pollution problem discussed and to be discussed in this report, whether air or water pollution, is directly linked to negative health impacts that are expected to affect both workers and any neighboring communities. However, in most cases plantations are not located adjacent to local communities. Still, the adoption of adequate occupational procedures is essential to minimize such risks where specific health and safety guidelines should be adopted and stringently followed and implemented.

Furthermore, a lack of proper training of the staff in charge of operations and maintenance could expose them to adverse health risks. The presence of mechanical equipment may expose the workers to sharp objects as well as fire and explosion risks. Uncontrolled access to the main site including workshop, storage facilities as well as off-site facilities may result in various hazards. Physical injuries that can be related to occupation risks are summarized in (Table 5-5).

Table 5-5: List of Physical Injuries.

Hazards	*Potential Risk*
Snake bite	Low 4 – 4 cases per year- not known if hospital stocks anti venom
Cuts from slashing/weeding	High but relatively rare considering the size of workforce
Burns	High during new clearing bit incidents are rare

5.1.8 Impact on Landscape and Visual Amenity

Visual intrusions rise from the inevitable presence of equipment, materials, piles of roots, and the open storage of wastes. Some offsite locations may easily be viewed from the road (Figure 5-6) and from higher altitudes if located in a flat terrain. The on-site facilities are also easily viewed from the road (Figure 5-6). Therefore, BR Fuel's operations and facilities have significant impacts on the landscape causing disruption of the natural landscape in the area.

The project aims at cutting parcels of trees of no more than 50ha blocks. This action of cutting large parcels of trees and clearing the land will enhance land degradation and result in cleared land that has a negative impact on the surrounding scenery. However, this is anticipated as a temporary situation that will be recovered by the replanting process. Moreover, given Liberia's situation, the machinery and evidence of redevelopment could actually be a positive image as it could be seen as a sign of development and security and thus provide a sense of stability and hope for the people, especially after the devastating Civil War that halted almost all sorts of progress and development.

Figure 5-6: External view overlooking the project sites.

5.1.9 Socio-Economic Impacts

The harvesting of rubber trees from redundant plantations is a sustainable practice which supports employment in the rubber sector, improves resource use and reduces the incentive for unsustainable harvesting. The harvesting of redundant rubber tree plantations provides full-time and part-time employment in rural and regional areas. While the number of people employed in this industry may seem relatively small, it is significant for the individuals concerned, their families and their community as a whole. Such employment is important in rural areas where alternative employment opportunities are restricted (BR Fuel HMP, 2009). Furthermore, by catalyzing the rejuvenation of the labor-intensive rubber industry, BR Fuel's activities lead to large-scale job creation in rural areas.

This Social Impact Assessment (SIA) is divided into seven main categories:

1. Demographic Impacts (Impacts of the project which may cause changes in the size and makeup of the population of the areas affected by the project)
2. Social Infrastructure (Impacts on the social characteristics of the community including housing, water and power supply, educational, health and recreation, transport and public safety)

3. Land Use
4. Social Relations
5. Cultural Property (Including religious, historic and archeological sites)
6. Economic Activity (Primary and multiplier effects)
7. Human Rights

5.1.9.1 Demographic Impacts

Major demographic changes at on-site (main area) and offsite (farms/concession areas) are not expected to occur as a result of the project.

Buchanan currently employs a total of 425 employees: 400 Liberians and 25 Expats. The presence of expatriate staff at the various sites is limited (about 3% of staff are expats) and is not anticipated to cause stress on the local communities and their life style. Moreover, one of BR Fuel's key goals is to work Liberians into the positions held by expats as soon as possible. Expansion of the project in the future aims to sustain the high local population employment rates limiting demographic changes. If future expansion of the project presents the possibility of increased demographic shifts, then development of an Influx Management Plan will help prevent/reduce adverse impacts of any of these changes on local nearby communities.

Employees harvesting at offsite farms/concession areas are only expected to remain in the area for the duration of their respective responsibilities such as harvesting, transport, monitoring, and assistance in replanting/capacity building operations. After this local area demographics due to the direct effects of the project activities should revert back to pre-project levels.

Indirect demographic changes may occur as a result of improved economic status leading to better purchasing power and new business influx as a result of this, particularly in the Buchanan area. In addition, rejuvenation of the rubber industry due to replanting would also provide new job opportunities. This can lead to the in-migration of new populations seeking livelihood opportunities in these areas.

Rehabilitation and improvement of transport infrastructure is also predicted to indirectly promote demographic changes by easing access into and out of the project areas. Such demographic changes are expected to occur at a pace consistent with the economic development of the regions in which BR Fuel is operating, and are expected to help alleviate the population pressure on Monrovia.

5.1.9.2 Social Infrastructure

With anticipated project activities of a significant magnitude off-site and on-site, there are potential impacts on the local communities. These aspects usually range from basic concerns such as insufficient project information, to ignorance of its effects on the present way/quality of life, health, safety, available infrastructure, culture, traditions, and customs. For impoverished and isolated communities, these considerations take a higher priority, as there are expectations with regards to employment opportunities and basic amenities such as water supply, sanitation, and healthcare.

The operation of BR Fuel will have direct and indirect benefits to the workers such as medical services, vocational training, skills enhancement and capacity building (regular training of local fire fighters and donation of a fire truck). The project also provides support to schools, sponsorship of an orphanage, and support to community efforts by regular use of equipment and expertise (BR CSR, 2009).

The increased traffic for the transport of material and workers to the site can potentially place stress on roads and road traffic. Table 5-6 describes general examples of potential social and economic impacts of BR Fuel.

Up till now, BR Fuel has invested approximately $480,000 in the building of roads and other infrastructure to access rubber farms. The company forecasts a projected investment of $13million in the next thirteen years in road and other infrastructure rehabilitation, as well as $22.5 million for port development. Up to date the total combined length of roads rehabilitated has reached 557 km.

5.1.9.3 Impacts on Land Use

The nature of BR Fuel operations results in restoration and rehabilitation of previous land use designations in areas of project activities. Disturbances in land use at farm level due to operations is limited to the period of harvest activities and a short period afterwards when intercropping changes land use temporarily until newly planted rubber trees are fully reestablished and productive (Figure 5-7).

BR Fuel projects take place on pre-existing farms. BR fuel does not operate in natural forest areas and as such no change in land use designation of these areas is expected occur due to BR Fuel project operations.

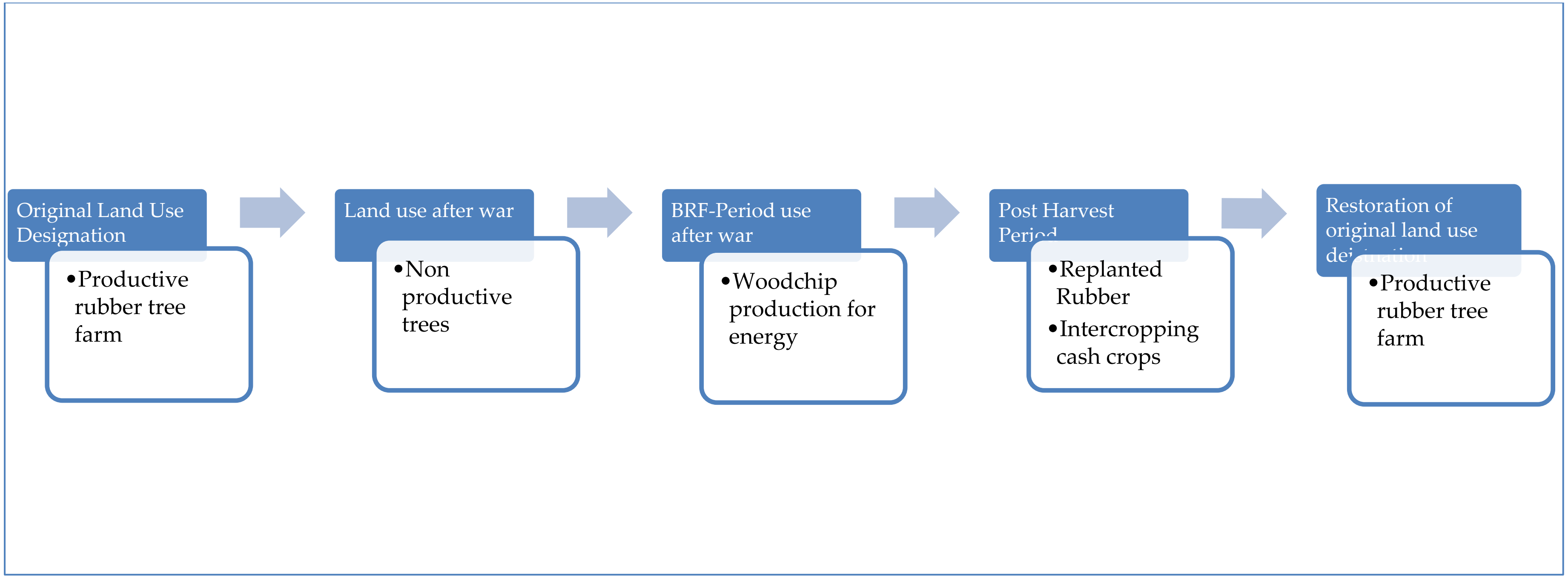


Figure 5-7: Land Use Flow Diagram.

5.1.9.4 Impacts on Social Relations

BR Fuel activities are projected to help in the restoration of the rural community social relations and activities disrupted as a result of the civil war, by restoring the previously economically viable production of established rubber tree farms.

Impacts on family relations are foreseen to be positive due to a projected decrease in financial stresses on the families of farm owners and their employees, as well as increased capacity building due to training and support provided by BR Fuel and their partners to the farmers.

Stakeholder participation is one of the underlying principles of sustainable development and with the aim of promoting sustainable rubber farming initiatives, BR Fuel is currently working with several partners to support the creation of a Farmer Association to secure and manage the supply of biomass from 121 farmers located in the Todee District.

A possible negative impact on social relations may occur where conflict arises between different ownership claimants of abandoned or unproductive rubber farms. However, this can be avoided by ensuring that no harvesting occurs in farms where there are any questions regarding land rights.

5.1.9.5 Impacts on Economic Activity

The Liberian economy relied heavily on the export of natural rubber prior to the civil war. As a result of the conflict, many rubber tree farms were abandoned, rubber trees “slaughter tapped” or left to age past the age of viable economic rubber productivity (at approximately 30 yrs of age).

By harvesting non-producing rubber trees and replanting with a new generation on a 30-year cycle, BR Fuel would be contributing to the revitalization of the natural rubber industry in Liberia hence contributing to poverty alleviation and economic development goals. Both genders will be included during land preparation and replanting to ensure that females are not excluded from the benefits of the project.

In Liberia, the cost of developing a typical three-hectare plot smallholder farm requires an outlay of $3,840, including labor inputs, a prohibitive amount for the majority of smallholder farmers. Yet that same three-hectare smallholder farm has the potential to employ three to five workers and generate $1,250 in income per month. On a net present value basis, investing in a rubber farm of this size may be worth $25,000, including planting and maintenance costs (through year seven after planting), and latex sales and harvesting costs during the plantation's productive life (years seven to thirty-two (as a maximum) after planting).

At the individual farmer level, economic benefits would occur from the following actions:

1. Payment for woodchips by tonnage harvested.
2. Remnant branches which will be left after harvest, and can be used privately for fuel wood production or converted to charcoal for sale, providing another source of income to the farmers.
3. Short term: intercropping agricultural products (for sale and personal use). This should also help improve food security status of the farmer until economic benefits of rubber production are attained.
4. Longer term: natural rubber production will resume from newly planted trees beginning at the age of approximately 6 yrs old.
5. In the long run the farms can be re-harvested on a 30 yr cycle allowing the operations to become a highly sustainable form of resource allocation and economic activity.
6. Other capacity building, technology transfer and market development benefits of working with BR Fuel and its partners.

Secondary multiplier effects resulting from increased employment and purchasing power in rural areas will contribute to poverty alleviation and economic development in these areas.

The question of potential competition of woodchip production with the production of charcoal from rubber trees, resulting in an increase of charcoal prices (which would negatively impact downstream users of charcoal) was addressed during stakeholder consultations undertaken by BR Fuel.

The results of these consultations show that in fact remnants from harvest operations (roots/branches) left over for charcoal production are not currently being completely utilized, being more than what is needed for current charcoal production levels by farmers. In addition there is currently a large surplus of old rubber trees in most regions where charcoal production is taking place. According to the Rubber Farmer's Association, coal prices mainly depend on distance and transportation, with the cost of transport being the highest cost in the charcoal production process. However, the Forestry Development Authority (FDA) suggested that the issue should be investigated more since there are no official records in Liberia showing the variation of charcoal prices over time as well as the factors influencing prices. FDA expressed willingness to work along with BR Fuel in order to make such statistics available and felt that any impacts identified through further research could be addressed through adequate mitigation measures. BR Fuel acknowledges the need to gather more information on the potential long-term impact of its operation on charcoal production and plans to work with partners to collect information, consult with relevant stakeholders and monitor the issue over time.

5.1.9.6 Human Rights

BR Fuel is expected to have only a positive impact on Human Rights issues in the areas in which it operates. BR Fuel operates in accordance with both Liberian Labor Laws, as well as international standards regarding labor and human rights issues. It has a strong anti-discrimination and equal opportunity policy and recognizes employees' freedom of association and right to collective bargaining. It is currently in the final stages of negotiating the Collective Bargaining Agreement with the employee elected union. The company does not support any kind of forced, compulsory or child labor. In keeping with Liberian law and ILO guidelines, BR Fuel does not employ anyone below the age of 18, or below the age of 16 in the case of internships or apprenticeships. Under no circumstances shall internships or apprenticeships interfere with a student's ability to attend school.

There have been allegations of child labor on rubber plantations in Liberia in the past. While only allegations have been made, BR Fuel takes the issue seriously and is integrating relevant provisions into its supplier contracts and code of conduct. Although BR Fuel has not encountered any child labor on the rubber farms on which it works, it has defined a clear policy not to work with rubber plantations supporting unlawful child labor. In the case of smallholder, family farms, BR Fuel is integrating issues around hazardous child labor into its capacity building programs with farmers. The company recognizes that child labor is a systematic problem throughout the globe that can only be addressed through cooperation amongst government, the private sector and NGOs. BR Fuel hopes to work with partners on a study on child labor in the rubber sector in Liberia in order to better understand its extent, its drivers, and potential mitigation measures.

Finally, BR Fuel invests heavily in on the job training and is developing programs for capacity building and career development of its employees.

Table 5-6: Potential socio-economic impacts of BR Fuel.

Impact	Beneficial	Adverse
Economic	• Employment generation • Expenditure of wages in local area • House purchase and rental • Equipment and services procurement • Local authority business tax/rates revenue • Increase in agricultural income • Increase in property value	• Negative Economical impacts are not anticipated
Social	• Indirect beneficial community impacts from employment and provision of skilled workforce • Provide medical services and some educational benefits, as well as training at least for employees and workers • Positive impact on human rights from operating according to Liberian Law as well as strict international standards	• Risks of occupational and environmental health issues associated with waste scavenging. • Nuisance to nearby villages due to increased dust, noise, emissions, traffic and level of activities.

5.1.10 Traffic & Road Network

During operation, the facility will result in significant impacts on the traffic flow along the roads leading from the sites of operations as well as the main site to the port where the wood chips are deposited, particularly as the annual biomass generation targets increase. While some roads are paved with asphalt, yet not in good condition (Figure 5-8), others are not paved and in bad condition, especially during wet seasons (Figure 5-8). In addition, traffic impacts are expected along secondary and tertiary roads, depending on the location of off-site activities and routings as the project requires the use of trucks and heavy equipment almost on a daily basis for different purposes. This will lead to an increase in the transportation fleet over time, as well as the use of the road network.

Also, the transportation of equipment, material, logs, roots and wood chips, whether to the port, the power plant, or to the working sites, could cause hazards to other users of the road network (already in bad condition) if not transported in safe manner. Such practices could lead to accidents and falling of material and thus threaten human life. Meanwhile, roads will also be improved (graded with adequate drainage) as a result of BR Fuel working in the area – BR Technical Services road rehabilitation and maintenance team will do this. Furthermore, Liberia's road infrastructure will improve as the country develops as a whole.

The significance of impacts on road networks may increase as the scope of operations widens in the future. Incremental loss due to repeated and increasing use of the road networks and infrastructure that will occur as operations expand will be mitigated by the Buchanan Renewables Technical Services Group operations which aim to repair and rehabilitate these networks. The increase in road traffic due to expansion may increase the emissions profile of the project however, increasing total emission levels in the lifecycle of the project.

Figure 5-8: Road conditions after a period of rain.

5.1.11 Cultural Heritage

Due to the fact that the sites are not fixed and could vary from one area to another, it is not feasible to tell whether there are known cultural heritage sites or archaeological remains on sites. However, a family cemetery/graveyard exists few meters across the road from the main site of BR Fuel in Buchanan (Figure 5-9). Potential cultural heritage sites will be identifies in the site specific impact assessments and harvesting plans conducted for each site.

Figure 5-9: few graves existing few meters opposite of the main entrance gate of BR Fuel's workshop site (on-site).

5.2 Cumulative Impacts

Cumulative impact assessment can be described as changes to the environment that result from an action in combination with actions from the past, present, and reasonably foreseeable future. As such, cumulative impacts may be seen as arising from one of four cumulative effects described below:

1. Spatial Crowding (several actions combine to cause effect in an area that is not large enough to cope).
2. Temporal Crowding (the environment is not allowed to recover from a previous action before a new action causes impact).
3. Incremental Loss (gradual disturbance causing incremental loss).
4. Indirect Effects (an action causes new actions to occur).

Cumulative effects can also be described as additive (where magnitude of impact equals sum of combined effects) or synergistic (where the magnitude of impact is greater than sum of individual effects).

5.2.1 Spatial Crowding

BR Fuel activities can be geographically divided into three main areas:

1. Main site: based in Buchanan Grand Bassa County
2. Large Concessions and smallholder rubber farmer holdings: spread over different counties in Liberia.
3. Transport infrastructure including roads and bridges utilized to transport material to and from main operational site.

Spatial crowding due to above operations is expected to be low for negative impacts due to the following reasons:

1. The operation sites are well delineated and widespread over different counties in Liberia lessening the risk of spatial crowding. Operations in different areas of large concessions or in close smallholder farms can be undertaken on a rotational basis, as necessary, to decrease the accumulation and localization of environmental impact, especially on soils and watercourses. Furthermore, concessions and large holder farms will be harvested in line with the annual sustainable cut of the farm and in keeping with good economic practices for the rubber farmer, therefore reducing the spatial concentration of operations.
2. Environmental and Social Impact Assessment have been carried out to assess projected impact of operations and prepare contingencies for decreasing/eliminating them.
3. The operation Environmental Management Plan includes strict mitigation and monitoring procedures to lessen environmental/social impacts at individual offsite, infrastructure and onsite areas, hence decreasing

cumulative negative impact resulting from any geographical crowding of operations. Regular environmental monitoring will also include action plans for any complaints and critical level results.

5.2.2 Temporal Crowding

The nature of the operations generally does not lend itself to temporal crowding. After the non-productive rubber trees have been harvested, the newly planted rubber trees are expected to grow and produce economically viable amounts of latex for 25-30years. Hence re-harvesting at a farm is not projected to occur for approximately three decades resulting in little or no temporal crowding.

5.2.3 Incremental loss

As described above, disturbance at farm level due to operations is limited to a period of harvest time and a short period afterwards when intercropping changes land use temporarily. There is no expected further gradual incremental loss. What is expected due to operations is thus incremental gain as recovery and revitalization of sequentially harvested rubber farms becomes positive additive gain.

Incremental loss due to repeated and increasing use of the road networks and infrastructure that could occur as operations expand will be mitigated by the Buchanan Renewables Technical Services Group operations which aim to repair and rehabilitate these networks, as well as improvements in Liberia's road infrastructure. So far the company has invested approximately $480,000 in building road and other infrastructure to access rubber farms. Over the thirteen year forecast period, the company has budgeted US $13 million for rehabilitation of roads and other infrastructure and US$22.5 million for port redevelopment, with immense public spillover benefits. Also 557 km of road have been rehabilitated.

The increase in road traffic due to expansion may lead to an increase in the emissions profile of the project however, increasing total emissions levels in the lifecycle of the project.

5.2.4 Cumulative Indirect Effects

A cumulative improvement in economic benefits at farmer level is projected to lead to secondary multiplier effects resulting from increased purchasing power in rural areas, contributing to poverty alleviation and economic development in these areas.

Apart from the initial payment to the farmers for harvested wood, intercropping as well as rehabilitation of the rubber trees will provide financial and food security to the farmers in the short and longer term. Because of this, operations are projected to be a highly sustainable form of resource allocation.

BR Fuel sources many of its support operations in local markets, and will contribute to national capacity building by providing training and education to employees and rubber tree farmers further contributing to community development.

Questions regarding a possible increase in the price of coal as a result of competition from project activities were allayed during stakeholder interviews as discussions showed that remnants left behind from harvest operations are more than what is currently needed for coal production, and that there is a surplus of aged rubber trees well beyond what is needed for current coal demand. Furthermore it was noted that the highest cost of coal production was in cost of transportation which depended on distance from market. In addition, Buchanan Group is planning to build a woodchip thermal power plant which would provide a projected 35MW of electricity to the capital Monrovia, providing a new renewable source of energy in Liberia and decreasing the capital's dependence on home charcoal use substantially.

A second issue regarding charcoal production is the question of whether there may be an increase in damage to Liberia's tropical forests as a result of charcoal production moving into new areas secondary to competition from the woodchip industry for wood. However, it is important to note that deforestation in Liberia is a previous and ongoing issue and as noted above, due to the surplus in aged rubber trees the project is thus not expected to impact the current rate of deforestation.

5.3 SUMMARY OF IMPACTS

Potential impacts from the main activities of the proposed project have been described. Impacts are measured based on their type as they could be directly or indirectly affected by the whole project; the nature of the impact reflects if the impact is positive or negative; duration emphasizes if the impact is permanent or temporary within the project time duration; and magnitude is the power of the impact on a certain component. The significance of impacts on each parameter is the result of the different assessed factor and is summarized in Table 5-7.

The impacts discussed in this section outline the worst case scenario as mentioned earlier; however, many of the potential impacts have been subjected to and will be subject to mitigation by BR Fuel through implementing the recommendations of the Harvesting Management Plan.

Table 5-7: Summary of Impacts Significance

Impact	*Type*	*Nature*	*Duration*	*Magnitude*	*Significance*
Air quality	Direct	Negative	Permanent	Moderate	Moderate
Water quality	Indirect	Negative	Temporary	Low	Low
Soil cover	Direct	Negative	Permanent	Moderate	Moderate
Biodiversity	Direct	Negative	Permanent	Moderate	Moderate
Noise	Direct	Negative	Temporary	Moderate	Low
Land-use	Indirect	Negative	Temporary	Low	Low
Socio-economic	Direct	Positive	Permanent	Moderate	Moderate
Health and safety	Direct	Negative	Permanent	Moderate	Moderate
Visual amenity	Direct	Negative	Permanent	Moderate	Modrate
Sanitation	Indirect	Negative	Permanent	Low	Low
Road network	Indirect	Negative	Permanent	Low	Low

6 ANALYSIS OF ALTERNATIVES

The analysis of alternatives in the context of the proposed woodchip biomass production includes comparison between the various available renewable energy resources options and determination of the most suitable option.

6.1 RENEWABLE ENERGY RESOURCES OPTIONS

Energy resources exist in different forms; some exist as stocks and so are exhaustible, others exist as flows and are inexhaustible, and a third form is based on exhaustible stocks that can be leveraged to resemble renewable (UNDP, 2000).

Various alternatives for biomass energy are available. These alternatives include hydroelectric power generation, solar power, wind power, and tidal power.

6.1.1 Hydroelectric Power Generation

Hydroelectric power generation provides a clean, renewable and sustainable source of energy. Advantages include decreased use of fossil fuels for electricity generation, and hence decreased atmospheric pollutants and Green House Gas emissions (GHG) emissions, as well as increased energy security due to decreased dependence on outside nations for energy.

In addition, there are upstream and downstream secondary positive impacts such as potential for development of freshwater agricultural fish industry (aquaculture) in the reservoir formed by the dam, as well as decreased risks of flooding in downstream areas, and provision of improved irrigation control for agriculture.

However economically, construction of large hydroelectric power projects requires high up front financial costs which may be difficult to secure, as well as continued maintenance costs including the possibility of the need for a large financial outlay in the future to clear of any siltation that may occur and affect the functioning and productivity of the project.

Social impacts of large hydroelectric power projects can be immense, especially where they result in major resettlement of surrounding populations due to reservoir formation. Flooding by the newly formed reservoir may also result in the loss of heritage, cultural and archaeological sites. In addition the new surface still-water body formed may result in an increase in vector borne diseases in the region.

Environmental impacts include the flooding of surrounding regions by lake formation which will affect the local floral and faunal habitats and niches in the surrounding areas. Furthermore, due to decreased flow and sediment retention in the reservoir, there will be decreased nutrient delivery downstream to agricultural and fishery industries. In addition the advantages of low greenhouse emissions of hydroelectric power projects have been called into question, as large amounts of carbon are tied up in plants and are released when the reservoir is initially flooded and the plants decompose. Later on, plant matter settling on the reservoir's bottom decomposes anaerobically resulting in a build-up of dissolved methane which is released into the atmosphere when water passes through the dam's turbines.

Micro-hydro and pico-hydro electricity schemes result in less negative impacts to the surrounding environment but are limited in their power generation potential.

6.1.2 Solar Power

Solar energy is one of the Earth's most abundant resources and theoretically has the potential of providing large amounts of clean, renewable energy, many times current energy demand. In addition solar power has the potential to decrease dependence on fossil fuel based sources for power generation.

Solar power can range from small home based photovoltaic and solar thermal sources, to large solar power plants that can generate hundreds of MW of power.

Home based solar energy initiatives can provide off-grid energy generation to rural communities, contributing to rural development and decreasing detrimental health impacts in rural areas which are highly dependent on home based wood fuel/charcoal burning as a source of energy. During nighttimes and on cloudy days, continuance of supply is secured by rechargeable batteries which store the energy; however this can lead to the question of environmentally responsible disposal of these batteries once they reach their end of their life span.

Larger solar power generation initiatives have extremely high upfront cost requirements, and usually need large flat landscape as viable locations, preferably in desert or arid areas. About 1 percent of the world's desert area used by solar thermal power plants would be sufficient to generate today's world electricity demand (UNDP, 2000). Concentration Solar Power Projects in addition require continual maintenance of Mirror systems and solar concentration collection towers, resulting in added maintenance costs. Furthermore, a functioning grid is required to deliver the electricity to end-users. Another production issue is the fact that the supply of silicon used for the manufacturing of photovoltaic cells has suffered with gaps forming between supply and demand in recent years.

New developments such as "thin film" solar cell technology are expected to bring down costs of production of solar cells as well as remove the dependence on silicon in the manufacturing process in the future.

Solar power currently has a very low capacity factor and, thus, is not generally used as base load power. Its effectiveness also depends heavily on the climatic conditions.

Negative environmental impacts of an established large solar power plant are mostly related to the change in visual amenity, and encroachment on wildlife habitat. Apart from this, negative impacts lie mainly in the production process as the extraction of silicon for the creation of solar cells requires the use of fossil fuels; and in the proper disposal of storage batteries (which contain lead and cadmium) at the end of their life span.

6.1.3 Wind Power

Energy derived from wind requires no fossil fuels and emits no pollution that is directly related to electricity production. The production of the wind turbines, however, is costly and requires significant resources.

Wind turbines start operating at wind speeds of 4 meters per second (around 10 miles an hour) and reach cut-out speed at approximately 25 meters per second after which they have to be shut down to protect the system from damage. Other sources of energy are required when the wind speeds fall below requirements for energy generation as wind is erratic, highly variable in speed both regionally and locally. Thus, the capacity factor of wind power is extremely low and it is not generally relied upon for base load power.

Wind farm installation can have a variety of negative environmental impacts ranging from visual impact on the landscape, and noise disturbance, to their effects on wildlife such as birds and bats in terms of habitat loss and collision risk. Other impacts include electromagnetic interference with radio, television, and radar signal.

6.1.4 Tidal Power

In countries with long coastlines, or a bay or inlet with narrow opening that could be dammed to regulate water flow in and out, and large tidal swings (at least 5 meters difference between high and low tides), another possible source of renewable energy can be harnessed from tidal power. This source of energy suffers from high engineering costs, environmental impacts of dam building, and effects of the projects on tidal swings (which could negatively impact coastal marine ecosystems). Unlike wind and solar power, tidal energy has the advantage of the potential to provide a near continuous source of energy eliminating the need for a backup system during down times. This source of energy, however, is not yet well developed.

6.1.5 Biomass Energy

The term biomass refers to the total mass of all the organisms living on earth. In an energy context, the term biomass has become a catchall for various ways of deriving energy from organisms or from their remains. Indirectly, biomass derived energy is ultimately solar energy, since most biomass energy sources are plant materials, and plants need sunlight to grow. Biomass energy sources can range from dedicated energy crops (herbaceous or short rotation woody crops e.g. coppice silviculture), to agricultural crops (though these have fallen out of favor slightly due to the question of competition with food production), agricultural crop residues, forestry residues, aquatic crops (e.g. algae, kelp), municipal and animal wastes.

There are competing uses for biomass resources because of their economic and environmental value. Biomass can be used to generate power, heat, steam, and for producing transportation fuels. Biomass is also used by the food processing industries, animal feed industry, and the wood products industry, which includes construction and fiber products (paper and derivatives); along with chemical products made by these industries that have diverse applications including detergents, fertilizers, and erosion control products (Milbrandt, 2009). Woody biomass has been used as a primary energy source in many rural areas in developing nations, where it is mainly used for cooking and heating.

Biomass fuels are burned to release their energy, so they share the carbon-dioxide-pollution problems of fossil fuels. Some biomass fuels, like wood, also contribute particulate air pollutants. However, unlike fossil fuels, biomass fuels are renewable. When used in close quarters with poor ventilation, biomass incineration can result in the release of toxic indoor pollutants as smoke (combinations of SO_x, NO_x, CO, VOCs, heavy metals and particulate matter) which disproportionately affect the health of women and children exposed. The smoke indirectly increases the risk of respiratory tract infection such as pneumonia, chronic obstructive airway disease, lung cancer, incidence of tuberculosis, cataracts and adverse pregnancy outcomes (WHO, 2005).

On a larger scale, biomass based power plant initiatives have lower atmospheric emission profiles than fossil fuel based systems, and can provide a viable "green" alternative to the burning of non-renewable fossil fuels for energy.

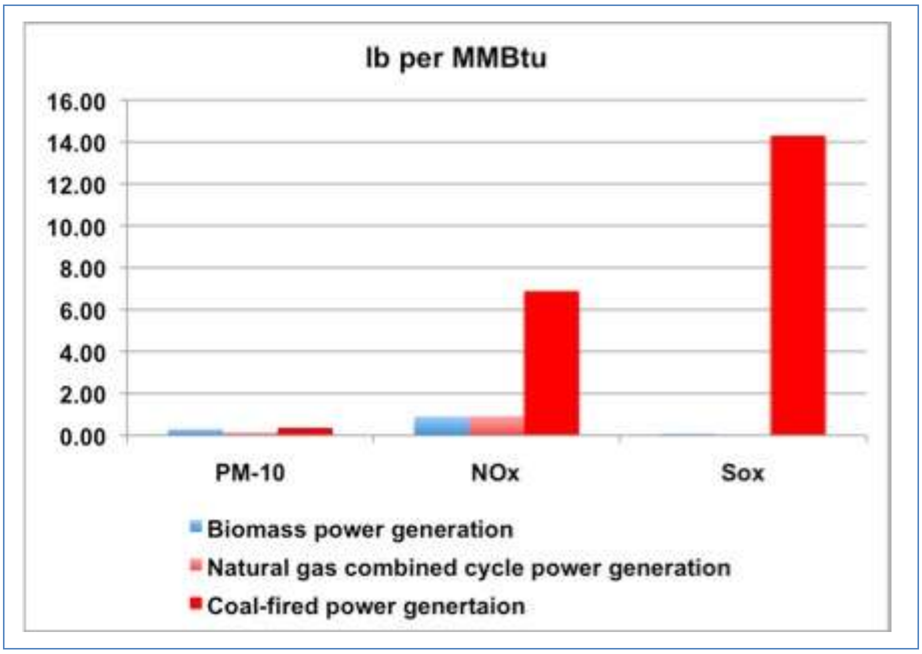


Figure 6-1: Comparison of emissions. ***Source:*** **Bain, Amos, Downing & Perlack (2003). "Biopower Technical Assessment: State of the Industry and Technology." National Renewables Energy Laboratory, Golden CO**

Table 6-1: Energy Contents of Different Types of Biomass. Source: BiofuelsB2B

Type of Biomass	*Energy Content*
1 ton of coal	2.5 MWh
1 ton of wood pellets	1.8 to 2 MWh
1 ton of sawdust	1.8 MWh
1 ton of wood cuttings	0.8 to 1.5 MWh
1 ton of coffee dregs	1.6 MWh
1 ton of sewage sludge	10 MWh

Energy from biomass, when sustainably sourced, can be a low cost form of renewable energy and has the added benefit of being carbon neutral, as carbon emitted upon incineration is balanced by carbon absorbed from the atmosphere during the growth and development of the plants involved. Hence apart from local/national benefits, by using biomass for energy generation, global positive impacts are expected due to the decrease in GHG emissions.

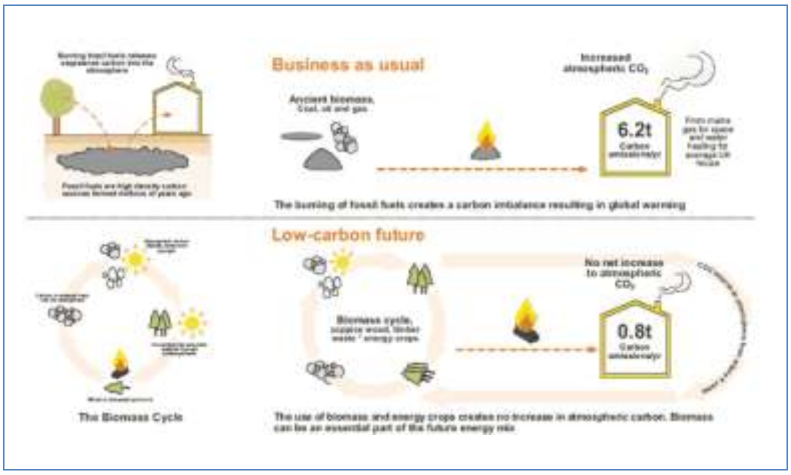


Figure 6-2: Comparison in CO_2 emissions between business as usual scenarios and use of biomass. ***Source*: XCO2 conisbee Ltd**

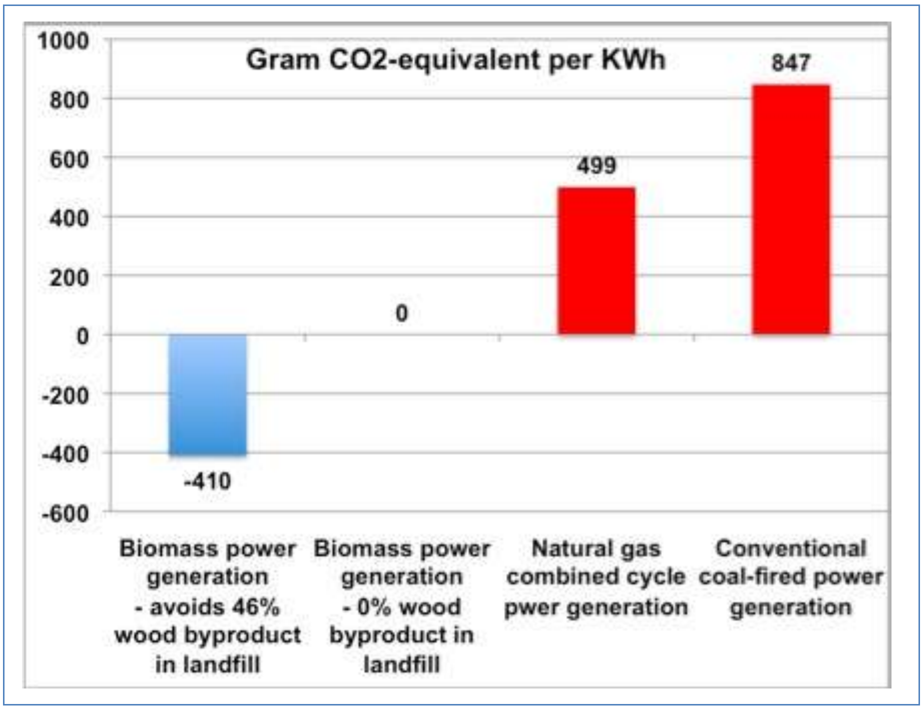


Figure 6-3: Lifecycle GHG emissions. ***Source:*** **Mann, M.K.; Spath, P.L. (2004) "Biomass Power and Conventional Fossil Systems with and without CO_2 Sequestration-Compring the Energy Balance, Greenhouse Gas Emissions and Economics." Natural Renewables Energy Laboratory, Golden CO**

Another benefit of biomass is that it can be co-fired with coal in existing coal plants, thus minimizing costly capital investments required to produce, and facilitating conversion to, green energy.

Energy generation through biomass incineration can thus form a viable renewable alternative to fossil fuels, and in addition can give energy security and independence to non-fossil fuel producing nations, driving economic recovery, as well as helping improve rural development.

6.2 RENEWABLE ENERGY ALTERNATIVES IN LIBERIA

Liberia has enormous renewable energy potential. Prior assessments of the renewable energy resource potential in Liberia have demonstrated abundant hydro, biomass, and solar resources (NEP, 2009 and REEEP, 2007).

With six major rivers, which drain over 60% of the country's water, Liberia has considerable potential for hydroelectric power. Short coastal waterways drain about 3% of the country's water. This intensive drainage pattern indicates considerable potential for hydroelectric power in Liberia (NEP, 2009). At the onset of civil war there were three (3) operational hydroelectric power plants in Liberia: Harbel (Firestone) 4MW; Mount Coffee (LEC) 64MW; and Yandahun (a community micro hydro in Lofa County), 30 KW The Mount Coffee and Yandahun plants were destroyed during the war, but the Harbel plant is still operational (NEP, 2009 and REEEP, 2007).

Feasibility studies carried over the period 1976-1983 identified at least 14 large-scale schemes in the six main rivers. The Cavalla River has a single largest potential (225MW at Tiboto) but with more than half of this in Cote d'Ivoire; bilateral cooperation is required for its development. Similarly, the Mano River, with the potential of up to 180 MW, has nearly a quarter of its basin in Sierra Leone. However, since four of the six river basins are within Liberia's borders, they could be developed. The major drawback is that all suffer from the problem of low-head flow, requiring huge investment in storage or reservoir to maintain firm capacity during the dry season. About 24 other sites have been identified for small hydroelectric schemes (up to 5 MW) (REEEP, 2007).

In addition, annual insolation shows good prospects for the application of solar technologies such as photovoltaic and solar thermal systems. Though no official renewable resource assessment has been carried out in Liberia, preliminary estimates suggest that the monthly average daily solar radiation on horizontal surfaces in Liberia is between 4.0 and 6.0 kWh/m^2/day (NEP, 2009).

Because the sun does not shine with equal intensity every day, at night, and during inclement weather—cloud cover, rain, etc.—a storage factor must be employed with solar power technologies. Therefore, with appropriate system design solar technologies are considered highly suitable for widespread deployment and for all seasons. Such systems design, however, is still not technologically advanced enough for solar to provide base load power throughout all seasons. Furthermore, the cost of solar remains financially prohibitive.

Regarding wind energy potential, there is no current data on wind speed across the country, although Liberia is situated in a low wind region. However, direct observation along the coastal region shows good prospect for the development of wind power. Thus, there is a need for intensive wind resource assessment along the coast and inland for the evaluation of wind energy potentials in the country (REEEP, 2007). Again, wind power does not provide sufficient capacity for base load power production and could only be used to supplement and reliable source of cost-effective base load power.

Finally, geothermal resources do not appear to exist in Liberia. Though higher heat flow values are found offshore to the south and west in the Guinea and Sierra Leone Basins, and are attributed to possible tectonic activity, the thermal effects of the activity are not thought to extend inland to the Liberian Shield.

6.3 Biomass Alternatives in Liberia

In Liberia, as in nearly all of Sub-Sahara African countries, biomass (firewood, charcoal, and crop residues) is the primary energy source used for domestic cooking and heating. Up to 99.5% of the population relies on biomass-based fuels according to the United Nations Development Programme (UNDP, ?).

Liberia is endowed with considerable biomass resources. A variety of biomass resources exist in the country in large quantities and with opportunities for expansion.

6.3.1 Agricultural Resources

About 60% of the country is covered by forest and woodland. The rain forest soils, while well drained, are highly leached, making Liberia better adapted to tree crop agriculture than to annual field crop production.

6.3.1.1 Food Crop Residues

It is estimated that some 125,000 tons of food crop residues are produced each year in Liberia (Table 6-2). The corresponding energy content is about 2,100 TJ, equivalent to 188 GWh of electricity (if the average conversion is 1.5 MWh per tonne of dry biomass).

However, the potential use of the food crops residues for centralized electricity generation is limited due to the lack of large-scale food crops production and their dispersion. Moreover, many crop residues and byproducts are seasonal and become available all at once at the same time of the year. Therefore, treatment and storage facilities will be required if they are to be made available as a bio-power feedstock throughout the year.

Table 6-2: Food Crop Residues in Liberia. ***Source:*** **FAOSTAT 2005; Koopmans and Koppejan 1997.**

Commodity	Production (tonnes)	Residue Type	Crop to residue Ratio	Moisture Content (%)	Residue (dry tones)	LHV (MJ/kg)	Total Energy (TJ/yr)	GWh
Rice	110,000	Straw	0.45	12.71	43,209	16	691	65
		Husk	0.27	12.37	26,026	19	494	39
Cassava	490,000	Stalk	0.06	15	24,990	17.5	437	37
Other root and tuber crop	64,500	Stalk	0.06	15	3,290	17.5	58	5
Groundnut	4,800	Shells	0.48	8.2	2,115	16	34	3
		Straw	2.30	12	9,715	18	175	15

Commodity	Production (tonnes)	Residue Type	Crop to residue Ratio	Moisture Content (%)	Residue (dry tones)	LHV (MJ/kg)	Total Energy (TJ/yr)	GWh
Maize	15,000	Stalk	1.00	15.5	12,675	15	190	19
		cob	0.25	8	3,450	15	52	5
Total	684,300				125,469		2,131	188

Note: other root and tuber crops include sweet potatoes, coco yams, and yams; GWh calculation assumes that a tonne of dry biomass generates on average 1.5 MWh$_e$ with the efficiency in the range of 20 – 40%.

6.3.1.2 Cash Crop Residues

Cash crops grown in Liberia include rubber, coffee, cacao, coconut, sugarcane, plantain/banana (also serving as food crops), oil palm, pineapple, and kola nut (Table 6-3). Rubber, cacao, and coffee make very important contributions to the Liberian economy, accounting for 22% of GDP in 2005.

Currently, cash crops in Liberia are grown predominately on small household farms, except rubber and oil palm, grown on a range of small-, medium-, and large-scale production systems. Opportunities for growing cash crops on mid-size, commercial farms are anticipated. Table 6-3 summarizes cash crop residues generated annually in Liberia and their relative energy content according to a study conducted by FAOSTAT. The total amount of crop residue, including only branches from rubber trees, is estimated by FAOSTAT to b 3.9 million tons of biomass, equivalent to about 63,000 TJ per year (5,890 GWh of electricity). Residues from banana and plantains have the largest contribution (67%), followed by biomass material from oil palm fruit (15%), and rubber wood branches (8%).

Table 6-3: Cash Crop Residues in Liberia. *Source*: FAOSTAT (production in 2005); Koopmans and Koppejan 1997; Sajjakulnukit, B., et al 2005)

Commodity	Production (tonnes)	Residue Type	Crop to residue Ratio	Moisture Content (%)	Residue (dry tonnes)	LHV (MJ/kg)	Total Energy (TJ/yr)	GWh
Coffee (green)	3,200	Husk	0.18	13	501	17	8.52	0.75
Cacao (beans)	3,000	Pods	2	13	5,220	18	94	7.83
		Pruning's	2	11	5,340	18	96	8.01
	17,000ha	Wood (replanting)**	5.76 dry tonnes/ha	N/A	9,792	18	176	14.69
Oil Palm (fruit)	183,000	Empty fruit bunches	0.43	9	71,757	16	1,148	107.64
		Fibre	0.15	10	24,705	16	395	37.06
		Kernel shells	0.05	13	7,961	17	135	11.94
		Fronds	2.6	48	247,416	8	1,979	371.12

Commodity	Production (tonnes)	Residue Type	Crop to residue Ratio	Moisture Content (%)	Residue (dry tonnes)	LHV (MJ/kg)	Total Energy (TJ/yr)	GWh
	30,000ha*	Wood (replanting)**	80 dry tonnes/ha	N/A	240,000	18	4,320	360.00
Coconuts	81,000	Husk	0.42	10	30,618	19	582	45.93
		Shells	0.7	13	49,329	18	888	73.99
		Fronds	2.4 dry tonnes/ha	N/A	194,400	18	3,499	291.60
	81,000ha*	Wood (replanting)**	0.96 tonnes/ha	11	7,776	18	125	11.66
Bananas and Plantains	152,000	Peels	0.25	15	32,300	17	549	48.45
	29,000ha	Stems/leaves	89 dry tonnes/ha/yr	N/A	2,581,000	16	41,296	3,871.50
Rubber Branches	58,000ha	Branches (replanting)**	44 dry tonnes/ha	N/A	254,000	18	4,572	381.00
		leaves	1.4 tonnes/ha	15	68,663	18	1,236	102.99
Sugarcane	255,000	Bagasse	0.29	49	37,715	18	679	56.57
		Tops/leaves	0.3	50	38,250	16	612	57.38
Pineapple	1,200ha	leaves	80 tonnes/ha/yr	80	19,200	14	265	28.80
Total					3,925,943		62,655	5,889

N/A – Not applicable; * Includes large-scale plantations only; ** Residues are calculated for 10% of current cacao, rubber, coconut, and oil palm tree stock; GWh calculation assumes that a tonne of dry biomass generates on average 1.5 MWh_e with the efficiency in the range of 20 – 40%.

6.3.1.3 Animal Manure

The livestock sector has never been a major feature of the agriculture sector in Liberia; nearly half of this livestock being poultry. Potential biogas production that can result from the digestion of livestock in Liberia is estimated at about 36 hm^3 per year, equivalent to 219 GWh (Table 6-4).

Table 6-4: Animal Manure and Biogas Potential in Liberia. *Source*: MOA 2007; Manure generation per day considers medium size animals

Livestock Type	Population in 2005 (heads)	Manure(kg/head/day)	Biogas yield(m^3/kg)	Annual Biogas Production (hm^3)	GWh
Cattle	25,000	10	0.04	3.65	22
Sheep/goats	435,000	2	0.05	15.88	95
Pigs	131,000	1.5	0.07	5.02	30
Poultry	5,428,000	0.1	0.06	11.89	71
Total	6,019,000			36.44	219

The calorific value of biogas is about 6 kWh/m^3, which corresponds to about 0.5 liter of diesel oil. The net calorific value depends on the efficiency of the burners or appliances. hm^3 – cubic hectometer or 1,000,000 m^3

6.3.2 Forest Resources

Wood residues from logging and wood-processing activities can be used to generate heat, electricity, liquid fuels and solid fuels (wood pellets, wood-chips, charcoal briquettes, etc). It is estimated that about 19.6 hm^3 of forest residues could be collected in Liberia, equivalent to 162,645 TJ per year, or 15,248 GWh of electricity (Table 6-5).

Table 6-5: Forest Residues in Liberia (NREL, 2009).

Forest Residues	Volume (hm^3)	Weight(Mt)	Total energy (TJ/yr)	GWh
Logging	8.71	6,898	110,373	10,347
Saw-milling	10.89	3,267	52,272	4,901
Total	19.6	10,165	162,645	15,248

hm^3 -cubic hectometer (1 hm^3 = 1,000,000 m^3); Mt – Megatonne (10^6 tonnes); conversion of volume to mass is based on average density of 792 kg/m3 for logging residues and 300 kg/m3 for saw-milling residues with a moisture content of 20%. GWh calculation assumes that a tonne of dry biomass generates on average 1.5 MWh_e with the efficiency in the range of 20 – 40%; Air-dry wood (20% moisture content) has an energy value of about 16 MJ/kg.

6.3.3 Urban Resources

Municipal solid waste, particularly the biogenic fraction, is a resource that can be converted to electricity, heat, gaseous and liquid fuels through thermo-chemical (incineration, pyrolysis, and gasification), and bio-chemical (anaerobic digestion and fermentation) conversion processes.

The amount of municipal solid waste generated annually in Liberia’s major urban areas is estimated at 270,000 tones. Based on the waste composition in Liberia, biogenic materials represent 64% of this amount, i.e. 172,000 tones. The electrical energy that can be generated from this biogenic portion is estimated at 52 GWh per year.

6.4 Do-Nothing Scenario

Should BR Fuel not proceed with the current initiative, the status quo is projected to continue into the near future. It is possible that the rubber industry will continue to be stagnant; farmers with non producing rubber trees might continue to have economic hardship with very little recourse for improvement of their current economic status except for dependence on outside aid or initiatives. The direct and indirect economic and social benefits that would have been accrued by the farmers and their employees due to the project would now be lost.

Several rubber farm lands would languish and be agriculturally unproductive. Unsustainable harvesting would continue to occur as farmers cut down rubber trees for firewood or for conversion to charcoal, without having the means for replanting the trees or the capacity for intercropping as a short term economic alternative. Once the rubber trees are harvested, their protective benefits are lost and the exposed soil would become highly susceptible to erosive forces, especially during the heavy rains in the wet season, devaluing the land and decreasing its future productive potential.

In the very long run, as the numbers of available non-productive rubber tree decreases around the country, unregulated and illegal harvesting will move into the natural forests immensely increasing the rates of deforestation in Liberia.

In addition loss of future BR Fuel initiatives such as the biomass powered power plant would also mean the loss of a projected 36 MW electricity supply to the capital, and escalating energy supply issues as the population grows, with continued dependence on imported fossil fuels for energy into the near future until other renewable alternative energy supplies are established.

7 ENVIRONMENTAL MANAGEMENT PLAN

7.1 OBJECTIVES OF ENVIRONMENTAL MANAGEMENT PLAN

The environmental management plan (EMP) will ensure that the performance of BR Fuel will comply with all technical, regulatory, and institutional requirements. The EMP is essential to ensure that identified and potential impacts are maintained within the allowable levels, unanticipated impacts are mitigated at an early stage (before they become a problem), and the expected project benefits are realized.

In the EMP, the environmental objectives of BR Fuel should be clearly stated, and communicated to all staff to provide the necessary cohesion between planning, engineering, collection and operation. Moreover, the EMP should be strictly implemented without ignoring any detail.

The EMP has clear targets and times as well as clearly allocated responsibilities among the different personnel working at the company. The EMP assists in the systematic and prompt recognition of problems and the effective actions to correct them. Table 7-1 describes the items that will help the management in achieving high environmental performance. These include understanding environmental priorities and policies, ensuring proper management at all levels of the project's operation, knowing the regulatory requirements, and keeping up-to-date operational information.

Briefly, the execution of the EMP will facilitate efficient implementation of mitigation measures to minimize impacts, accident prevention, effective operation and maintenance of the operational site, and proper training, awareness and information diffusion among the BR Fuel's personnel.

Table 7-1: Environmental awareness checklist for management.

Item	*Main Requirements*
ENVIRONMENTAL PRIORITIES AND POLICIES	• ENVIRONMENTAL OBJECTIVES ARE CLEARLY DEFINED • ENVIRONMENTAL ISSUES (SUCH AS THOSE RELATED TO AIR POLLUTION, EFFLUENT DISCHARGE AND SAFETY) ARE UNDERSTOOD
MANAGEMENT	• ENVIRONMENTAL AND SAFETY RESPONSIBILITIES ARE CLEARLY ALLOCATED • STAFF TRAINING PROGRAMS ARE DEFINED AND CARRIED OUT • MONITORING RESULTS ARE REGULARLY RECEIVED AND ACTED UPON
REGULATORY REQUIREMENTS	• POLLUTION REGULATIONS – AIR, WATER, AND SOIL STANDARDS ARE KNOWN • HEALTH REGULATIONS (WORKPLACE) ARE KNOWN • LOGISTIC REGULATIONS (HANDLING AND CARRYING) ARE KNOWN
OPERATIONAL INFORMATION	• ANALYTICAL PROCEDURES ARE UNDERSTOOD • MONITORING DATA ARE COMPILED AND SUBMITTED ACCORDING TO SCHEDULE • MONITORING DATA ARE CHECKED BY QUALIFIED PERSONNEL WITH APPROPRIATE RESPONSIBILITY

7.2 MITIGATION MEASURES

The mitigation plan identifies the actions that can be undertaken to minimize or eliminate the negative impacts while improving the positive impacts. The Impact Assessment section has shown the potential negative and positive impacts of the project's operation. Nevertheless, actions to minimize the likelihood and significance of possible negative impacts are summarized in Table 7-5 & Table 7-6. Management at BR Fuel is responsible for the implementation of these measures to avoid unnecessary impacts to take place.

7.3 SIGNIFICANCE OF MITIGATION MEASURES

Mitigation refers to the set of measures taken to eliminate, reduce, or remedy potential undesirable effects resulting from the proposed action, in this case BR Fuel. Mitigation should be typically considered in all the operational stages of BR Fuel, namely the off-site operations (tree cutting, branches sawing, land preparation and replanting, wood chips, log or root transportation, wood chipping or root grinding, internal roads rehabilitation, transport management and loading and shipping of wood chips).

Potential adverse environmental impacts induced by operations off-site and on-site may include, as described in the previous section (a) health and safety concerns (b) air quality (c) impacts on water quality (d) soil quality degradation (e) generation of noise from traffic and machinery (f) impacts on biodiversity (g) generation of solid waste.

Mitigation measures should be monitored on a continuous basis in order to achieve the highest control with minimum risks. The supervisor engineer and the environmental officer are the main personnel to ensure that mitigation measures are employed in the right way.

The subsequent paragraphs describe the mitigation measures that should be followed to minimize the above-summarized impacts.

7.4 Description of Mitigation Measures

As identified earlier, potential adverse impacts of BR Fuel's activities may include degradation of soil quality, emission of gasses, noise generation, and production of effluents, health and safety concerns, and generation of solid waste. Proposed mitigation measures for the above-mentioned adverse impacts are discussed in the following paragraphs. Table 7-5 & Table 7-6 summarize such mitigation measures, their monitoring for actions affecting environmental resources and community members. Such measures should be set as primary conditions to assure a proper management of BR Fuel as well as the implementation of the Environmental Management Plan (EMP).

In order to be applied efficiently, mitigation measures should be typically considered at the different operational stages of the BR Fuel facilities namely the off-site operations (tree cutting, branch sawing, land preparation and replanting, wood chip and log transportation, internal roads rehabilitation, wood chipping and root grinding transport management and loading and shipping of wood chips, and on-site activities. Every single issue discussed earlier should be addressed and resolved, including water resources, wastewater and solid waste disposal, air and noise emissions and finally occupational safety. The supervisor engineer and the environmental officer are the main personnel to ensure that mitigation measures are employed in the right way.

The following section will discuss the mitigation measures and plans recommended by the study team and design an environmental monitoring plan paralleled with a record keeping/reporting process.

7.5 MITIGATION MEASURES ON-SITE/WORKSHOP/PORT (WOODCHIP STORAGE) FACILITY

7.5.1 Mitigating Impacts of Air Emissions

One source of air pollution resulting from operational activities around the site is particulate matter (PM) mobilized from vehicle traffic on the laterite roads between the main site compound and the port facility during the dry season. PM emissions on BR Fuel facilities will be limited, as the main site compound is covered in crushed rock and the port facility is concrete. In general, control techniques for minimizing PM emissions involve watering of surfaces or chemical stabilization. Watering is the most common and generally the least expensive methods, and provides adequate temporary dust control. Regular watering practices cause aggregation and cementation of fine particles to the surface of larger particles, thus achieving a reduction of more than 50 percent in the rate of fugitive dust emission. The use of chemicals to treat exposed surface provide longer dust suppression, but may be costly, have adverse effects on plant and animal life, or contaminate the treated material.

Surface improvement offers long term air pollution control techniques since the amount of emission reduction is directly tied to reducing surface silt content. These include covering the road surface with a new material of lower silt content, such as grading of gravel roads, help to retain larger aggregate sizes on the travelled portion of the road leading to the site and thus helping reduce emission. The amount of emission reduction is tied directly to reducing surface silt content.

Other mitigation measures that are recommended for the main site include, maintaining good housekeeping practices throughout the operation of the main site. These low cost measures include periodic removal of any dust producing material, covering trucks or vehicles that transport materials to or from the main site. Vehicles speed to or from the site should also be limited to 10km/hr.

Other types of pollutants are associated with the operation of the main site. These pollutants comprise of CO, NO_2, SO_2, PM and HC and are mainly emitted by cars and truck traffic to and from the site, as well as generators, conveyor belts, and wheel loaders. These pollutants are also associated with fuel combustion for energy production on site. Measures to reduce such emissions include proper maintenance and the adoption of standard operating procedures for transport (minimizing idling, ensuring high quality fuel through fuel filtration) and a traffic management plan in order to minimize congestion where possible. Concerning on-site emissions, proper maintenance procedures, and the quality of diesel fuel used are important to reduce emissions. In addition, equipment should be turned off when not in use, which would reduce power needs and emission of pollutants. BR Fuel will also investigate options for the use of biofuels to minimize traditional diesel requirements.

Risks of fire occurring at the main site could also have negative impacts on air quality. Fire control measures such as equipping the site's facilities (especially the workshop, fuel storages facilities, warehouses, clinic, woodchip storage facility at the port etc.) with basic firefighting equipment, assigning a team for fire watching, and providing emergency numbers at several locations through the sites should be adopted. Although these measures are beneficial for fire control after it occurs, prevention measures should be adopted to reduce the risk of fire occurrence. Such measures include:

- Prohibit littering within the site.
- Store flammable liquids such as fuel or chemicals/products in safe storage areas. Safe storage areas for chemical and fuel substances should be:
  - o Separated by means of fire resistant material with a minimum fire resistance of two hours.
  - o Equipped with suitable shelving, if necessary, constructed of non-porous and non-combustible material.
  - o A properly ventilated area; this includes forced ventilation from floor to ceiling with exhaust above roof level, and ventilated to the open air in such a manner that vapor cannot accumulate inside the store.
  - o Clearly marked with a sign indicating that it is such a store and also indicating the maximum amount of liquid material that may be stored therein.
  - o Equipped with facilities to store personal protective equipment for the users in such a way as to prevent contamination thereof.
  - o Equipped with or located near washing facilities for personal hygiene, adequate and appropriate to user's expected exposures.
  - o Equipped with fire extinguishers of a quantity and type suitable for the expected fire risk, in an accessible location close to the store.
  - o A communication system to the main office or emergency system is recommended.
  - o Fire extinguishers of the approved type positioned near an escape route

    - Spill control and clean-up materials
    - Approved eye/face wash and shower nearby
- Remove dried vegetation (such as grass, weeds, etc.) around and within the site.
- Assure that exhausts of vehicles within the site are not hot enough to induce fires by frequent maintenance and inspection of vehicles.
- Prohibiting smoking in the workshop, in the vicinity of the fuel storage facilities, near vehicles, near the woodchip storage and areas that are designated with risks of fire occurring.

7.5.2 Mitigating Impacts on Water Resources

Knowing that the local population depends on water from shallow wells for drinking and on surface water in streams, ponds, for washing, fishing, and irrigation, it would be necessary to effectively control the impacts on water resources through appropriate design and site management practices. The primary sources of potential impacts on water quality will be from pollutants such as oil and fuel products in site runoff water which enters surface water. As such, the surface runoff and storm water should be diverted away from the main site including the workshop and chemical storage facilities and all site runoff should be directed into site-storm drains along with adequately designed sand/silt techniques removal such as sand traps, silt traps and sediment basins, and oil/water separator. In addition, rainwater received on the site should be directed into these drains with silt/debris removal facilities and oil/water separators and not directly to the environment. Silt/debris removal facilities should be maintained whereby deposited silt and debris are regularly removed after each rainstorm to ensure that these systems are functioning properly at all times.

Water bodies are impacted by runoff from collected wood piles at the port facility. During rainy weather, water infiltrates through the fine particles of wood and discharge into the natural river crossing next to the site. Organic matter will be loaded into the river mainly affecting the oxygen level in the river. A mitigation measure that has to be taken into consideration has to be carried out by preventing the contact of rain water with the woodpiles. This simple method avoids the higher cost of treating the running water body. It is required to cover the wood piles with to minimize the action of rain and wind on the piles. It may be possible to build-up high roof storage with one open wall to load and unload the material. Rain water hitting the roof has to discharge into nature through a collecting drainage. Until such time as a cover can be built, BR Fuel will build a simple filtration system into the current drainage.

The domestic wastewater resulting from the administrative building and workers facilities should be collected in a separate septic tank. Once the collection tank reaches its full capacity, it should be transferred to a planned wastewater treatment stations (if available) or to a wastewater disposal site approved by the EPA.

Water used in vehicle and plant servicing areas, vehicle wash bays and lubrication bays should be collected and connected to the drainage system via an oil/grease trap. Washing water generated from the action of vehicles washing should be conveyed to a local network or to a septic tank or can be biologically treated in a constructed wetland or other filtration system. Oil leakage or spillage should be contained and cleaned up immediately as in Appendix B. Spent oil and lubricants should be collected and stored for recycling or proper disposal. In addition, all fuel tanks and chemical storage areas should be provided with locks.

Other impacts that result from the haphazard disposal of the collected oil and lubricants generated from equipment maintenance workshop on-site should be mitigated to curb any surface and groundwater pollution. As such, the provision of dedicated storage areas, with spillage protection, for potentially polluting materials but not limited to substances such as oils, fuels, lubricants, preservatives, herbicides, pesticides (if any), and chemicals in solid or liquid form, is necessary. Every effort should be made to minimize water use during cleaning of working areas and vehicles (e.g. adopting dry cleaning practices prior to water cleaning). In addition, oil-water separators and sand precipitators should be constructed at all workshops on-site in order to limit mixing with cleaning water. Spent motor oils should be collected in sealed containers and stored in workshops until a management plan is devised for recycling or disposal of used oils. It is also recommended to develop work instruction to ensure that these materials are handled correctly.

Concerns about woodchips falling into the water in the Port of Buchanan during ship loading are unlikely to have a significant impact on the sea ecosystem in the near term; however, as the company exports more regular shipments, such spillage could be of concern. This should be addressed through the use of a new, taller conveyor system that does not require an elevated platform of woodchips on which to operate. However, if the issue persists, even with the new system, large tarpaulins can be placed between the commercial quay in the Port of Buchanan and the ship in order to catch any stray woodchips.

7.5.3 Mitigating Impacts on Soil

The consideration of the mitigation measures proposed for preserving water quality at the workshop site has a direct impact on preserving the soil cover from any contamination.

7.5.4 Mitigating Impacts on Biodiversity

Protecting the ecosystems surrounding the main site facility is easily achieved by applying the water and air quality preservation measures discussed earlier in this section.

Further recommended mitigation measures to minimize or eliminate the impacts on the biodiversity of the area are presented below:

- All waste resulting from operational activities, more specifically chemicals and storage containers, or any other activity should be collected and disposed properly in an allocated disposal site such as a sanitary landfill, or an alternative disposal site. Disposal of chemical wastewater into swamps (if any) should be strictly prohibited;

- Prohibit direct discharge of wastewater into water bodies;
- Maintain cleanliness within the main site and port facilities (preventing spillovers, cleaning roads and ground, etc.);
- Appropriate landscaping of the plant grounds with planting of suitable trees, grass and flowers;
- Maintain a buffer zone around the site to minimize disturbance to animals;
- Minimize the outward light emissions at the facility; and
- Avoid any alteration of the physical and chemical components of the habitat surrounding the facility site.

7.5.5 Solid Waste Management

The general refuse from the administrative facility units, recyclables should be stored in dedicated areas within the facility until collection or transfer to appropriate areas and chemical/hazardous wastes should be properly contained and disposed.

The facility should accommodate for an adequate storage area (roofed, impermeable paving, proper drainage and ventilation) with a capacity of at least one nominal day throughput to ensure that wastes are not haphazardly stacked in case of system failure or peak throughputs. Figure 7-1 includes the location of the fuel tanks, the generator rooms, and lubricants storage facilities. Onsite is limited to 5000L fuel trucks. Oils are only taken to sites as required from the yard storage area. The storage locations as well as mobile fuel trucks are equipped with spill kits.

Storage takes place in separate areas that have impermeable floors, adequate ventilations, roofs to prevent rainfall from entering, and separated from flammable materials. The location of the storage site is situated away from main offices, and clinic (Figure 7-1), and wells used for the supply of drinking water. The location of the storage site should also take account of possible pollution risks from leaks and spillages.

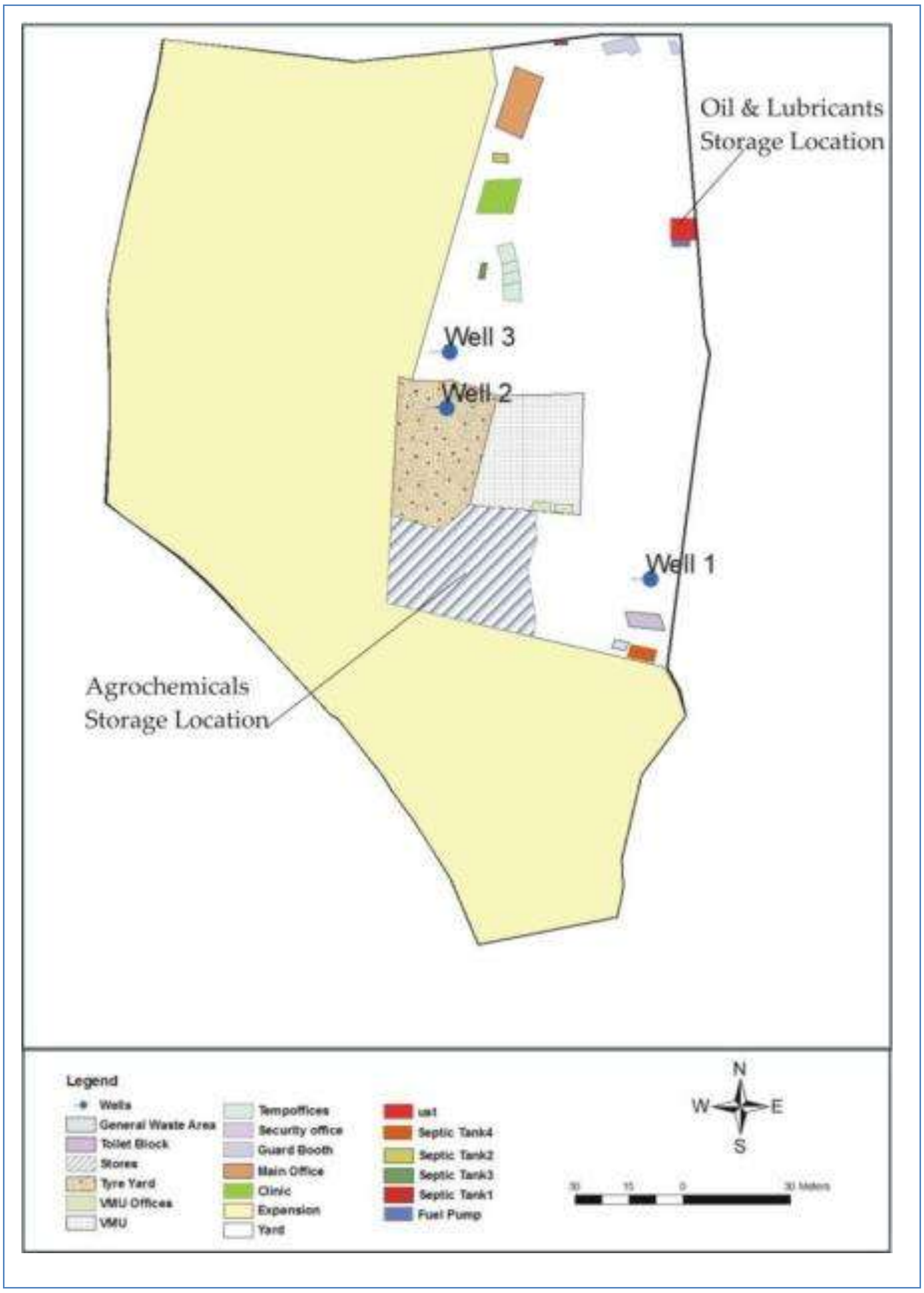


Figure 7-1: Storage location of lubricants, fuel and agrochemicals.

In addition, all chemical wastes should be clearly labeled in English, stored in corrosion resistant containers, and arranged so that incompatible materials are adequately separated. Fuel is securely stored in bowsers with on-site mobility. Litter within the facility should be cleaned continuously as well as on access roads.

4-5 trained personnel are assigned to the fuel and lubricant station. They look after and inspect the fuel and lubricants and ensure containers in good working order. They issue all requests, which detail the amount needed for a specific purpose and are approved by Managers. A 50 kg fire extinguisher and sand pit with shovels is located near to the fuel station. The assigned workers are trained in spill prevention techniques when distributing fuel and lubricants. The fuel pump and lubricant bay are locked and cannot be accessed by unauthorized personnel.

Agrochemical containers are managed and distributed by the Stores Manager. The Manager and Asst. Manager for the Agriculture Department approve the distribution of agrochemicals. Materials are kept in areas (Figure 7-1) with limited access that are equipped with secondary containment.

All containers of chemicals, oils and fuel are properly labeled.

Agrochemicals are usually supplied in containers that are kept locked and are resistant pressure and corrosive actions. All Hazmat items are stored in a locked container, out of direct sunlight with restricted access. Also if the item is a fluid it is stored in a contained storage area to minimize spillage risks.

Boundary fencing should be provided around the storage area to intercept litter scattering. The fence should consist of non-combustible wire screens, 3 m high, and with a mesh of 50 mm or less. In order to enhance the efficiency of the fence, trees may be planted along its perimeter. The structural design of fences, gates, and wickets should consider the most unfavorable case of crosswind, pressing larger pieces of waste and matter flying against the fencing line. Regular collection excursions should be conducted to collect litter from the screens around the perimeter of the site.

The burning of refuse during the operational phase on site should be strictly prohibited and penalized, except in the incinerator. General refuse is generated largely by food service activities on-site, and as such reusable rather than disposable dishware should be promoted if feasible.

The following should also be addressed on the main site:

- Designate suitable locations for storage of solid and hazardous management wastes generated during operational activities;
- Segregate different streams of hazardous wastes such as lube oils, spent solvents, skimmed oil from wash areas, etc;
- Provisions for spill containment to minimize the generation of hazardous wastes at the fuel storage tanks, diesel generators, air compressors, etc.;
- Segregated storage of hazardous waste streams such as tank bottoms and oily sludge, spent catalyst and packing media, used oil sludge – the size, type and secondary containment to be provided for such wastes to be conceptualized and a waste management facility should be earmarked on the plot.
- The waste management facility should be adequately designed to prevent contamination of storm water and groundwater – enclosed facility with impervious lining for pits;
- Provisions for spill containment to minimize the generation of hazardous wastes at truck loading and unloading areas, processing area and storage tanks;
- As no onsite pre -treatment or disposal of hazardous waste is envisioned, disposal of solid waste will be through an EPA certified contractor who will also dispose the collected solid waste on sites approved by the EPA. As facilities for off-site disposal of such wastes are limited in Liberia, the most sanitary options for waste disposal are through EPA certified sites, which are generally dump sites. Given these circumstances, BR Fuel will undertake to confirm with the EPA that the disposal sites have been approved for solid waste disposal. The frequency of solid waste collection is indicated in Appendix C which also shows the contract between BR Fuel and the solid

waste contractor (Libra Sanitation), collection point, ultimate disposal area, EPA letter of approval for ultimate disposal areas, letter of permit for Libra Sanitation by Buchanan City Corporation, and letter of recognition for Libra Sanitation from EPA.

- For non-hazardous wastes such as packaging material, empty containers, canteen/office wastes, sewage sludge, etc., segregated storage to be sized based on generation rate and disposal to a suitable licensed (by the EPA) landfill or recycling facility.
- Install monitoring wells in the up gradient and down gradient directions to sample/detect groundwater contamination; and
- Implement waste consignment notes indicating source/dates/quantities of generation along with periodic analyses of contents.
- Waste generated from equipment lubrication and repair has to be separated and stored in areas clearly designated and labeled for future disposal.
- Worker training should include instructions on how to dispose the different types of waste in separate containers emphasizing the need to protect the environment.

Chemical wastes generated during the operational phase include containers that were used for storage of chemical waste on-site, the chemical residue as well as contaminated material. These materials should be segregated and properly stored and disposed off on sites approved by the EPA or through solid waste contractor(s) that are also approved by the EPA. Storage should take place in separate areas that have impermeable floors, adequate ventilations, and roofs to prevent rainfall from entering. In addition, all chemical wastes should be clearly labeled in English, stored in corrosion resistant containers, and arranged so that incompatible materials are adequately separated. Every effort should be made to arrange for the recycling of any chemical waste generated on-site.

7.5.6 Mitigating Impacts of Noise

Noise for the site should not reach objectionable levels, and whenever possible, noisy operations within the facility premises should be enclosed. Since high noise levels at the main site are mainly associated with the power generation, it is recommended that noise prevention and mitigation measures should be applied in those buildings by enclosure or partial enclosure to reduce noise impacts at nearby receivers. In addition, it is very important to conduct periodic and proper maintenance as well as required repairs in order to prevent any malfunction in operations equipment that could cause high noise level.

Limiting the hours of operation for specific pieces of equipment or operation is also recommended, especially mobile sources operating through community areas. Operators of noisy equipment and noisy facilities must use earplugs or other war protection equipment such as ear muffs in order to reduce the impact of high noise levels on them. Permissible noise levels are listed in Table 7-2.

Table 7-2: Permissible Noise Exposure (OSHA).

Duration (hours per day)	*Sound Level (dbA) slow response*
8	90
6	92
4	95
3	97
2	100
1½	102
1	105
½	110
¼ or less	115

Other noise control methods and prevention that should be adopted for proper on-site practices to minimize noise emissions from the works during all times including but not limited to:

- Selection of equipment with low sound power level;
- On well-maintained mechanical equipment should be operated on-site;

- Equipment that may be intermittent in use should be shut down between work periods or should be throttled down to minimum;
- Installing suitable muffles on engine exhausts and compressor components;
- Improving the acoustic performance of constructed buildings, apply sound insulation if needed.

7.5.7 Mitigating Impacts on Human Health & Occupational Safety

Limiting the risk of injury at the sites of operation mainly lies in promoting awareness and good management practices among workers at the main site, especially when it comes to machine operation and chemicals handling, which has serious adverse impacts on those directly exposed to especially during storage, application and disposal. Recommended mitigation measures to be adopted at the main site include the following:

- Restrict unattended public access by proper fencing;
- Use adequate safety barrier and signs;
- Provision of guards on entrances to and exits from the site;
- Proper labeling storage of chemicals, oils and fuel;
- Promote safety education through training about the fundamentals of occupational health and safety procedures.
- Provide appropriate personal protective equipment such as gloves, masks, ear plugs, gas detectors, brightly colored working overalls equipped with light reflecting stripes, safety boots, safety helmets, etc.;
- Keep uniforms and PPE clean and in good conditions and replace them on a bi-annual basis during the operation process.
- Provide personal ID cards for all employees.
- Provide fire extinguishers at different locations of the operational site and develop and emergency response plan in case of fire explosion;
- Control leakages through continuous maintenance of equipment and storage containers;

- Frequent sweeping to control dust accumulation;
- Provision of electrical grounding, spark detection and prevention;
- Elimination of external ignition sources;
- Enhance ventilation in enclosed areas;
- Provide appropriate lighting during night-time works;
- Use ergonomic designs for working stations;
- Maintain working spaces and walking surfaces to prevent slips;
- Provide adequate loading and off-loading spaces especially near the fuel storage facilities; and
- Implementing of speed limits for vehicles entering and exiting the site

The adoption of appropriate and necessary protective measures can reduce the potential health risks associated with the construction and operation phases. Such measures will become of high significance not only to the facility workers but also to the site management due to the financial savings associated with the reduction of lost days of work and medical treatment for those injured during operation.

7.5.8 Mitigating Impacts on Landscape and Visual Amenity

The site is associated with the presence of heavy equipment and transport vehicles. While this may be deemed as an intrusion into the visual space in another situation, uniquely, due to Liberia's economic difficulties, the evidence of ongoing activity may actually be taken as a form of positive impact by signaling a rejuvenation of economic vitality in the region.

Facility construction and operation phases will minimize vegetation disturbance as much as possible while keeping in mind the need for safe movement of trucks and machinery without obstacles at the site. By selecting appropriate paint colors the facility can blend in with the surroundings, and thus form an integrated part of the landscape. Light pollution will be kept to a minimum by using hooded directed lighting, and limiting lighting at night to areas where it is strictly required.

The visual intrusion and landscape alternation at the facility construction and operational phases of the project can be minimized by adopting several mitigation steps outlined in Table 7-3.

Table 7-3: Mitigation for landscape and visual intrusions.

Mitigation Measures
Minimize vegetation cover removal/disturbance when possible
Ensure storage of waste and equipment in proper location
Select appropriate paint colors with neutral earth-tone colors that will blend with existing facilities and the background of existing vegetation for all project facilities including building, fencing, and signs
Minimize lighting at the facility towards outward emissions. Except as required by the security and worker safety requirements, night lighting will be hooded to direct illumination downward and inward toward the areas to be illuminated in order to minimize nighttimes light and glare, backscatter to the nighttimes sky, and visibility of lighting to nearby roads and residence

7.5.9 Socio-Economic

Mitigation measures must be taken into consideration to ensure the dissemination of the positive socio-economic impacts of the project on the operation phases. The local community in the immediate vicinity of the facility should be given priority in terms of providing job opportunities, especially to individuals or families that may be negatively affected by the project development. As such, economic incentives should be provided to the local community by adopting policies to recruit locally and to hire local contractors as far as possible. An on-the-job training program should be implemented for those that do not have adequate skills. Provision of packages of information to workers moving into the area should help them to integrate into the local community more quickly.

Good management practice in terms of sensitive design, control, and monitoring of the site will be the primary means of ensuring that stress and concern about potential problems are mitigated. The instigation of a formal system which responds in a timely fashion to complaints related to all activities on site or off-site, is an important means of building confidence in the operations and management. Publication of data and reports on environmental performance can also be important in terms of providing direct evidence of commitment to effective management. A liaison between the BR Fuel and community should be established, whereby people can ask questions and voice their complaints, if any. In addition, systematic environmental awareness campaigns may be conducted by BR Fuel to introduce the public at large to the benefits of and the need for sustainable biomass.

Other key issues for socio-economic mitigation measures include:

- Consultations with the affected communities to inform them of any new projects where this will serve to provide sufficient project information, understand the concerns/grievances, manage their expectations, and relay information on how suitable mitigation measures are implemented to reduce residual and cumulative impacts.
- Continuously recognizing the community expectations regarding BR Fuel (in terms of contributing to local economy through infrastructure, welfare and employment generation
- In order to actively engage with the community, key staff with specific responsibilities and accountabilities needs to be assigned, such as CSR Manager, Environment Manager, Community Relations Officer (CRO), and support team.
- Owing to the quantities and characteristics of materials and goods to be transported to and from the project site by land and sea, a comprehensive Transport Management Plan (TMP) should be implemented by the Transport Manager.
- The project’s operational activities might lead to the influx of a number of expatriate people into the area for direct employment in the project as well as for indirect employment with service providing companies and for other

business activities, which will have potential impacts on the existing communities. Therefore, it is recommended that BR Fuel provide an adequate induction and introduction to Liberia and to the community for the expats they employ directly to minimize any potential conflicts.

BR Fuel will continue to work to implement human rights and labor practices in line with Liberian Labor Law and international standards, particularly with regard to non-discrimination, freedom of association and child labor.

7.5.10 Mitigating Impacts on Traffic & Road Network

During operations, environmental impacts associated with transport of raw material, final products, and other aspects necessary for the operation of the entire facility, will be controlled by good vehicle maintenance and housekeeping, adherence to permitted routes, observation of highway restrictions and maintaining responsible driving practices. Traffic control measures should be applied to site operations from the point of collection to the point of return. As such, one-way traffic networks within the site should be favored whenever deemed applicable. The recognition of highway speed restrictions and agreed/approved routing will be incumbent on all drivers' irrespective of local practices. The recognition of inter-site traffic procedures will also be incumbent on all drivers and the operator. Failure to observe the rulings in the area will be an uncompromising disciplinary matter. Control should be exercised over the number of vehicles permitted into the facility area at any one time. Traffic mitigation measures fall into two categories namely, those designed to control traffic entering and leaving the site and those designed to mitigate impacts around the site area. Table 7-4 provides examples for each category.

Table 7-4: Traffic control measures.

Location of proposed measures	*Typical examples of traffic mitigation measures*
On-site	• Entrance and exit located so as to provide maximum turning space and sight lines. • Vehicle movement in the direction of predominant traffic flow. • Adequate off-loading and loading space to ensure vehicles can wait on-site. • Adequate off-street parking for employees. • One-way traffic within the site to prevent obstruction to vehicles entering and leaving. • Speed restrictions on vehicles entering and leaving the site.
Off-site	• Traffic routing to avoid residential and congested areas • Use of locally designated traffic routes.

7.5.11 Mitigating Impacts on Cultural Heritage

During the site preparation phase and operation, chance-find procedures should be adopted. In the event where archaeological remains are found, operational activities should be suspended and notice should be given to concerned authorities.

It is important to note here the cemetery close to the workshop site. BR Fuel shall ensure that all staff will be informed of restricting any kind of work or disposal in the close vicinity of the cemetery. BR Fuel will respect and maintain the integrity of that cemetery by creating a buffer zone and consulting with the families of dead in case any kind of impacts are anticipated on those graves from BR Fuel's site activities.

7.6 Summary of Mitigations at The Workshop Site

Table 7-5: Summary of on-site mitigation measures.

Impact	*Recommended mitigation measures*
Air quality	• Watering of surfaces • Road surface grading • Maintain good housekeeping practices • Set speed limits of 10 km/hr on-site and off-site and cover trucks when necessary • Perform regular maintenance of vehicles • Ensure that vehicles are turned off when not in use • Ensure proper availability of firefighting system • Prohibit littering on-site • Prohibit any kind of smoke or fire on-site • Ensure that flammable chemicals are properly stored
Water quality	• Prevent oil spills and ensure proper containment • Divert oil/mixtures to sand/silt made channels • Ensure that the septic tank is emptied whenever full • Ensure that washing water from vehicles in drained in a sand/silt trap or in a constructed wetland for biological treatment • Ensure proper storage of oil and lubricants
Organic loading from rain action on wood piles at the port	• Prevent contact between rain and wood piles by building a high storage facility
Soil cover	• Ensure that mitigation measures for the preservation of water resources is properly done
Biodiversity	• Ensure proper management of solid and liquid wastes • Promote plantation of trees around the site • Prohibit any action that leads to the destruction of the ecological system • Prevent any hunting activities
Solid waste management	• Ensure proper sorting and labeling of different waste materials according to their nature • Fence the site border to prevent any flying material to deposit in nature • Prohibit any open fires • Provide proper containment of stored liquids and avoid any leakages • Train and instruct workers on proper segregation and management of different waste materials
Noise	• Reduce noise emissions by enclosing any continuous source of noise e.g. generator • Perform periodic maintenance of equipment • Limit vehicle circulation near residents to daily working hours • Install suppression equipment
Occupational health and safety	• Avoid public access by proper fencing and guarding • Use adequate signs and safety barrier • Provide proper labeling of chemical storages • Provide personal with proper personal protection equipment

Impact	*Recommended mitigation measures*
	• Train workers on emergency plans • Control leakages from equipment and storages • Provide appropriate lighting and ventilation in closed areas • Keep working spaces free from spills • Delineate spaces for loading and off-loading activities • Implement speed limits on-site
Landscape	• Promote trees plantation • Ensure proper management of solid and liquid waste
Socio-economic	• Promote jobs for local communities • Publicize data on environmental performances • Perform public consultations regarding new project
Traffic	• Provide drivers with a transport management plan (speed limits, traffic signs and directions of traffic routing, etc..)

7.7 Mitigation plan for off-site activities

The main impacts from the project have been identified in Section 2. The assessment of impacts and their significance leads to the preparation of a mitigation plan in order to reduce the level of impacts on the living surroundings and the ecological system. This chapter presents a mitigation plan that has to be adopted by the management of BR Fuel for off-site activities. The mitigation plan presents mitigation actions to be taken into consideration within the project implementation period and at the workshop site to ensure environmental practices.

Given that environmental and social impacts will be site-specific, depending on the period during which harvesting is taking place, the slope of the land and soil type, the proximity of water bodies, other physical features of the area, and the presence of nearby communities or cultural sites, this management plan serves as a framework of general principles to be followed to address potential impacts. While some practices will be relevant to all sites, others will be site specific and will be defined in the site-specific harvesting management plans.

7.7.1 Mitigating Impacts of Air Emissions

Based on the impacts section, the project will contribute to the introduction of gaseous emissions from the use of felling machinery, as well as increased transportation off-site. Transportation has its impact on several receptors: the ecological surrounding of the site being cleared, the ecological and social surrounding of the area being crossed by the daily fleet of trucks, communities along the road side and the workers on site. Emissions released from vehicles, external engines and machinery are composed of CO, NO, PM, SO_2 and HC.

These impacts can be mitigated as follows:

- Gaseous emissions from vehicles depend on the fuel combustion conditions. In order to achieve proper combustion by the respective engine, proper maintenance and checkup has to be carried out for each vehicle and machine.
- Full maintenance has to be done twice per year and routine check-ups should be executed to ensure proper use of any technical part within its allowed life span.
- Trucks should circulate at low speed and on the right side of the roads to avoid traffic and nuisance from their exhaust to the transportation system.
- Trucks should not be left idling when not in use.
- Explore options for using biofuels to power vehicles and machines.

While some dust is generated from felling and sawing trees, most dust particles result from the chipping of rubber trees. These particles are mainly of coarse size and may have an impact on the ecological and social surrounding. Given the fact that BR Fuel clears the land in preparation for replanting, most of the dust or wood particles will fall on soil, in many cases acting as mulch. Thus, the impact of the dust emissions will be highest on human health.

The following mitigation measures help the reduction of dust impacts:

- Dust particles are directly affecting the workers on-site. Workers have to wear protective clothes with long sleeve to prevent skin irritations, goggles to reduce direct contact to the eyes and a face mask.
- Notify all nearby communities before operations start and locate chipper sites away from community centers.

Once BR Fuel employs the new methodology of chipping trees at stationary chippers at the port facility or the power plant, the impact of wood dust will be isolated to one or two chipping sites, both of which are isolated from nearby communities. At the stationary chipping sites, the wood dust will likely fall on concrete and can be collected for use as mulch. The mitigation measures defined above will also apply to the stationary chipping site.

Dust may also be generated as an increased number of trucks travel along laterite roads in the dry season. This dust may impact communities and vegetation along the roadway. The impact of this dust can be minimized by reducing the speed at which drivers drive along laterite roads, particularly when they pass by communities, proper road maintenance, and watering of roads as required.

Other impacts on air quality are mainly associated with global impacts of CO2 emissions due to the removal of trees. However, this is temporal and is recovered due to the replanting of rubber trees during the planting season (rainy season) following felling, at a ratio of at least 1:1.

7.7.2 Mitigation of Impacts on Water Quality

Water bodies are of main concern as they provide habitat to flora and fauna species. They also provide water for irrigation, drinking and other domestic uses. Various forms of water bodies could be found among the different sites such as wetlands, lakes, streams and springs and has to be preserved from intruding activities that could influence their physical, chemical and biological characteristics.

Land clearance will increase the effect of soil erosion. Sediments will be carried by the water action and drained along the slopes. The discharge of these sediments in natural bodies will increase turbidity, water level and decrease the oxygen level.

As a mitigation measure to prevent sediment loads into the water bodies it is recommended to:

- Build a natural embankment around the water bodies that are susceptible to receive sediments from sloped terrain in their close vicinity.
- Avoid dumping of natural sediments or any debris left after the cutting of trees and the land preparation into nearby water bodies.
- Replant as quickly as possible after felling, particularly if felling takes place during the rainy season.

Another impact on water quality is the use of fertilizer, herbicides and pesticides. BR Fuel uses only minimal amounts of fertilizers applied directly to the area in which the seedling is planted. Similarly it uses pesticides sparingly in the nursery and on rubber farms in targeted cases. In order to reduce impact on surface and ground water the following actions shall be considered:

- Farmers should be trained to apply biological fertilizers from animal and trees debris in the form of compost.
- Chemical fertilizers should be applied in minimal doses, in a targeted manner, and during dry weathers where possible (planting season is in the rainy season).
- Nitrogen-fixing cover crops should be used to minimize the need for fertilizers.
- Ash from the power plant, root grindings and other wood waste should be used as mulch, as a means of improving soil stability and reducing the need for fertilizer.

The water quality of water bodies can also be deteriorated by the direct discharge of fuel, oil and chemical fluids. In order to preserve natural water sources it is required to:

- Stores used oil in containers and find an oil refinery or an industry that would be interested in reprocessing them.
- Staff should be trained in proper handling techniques to minimize oil spills.

- In case of oil spills, oil should be prevented from reaching water bodies, agricultural lands and other natural resources by spraying sand and absorptive material.

Riparian Management Zones (RMZs) or buffer zones also help to reduce run off of sediment or fertilizers into water bodies. Buchanan management has committed to preserving a buffer zone of at least 15 meters from both sides of the water body. This zone plays an important role in maintaining the local ecosystem and retaining sediments from discharging in the water system. Pre-harvest identification of water bodies will be followed by delineation of the fifteen meter riparian management zone on each side of the watercourse. This is to be left undisturbed to protect waterways. The measurement will be made from each side of a stream, measured from the top of the bank or the ordinary high water mark. The minimum zone width will also be adjusted for slope as indicated in Table 7-6.

Marking will be undertaken using color markers on trees at ten meter intervals to delineate the borders of the Riparian Management Zone (RMZ). Haul roads will be located outside RMZ's. Where a road must cross a stream, it will be stabilized and will cross at right angles. Energy dissipaters (rocks) will be used at inlets and outlets of cross-drainage culverts located underneath roads approaching a stream. Where needed, native grasses will be planted to strengthen the RMZ in zone areas judged to have a poor amount of vegetative cover and where accidental damage to the RMZ vegetation has occurred due to site operations.

Table 7-6: Minimum Riparian Management Zone Width Adjusted for Slope.

Slope of Land Above Water Body or Stream (%)	*Minimum Width of Riparian Management Zone (meter)*
0-10	30
10-20	35
20-30	41
30-40	47
40-50	53
50 +	Harvesting is not advised due to the high potential for erosion and sediment transport

Prior to initiation of harvesting all heavy machine operators and other personnel involved in site operations will be taken on a site tour by the site manager where identification of the delineated Riparian Zone will be undertaken. This will be followed by regular inspection for infractions during operations. Any debris found during inspection will be cleared and any damage will be repaired by planting with native grasses or fast growing native tree species.

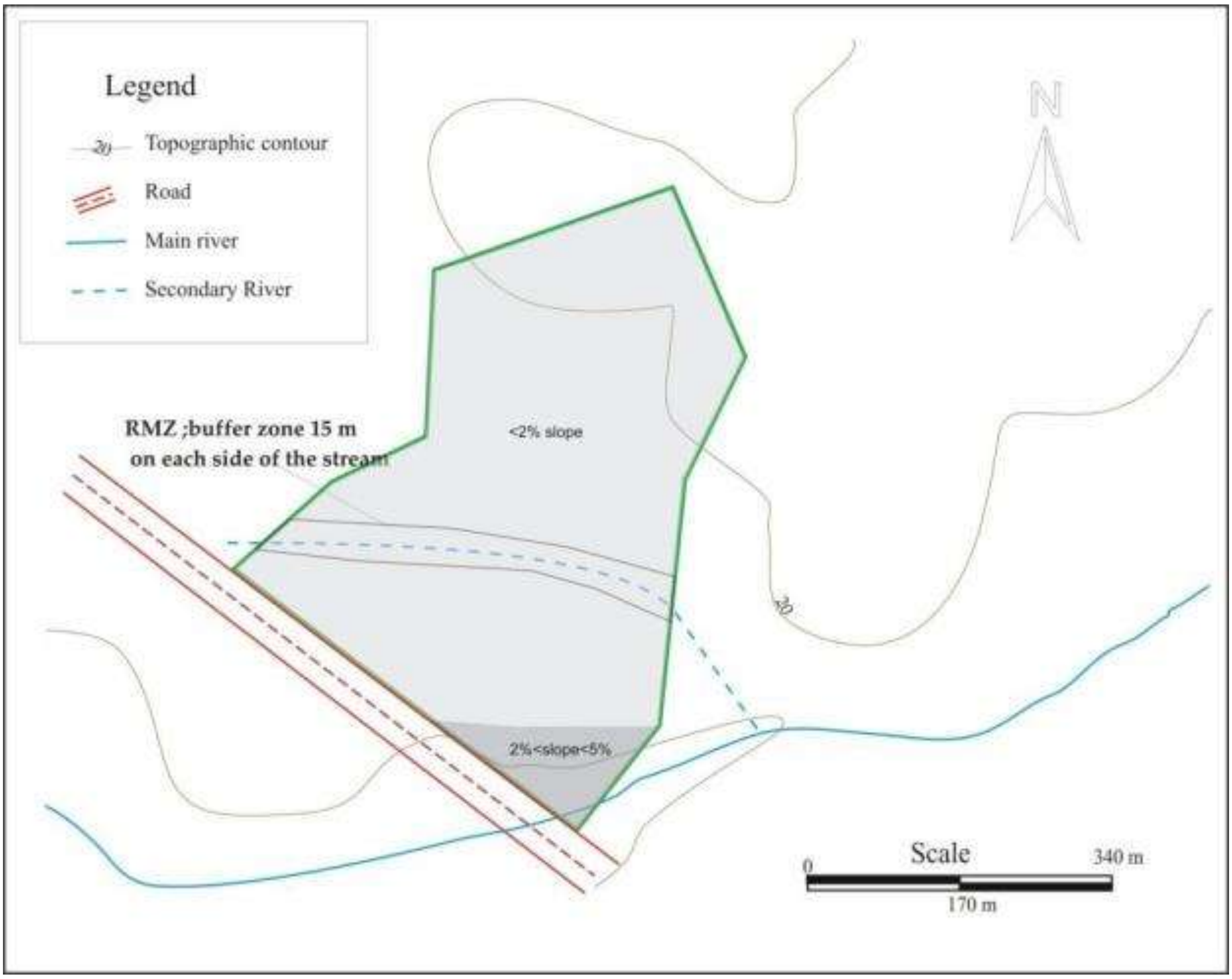


Figure 7-2: Riparian Management Zone, 15 meters on each side of the stream.

Buchanan mainly plans to rely on rain water for the irrigation of the newly prepared lands. It is important to preserve water resources by controlling water consumption by the help of water meters and the regulating the water demand. Workers should be aware of regulating water level according to the irrigation requirements. Limited irrigation is only required at the nursery during the dry season. Water is sourced from a nearby stream. It is recommended that rain water collection basins be built to use for irrigation purposes.

Local sanitation facilities for domestic use at off-site locations can also be mitigated to reduce impacts on nearby water bodies. Portable lavatories can be installed on the site with the wastewater tank being emptied into the main network or at the closest wastewater treatment plant, or simple drop toilets can be built. In case there is no close treatment plant, a small build-in treatment plant can be installed.

7.7.3 Mitigation of Impacts on Soil Cover

BR Fuel operates on more than one site, each of which has specific conditions and environmental characteristics. A description of measures for erosion control may significantly differ from one area to another since there are few factors, including field slope, stream size, soil type, crop characteristics, field length and duration of operation that influence soil erosion.

The main impact with the action of cutting the trees is the resulting arid land open to soil erosion by rain and wind. This activity results in affecting the soil properties, loss of nutrients and loss of habitat. These impacts to a large extent can be mitigated by the introduction of the following:

- Effective drainage system for runoff and transported sediments;
- Culverts; and
- Zero-removal of vegetation around water courses, namely stream, creeks, rivers.

The mitigation of the degree of soil compaction from operating machines is possible, but depends on the description of different ecologies (upland, lowland), seasonality of the operations, and the type of machines being used. The construction of outlet drainages and mini-culverts to control the volume and velocity of runoff from spilling over to adjacent roads or major footpaths is a recommended mitigation measures since runoff with steeper sloping profile increases flow velocity and soil erosion. In general, control techniques for minimizing soil quality degradation involve applying plant residues to exposed soil surfaces to reduce soil erosion. These activities which affect the soil properties including loss of macro/micro plant nutrients and loss of habitat are minimized by:

- Even spreading of mulch material and compost over the cleared lands that help in giving stability and nutrients to the soil cover. The nutrients generated from the decomposition of tree remnant residues will have the added benefit of decreasing the amount of artificial fertilizers later needed for replanting operations;
- Introduction of fast growing vegetation to reduce the loss of soil cover and provide a better filtration of rain water. These vegetations maintain the soil cover with their roots and should be distributed at the midpoint of every two rubber tree seedlings. The plantation aims at rehabilitating the land by improving the soil cover, limiting soil erosion and improving biodiversity and the landscape aesthetics;
- Conservation tillage. This simply means to leave a portion of vegetation in the ground, instead of stripping everything away. In the case of BR Fuel operations off-site, it could mean leaving a band of grass around the site, so that the soil stays within the boundaries of the site. BR Fuel’s ability to do this will depend heavily on the clearing requirements of the farmer;
- Construction of shallow ditches with a vegetative cover that collect rainwater from steep terrains and reduce runoff on the internal roads;
- Regular removal of sediments deposited in ditches and drains and, whenever possible, return them to the place from which they were eroded;
- Construction of water and sediment control basins that also help in reducing runoff;
- Designing roadside/shallow ditches with a vegetative cover that collect rainwater from steep terrains and reduce runoff on the internal roads;

- Introduction of furrow stream channel as cutback method on steeper slopes to reduce erosion and sediment losses;
- Maintenance of vegetative filter strip, including grasses, dense-stand crop along the bank of the cultivated area to reduce erosion and filter sediments;
- Introduction of control techniques such as straw with asphalt (blacktop) tack, straw with a net/mat, straw alone, erosion control mat, wood chips or rock, and hydromulch for reduction in sediment production. Importantly, the curlex mulch is more effective than filter windrow, but more expensive to apply in sensitive areas because they cannot be obtained from local resources. However, the combination of curlex mulch and filter windrows provides about 99 percent sediment reduction;
- The use of paved mats, plastic, jute, or combinations of artificial and natural materials also prevents soil erosion. These mats reduce water velocity from about 56 to 78 percent and protect seedling until the vegetation becomes firmly rooted.

Mulch will be applied in lines that are approximately 6 meters apart and perpendicular to the grade of the terrain. Mulch from roots and remnant vegetation will be applied at a rate of 6 tones/acre in a continuous blanket after removal of any stones or large debris. The mulch will be uniformly spread to allow sunlight and air penetration while conserving soil and moisture. The mulch will be re-inspected at biweekly to monthly intervals and reapplied when judged to be eroded.

Cover crop planting will begin during the planting season (rainy season) directly following felling (generally no more than 6 months after felling) to rehabilitate the land, decrease risk of erosion and potentially provide an economic crop for the landowner while the newly planted rubber trees are still growing. The crops include fast growing, nitrogen fixing legumes and beans, which would provide an added source of nutrient enrichment to the soil. Other crop options include natural grasses, yams, groundnuts, and cassava. Conservation tillage that leaves part of the vegetation in the ground, rather than stripping it all away at harvest will in addition decrease the rates of soil erosion.

The soil cover will also be deteriorated by the mismanagement of fertilizers, pesticides and agricultural chemicals applied during the plantation phase. The mitigation of this impact has been raised in the mitigation of water quality. While fertilizer application should be kept to a minimum, it must also be sufficient to replace the nutrients lost from the soil due to the impact of removal and use of the majority of the rubber tree. While this loss can be offset by the use of mulch and ash, it must be monitored over time so as to ensure adequate levels of fertilizer are being used to support the growth of the rubber trees and the natural vegetation.

The various activities of transportation and circulation around the site by the different vehicles will have an impact the soil and compact the top cover. As a mitigation measure, it is recommended to turn the soil cover after having cleared a parcel of land. The turning of the soil helps in homogenizing the soil cover and provides a better pathway for the oxygen. At a minimum, machines and vehicles should be kept to a single track where possible, so as to minimize compaction. It is anticipated that the impact of compaction will not be as great when BR Fuel employs the feller buncher/logging model requiring fewer machines and a smaller docking station on each site.

7.7.4 Stormwater Control

The rainfall ranges in Liberia, which is typical of the project area, are from 2000 to 4000 mm/year with an average of 2,372.

The primary effort in stormwater control will be to minimize permanent impact through mulching and rapid revegitation of the site post harvest using mulching and cropping procedures and plans. The institution of soil erosion monitoring and mitigation procedures and water drainage and sediment control will also optimize stormwater control.

Limiting contiguous harvest improves drainage, by limiting soil compaction and thus minimizing areas impervious to water. Soil damage is further minimized by minimizing travel distances, equipment used (under the logging methodology) and land covered. Furthermore, soil conservation is maximized by concentrating harvesting operations in the dry season (October to April) as far as possible, and thus operating project activities on dry rather than wet ground.

7.7.4.1 Ditch-line Construction Plans: Sizing, Spacing, Distances from Cutting Areas

Drainage Ditches will be used to pond surface water from small upland areas (less than 20 hectares) for short periods of time (less than 24 hours). In particular, they will be on sites with sandy clay loam, silty clay loam, clay loam, fine loamy sand, and will be located along sloping terrains (greater than 10%) and marshy concentrated areas of farms where erosion continues to evolve. The ditches will be located along contours and down sloping sections to convey runoff to designated areas. Distance between ditches depends on the contour of the land, slope and soil erosion susceptibility, as well as observed susceptibility of the land; however, for areas with a low risk of erosion (soil erosion susceptibility of 3-4 and a slope of less than 20%) ditches will generally be between 60-100 feet apart. This distance will decrease to around 30 feet as soil susceptibility and slope increase. The design adopted in this study is based on a ditch spacing of 30 m for a slope that is mostly gentle (less than 5%). Figure 7-3 illustrates the grid system for the study area. It mainly follows the topography and drains the water towards the drainage lines, utilizing, where possible, natural drainage features. Most of the ditches lead to the natural drainage lines, as using already existing drainages is better than implementing new drainage and altering the normal system.

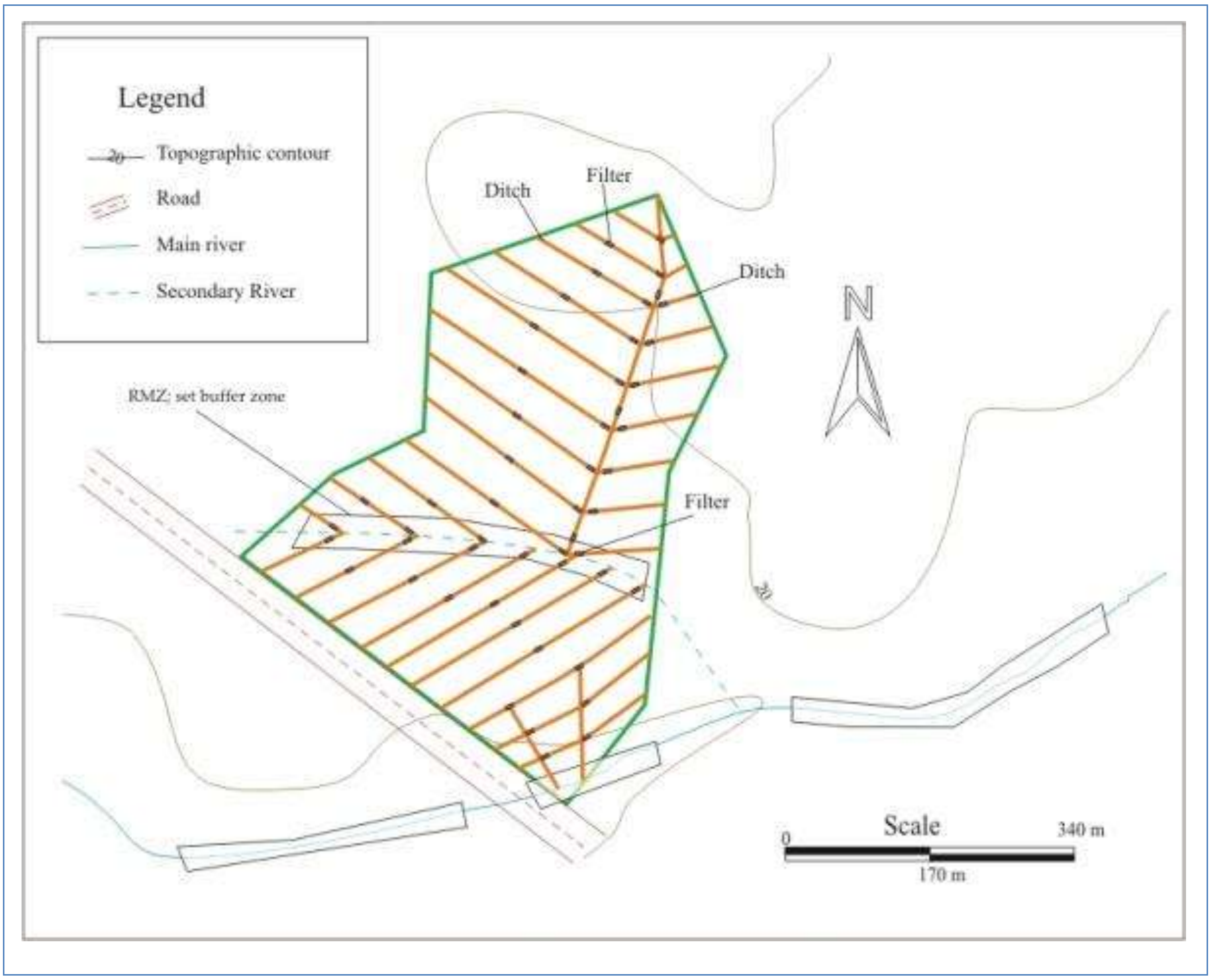


Figure 7-3: Drainage ditch network that shows the grid required for minimizing the soil erosion. The location of natural and vegetation filters are also shown on the map.

Despite the slope inclination at the site which is relatively gentle with a ten degree inclination occurring towards the stream, the soil type at the site is highly susceptible to erosion requiring ditches set at 100 feet apart and the planting of native grasses along the edges of the drainage ditches for increased stability. Ditches will be created in a grid fashion and are on average v-shaped trenches about 0.5 m wide and 0.3 m deep, with a shallow cross section, and are cleaned out every 2 weeks to 1 month depending on need. Drainage ditches should be maintained until such time as soil stability is regained.

7.7.5 Mitigation of Impacts on Biodiversity

Rubber plantations are not known to be biodiversity rich and are thus generally considered of low conservation value. Although the main activity of cutting the rubber trees does have an impact on the biological environment, this will be occurring on rubber farms, which are designed as agricultural plantations to be rotated on a 30 year basis. Hence the main receptors to be considered will be any local species that rely on those trees as their main habitat.

Mitigation measures have to be considered to reduce stresses on the ecological system:

- Identification and protection of areas of importance to biodiversity or to the local ecosystem (e.g. water bodies with Riparian Management Zones, other areas of high conservation value)
- The re-vegetation of disturbed soils will provide habitat to floral species. Soil sediments can also be reused in the rehabilitation of topsoil cover.
- As much as possible, the preservation of any type of animals found within the rubber farms should be done in order to have minimal harm to local species.
- Wetlands have to be preserved from any dumping or dredging as they are habitat to a wide variety of floral and faunal species.
- In large farm concessions, maintenance of landscape connectivity to decrease habitat fragmentation (e.g. using tree corridors, wetland corridors, and by leaving patches of ground cover) will allow species to move through the landscape to meet their habitat needs
- Harvest planning will ensure that harvest does not coincide with nesting or breeding seasons of local wildlife identified to be present on the rubber farms.

7.7.6 Mitigation of Impacts from Noise

Noise emissions are associated with trucks and vehicles circulating off-site and along the roads leading to the rubber farms. The main receptors are residential zones within the direct vicinity of the transportation trajectory. Various heavy machinery and equipment working off-site contribute to noise emissions, particularly the wood chippers. Noise emissions have an impact along the whole project as they are emitted along the different phases of the project. The direct receptors of noise emissions are the workers off-site.

The following mitigation measures help in reducing impact from noise:

- Nearby communities shall be notified in advance of felling operations taking place in their area.
- Cutting and sawing activities shall not be performed at early hours of the morning and later hours of the evening when the farm is close to a village unless for short periods of time.
- It is recommended to select equipment with noise suppression when ordering any new equipment
- Workers performing the various activities should be wearing ear protection devices to reduce the likelihood of hearing impairment among the workers.

It is anticipated that the noise impact of harvesting operations will decrease significantly as BR Fuel moves towards the use of stationary chippers. The chippers and grinders will be located at the port facility and the power plant, which are both isolated from nearby communities.

7.7.7 Mitigation of Impacts on Landuse

The project off-site could have indirect impacts on nearby agricultural lands. This could occur from oil spills, potential use of fertilizers and pesticides and soil erosion. Terrains with steep slopes could negatively affect downstream agricultural lands by runoff and sediment loads. Efforts should be made to carry out the proposed mitigation measures for air quality, water quality and soil cover that will minimize impacts on the agricultural lands within the project vicinity.

In addition, it is important to preserve any natural resources, old ruins, cemeteries and any public and cultural resource from the project's impacts. Activities should be prohibited if rubber trees are within those sites and a buffer zone of 15 m is to be set around such sites. The exact size of the buffer zone can be defined in consultation with relevant community members.

BR Fuel will continue to leave a portion of the roots and branches of the rubber trees for charcoal producers in regions in which it works in order to minimize the potential for charcoal producers to use wood from natural forest areas. Furthermore, BR Fuel will continue to work on existing plantations to avoid any potential impact on the encroachment of the rubber farms onto existing primary forest.

7.7.8 Mitigation of Socio-Economic Impacts

The project will result in positive impact to the local society. Jobs will be created, farmers' land will be of higher value, farmers will be integrated in plantation activities and national economic revenues will increase. In order to minimize the potential for suppliers to be involved in hazardous child labor or other negative social or environmental practices, BR Fuel should integrate social and environmental covenants in their supplier contracts and develop a supplier code of conduct. BR Fuel should appropriately train its employees to recognize and report any infractions and develop dialogue with suppliers on such issues. In the case of child labor, which is prohibited by Liberian Labor Law, as well as BR Fuel's internal policies, BR Fuel aims to work with other stakeholders in the industry to better understand the extent and drivers of child labor and devise any potential solutions required. It also plans to integrate capacity building on social and environmental issues into its partnership programs on smallholder engagement, such as the Todee Initiative.

A written statement in the CSR Policy will include commitment to adherence to the prohibition of child labor according to ***Minimum Age Convention, 1973 (No. 138)*** which sets the general minimum age for admission to employment or work at 15 years (13 for light work) and the minimum age for hazardous work at 18 (16 under certain strict conditions).

Next to that, the project will create nuisance to local comfort from dust and noise emissions. The execution of the previously mentioned mitigation measures will help in reducing negative impacts on residential areas within the project vicinity.

Mitigation measures recommended for the on-site operations are also applicable to the off-site operations.

7.7.9 Mitigation of Occupational Health and Safety

The project involves a number of personnel to achieve the different activities. This means that the workers off-site are directly affected by any resulting hazard. In order to avoid risks to human health the following mitigation measures have to be integrated within the management plan:

- Workers have to be provided with proper protective fittings; protective clothing (long sleeves), helmets, resistant gloves, air purifying masks, safety glasses, ear protection (ear muffs, ear plugs) as required for their specific tasks.
- Provide proper signs for transportation management and set speed limits for trucks in circulation off-site and on the national roads leading to the farms to avoid accidents and traffic.
- Identify possible detours for trucks so as to avoid high density areas.
- Provide proper lighting when needed off-site.
- Proper use of Signs and strips at any spill or hazard location, barrier tape to prevent falling in ditches and slippery areas.
- Delineate natural resources or buffer zone boundaries with strips to avoid any activity that could pose a threat to close resources.
- Provide first aid kits off-site.
- Provide fire extinguishers off-site.
- Provide workers with spill kits and absorptive material.

- Maintain fuel and chemicals in safe places and prohibit any smoke or fire to ignite off-site. Have clearly defined smoking areas.
- Train workers on first aid, fire fighting, and proper measures in cases of hazards.
- Provide sheets with emergency numbers; hospitals, fire fighting and police
- Train vehicle drivers and workers on proper functioning and maintenance of each machine used off-site.
- Delineate the area to be cleared with tape or other means and keep free spaces for proper management and transportation of trees and produced wood chips.
- Delineate areas for loading of woodchips and logs and identify potentially hazardous areas with signage at the port site.
- Provide any vaccine, pre-medication or preventative practices to minimize diseases transmitted by pests.
- Train workers on the proper application of fertilizers and pesticide and introduce them to the use of biological farming practices when replanting the lands.

7.7.10 Mitigation of Impacts on Landscape and Visual Amenity

The project aims at clearing parcels of rubber trees and will have a negative impact on the landscape. The proposed mitigation measures of planting cover crops or intercropping vegetation within the farms will contribute in decreasing the impact on the visual aspect. BR Fuel may also wish to post signs near harvesting sites indicating that replanting will take place. In addition, proper sanitation off-site gives a better visual impression to locals circulating around the site.

7.7.11 Mitigation of Sanitation

The project will result in daily generation of domestic waste and wastewater from work off-site. These types of waste would have a direct impact at the point of discharge in nature. As a mitigation measure it is required to:

- Prevent littering of domestic waste or any empty container from used chemicals.
- Solid waste has to be collected in separate containers as domestic, chemical and spare parts and transported on-site and managed with the waste collected at the workshop.
- Workers have to be able to identify waste material and dispose of them in the right location.
- Workers should be provided with the Material Safety Data Sheet in order to dispose hazardous material in a proper way.
- Green waste has to be left on the harvesting sites as it will naturally degrade and contribute to enhancing the soil cover.
- Physical, chemical and biological tests have to be performed for any newly found resource used to supply drinking water to the workers off-site.

7.7.11.1 Pit Latrines

Portable or pit latrines are required to provide sanitation and hygiene services to the workers. Pit latrines off-site should be placed in a convenient location, at least at a minimum safety distance of at least 200m away from streams, wells located or any other water body. Pit latrine will be placed downwind of the site and nearby households. The doorway of the pit latrine will also face the wind. The water and sanitation team will be responsible for the cleaning of the pit latrines.

Cleaning timing and procedures:

- At least twice a day and when dirty by applying regular housekeeping procedures.

- The holes will be covered always when the latrine is not being used.
- The emptying of pits containing fresh excreta presents significant problems due to active pathogens present in the sludge. Therefore, it is advisable to dig another pit for a new latrine. The original pit can be covered and the buried excreta will not cause any health risk. After 2 years, the excreta will no longer pose any health problems and the pit can be emptied and reused, with the excreta used as a fertilizer.
- Manual pit emptying should be avoided, or carried out with adequate protection for workers, to minimize risk of contamination with pathogens from the fresh faeces.

7.7.12 Mitigation of Impacts on Traffic and Road network

The project will require transportation of vehicles from the port facility to the rubber farms and vice versa. Trucks will transport wood chips to the port site. These transportation activities will require the use of the main roads and internal roads within the farm sites.

In order to maintain the national roads, it is recommended that trucks circulate at low speed, cover any material transported and do not exceed the allowed weight that every vehicle can transport.

In high population density areas, such as Buchanan, BR Fuel should seek out potential bypasses for its trucks, so as to minimize impact on the local population.

BR Fuel is aiming at rehabilitating internal roads and should ensure that no spills or hazardous liquids and other debris are left off-site after public works are undertaken. When rehabilitating these roads, BR Fuel should always obtain any additional laterite required from areas designated by local authorities, Public Works or the EPA for that specific purpose.

7.7.13 Summary of Off-Site Mitigation Measures

The mitigation plan has described the different mitigation measures for each parameter that could be potentially affected from the activities that would be executed within the project. The mitigation plan has to be adopted by the management of Buchanan and transferred to the staff to ensure proper environmental practices. The mitigation measures for the off-site project are summarized in Table 7-7.

Table 7-7: Summary of off-site mitigation measures.

Potential negative impact	*Recommended mitigation measures*
	Air Quality
Gaseous emissions from transportation	• Ensure proper maintenance of engines and any machine used off-site • Set low speed limits for trucks • Do not exceed a tool's life expectancy
Dust emissions from cutting, sawing and chipping of wood	• Require workers to use personal protective equipment during operations • Introduce the use of a dust collector directly after operations take place
Increase in green house effect	• Introduce the plantation of windbreakers at the borders of the cleared areas as required • Replant rubber trees at ratio 1:1.
	Water Quality
Sediment loading into downstream water bodies	• Build natural embankment at water bodies as required • Avoid littering or discharge of any debris into nearby water bodies
Water quality degradation by potential use of pesticides	• Raise farmer awareness on the application of biological fertilizers • Use chemical fertilizers in low doses and during dry periods
Water quality deterioration from chemical spills	• Store used oil in clearly identified containers • Provide preventative spill kits and absorbing material off-site
Disturbance to riparian zones	• Preserve any riparian zone detected off-site from any activities at a distance of 15 meters from both sides
Water consumption for the plantation of new trees	• Rely on rain water, rain water collection basins and regulation of water extraction

Potential negative impact	*Recommended mitigation measures*
Water quality deterioration due to local sanitation	• Encourage workers to use provided lavatories off-site • Empty lavatories wastewater tanks in any close wastewater treatment system or introduce a build up treatment plant
	Soil Cover
Degradation of soil cover properties	• Even spreading of mulch and organic material • Plantation of fast growing vegetation and crops • Excavate shallow water channels that collect rain water • Construct water and sediment basins that control runoffs • Maintenance of landscape connectivity to decrease habitat fragmentation. (e.g. using tree corridors, and by leaving patches of ground cover where appropriate) will allow species to move through the landscape to meet their habitat needs. • Harvest planning will ensure that harvest does not coincide with nesting or breeding seasons of local wildlife identified o particular plantations.
Deterioration of soil quality by potential use of pesticides	• Control and raise worker awareness of proper agricultural practices
Soil compaction due to vehicle circulation	• Turn the soil after clearing a land parcel
Biological environment	
Degradation of the biological environment	• Introduction of vegetation plantation among the cleared areas • Preservation of riparian zones as ecological corridors • Preservation of wetlands
	Noise
Increase in noise levels due to different vehicles and equipment used off-site	• Minimize cutting and sawing activities at early and late hours of the day at close residential areas • Purchase new equipment with sound suppression systems • Ensure that workers off-site employ personal sound proof devices
Disturbance to landuse	• Avoid extensive use of pesticides near agricultural lands • Avoid disturbance to any natural resource, public and cultural site
Socio-economic	• Integrate local residents in different phases of the project • Provide proper awareness on proper practices and working instructions • Prohibit employment of children

Potential negative impact	Recommended mitigation measures
Health and safety	• Provide workers with personal protective equipment • Provide safety signs, labels and stripes to avoid hazards and accidents • Raise worker awareness of chemicals used, storage and disposal • Provide spill kits and train workers on their use • Provide first aid kit, fire extinguishers, alarm bells and emergency numbers • Provide transportation signs and speed limits • Train workers on routine check-ups and maintenance of equipment • Provide workers with health care and required vaccines • Delineate free spaces during cutting, sawing, loading and unloading of material • Train workers on proper sanitation and hygiene practices
Landscape degradation	• Promote trees planting and vegetation of cleared site
Sanitation services	• Avoid littering in the open fields • Educate workers on sorting waste • Label bins according to waste type • Raise worker awareness of hazardous waste and proper management • Provide lavatories off-site and discharge wastewater in a treatment system • Perform laboratory tests for any source of drinking water given to staff
Access to road network	• Set speed limits and cover trucks transporting material • Collect any waste material resulting after each activity performed off-site

8 ENVIRONMENTAL MONITORING PLAN

The monitoring plan should be clearly stated and communicated to all relevant staff to provide the necessary cohesion between planning, engineering, collection and operation. Moreover, the monitoring plant should be strictly implemented without ignoring any of the details in the following sections.

8.1 COMPLIANCE MONITORING

In this context, compliance with the regulations set by the EPA to limit air, water, and soil pollution shall be observed. Compliance monitoring requirements include process control testing, process performance testing, and occupational health monitoring. However, local standards and regulations for such parameters have not yet been set. Therefore, reference will be made to international standards for guidance until the concerned authority in Liberia sets and publishes such standards and regulations. Meanwhile, Compliance monitoring shall be the responsibility of BR Fuel's environmental officer(s), supervisors and administration.

For effective compliance monitoring, the following shall be assured:

- Monitoring the performance and effectiveness of environmental management plans including mitigation measures.
- Identify the extent of environmental impacts predicted in the EIA on sensitive receivers.
- Determine project compliance with regulatory requirements.
- Adopt remedial action and further mitigation measures if found to be necessary.
- Train staff (operators, laboratory staff, maintenance team, etc.) and define responsibilities, and knowhow of the whole process.
- Adequate analytical facility, equipment and materials.
- Maintenance of all operational equipment and calibration of monitoring equipment.

- Provision of safety at all different locations of the working area and retention of records.

Throughout the operations of BR Fuel including those at the main site and offsite, qualified operators and laboratory staff should carry out process control and performance testing. If possible, the technical staff that would run the facilities at the main site and supervise the activities offsite shall attend training programs (in their relative domains) to improve their qualifications and update their information. It is recommended to involve BR Fuel's operators and staff members in regular and specialized technical workshops in order to promote knowledge transfer.

8.2 Impact Detection Monitoring

Impact monitoring includes periodic sampling to assess the impact of both BR Fuel's operations both at the main site and off-site on the environment and human health and to ensure their progress towards minimizing its negative impact. As such, the major objective of the monitoring plan is to ensure mitigation measures are implemented and the potential negative impacts are minimized.

BR Fuel's Environmental Team and the Environmental Officer should develop and implement a monitoring plan that would ensure environmental protection during operations and implementation of the mitigation measures. Table 8-1 presents a monitoring program for the different parameters relative to BR Fuel and its activities.

Monitoring of air quality, surface water quality, noise levels, groundwater quality, soil quality, odors, waste management practices, traffic, health and safety, landscape, and socio-economic indicators is outlined below for Buchanan Renewable Fuel. For certain parameters, sampling and chemical analysis are necessary to assess the extent of the impact. For other parameters, only visual inspection, photographic documentation and surveys by experienced personnel are needed. In the case of non compliance, efforts should be made to:

- Identify the most probable source.
- Verify the proper implementation of the specified mitigation measures.
- Review the effectiveness of environmental management plans including mitigation measures and propose alternative actions as appropriate.
- Increase the monitoring frequency to assess the effectiveness of remedial measures.
- Verify the proper implementation of good housekeeping practices.

Information about monitoring procedures, analysis methods, and equipment outlined in this section shall be updated by BR Fuel's management as necessary and according to site specifics and conditions. Flexibility in implementation is essential as long as the objectives are met.

8.3 WATER MONITORING

This section provides guidelines for the proposed monitoring program based on current and available information.

Before the initiation of any work off-site, surface water and groundwater quality should be monitored to establish baseline data and to identify any existing pollution sources for accurate analysis and interpretation of the monitoring results during the operational phase. A comprehensive surface water, groundwater, and effluent discharge sampling program should be implemented during the operation phase targeting several physical, chemical, and biological parameters as presented in Table 8-1. As for water consumption, Buchanan will mainly rely on rain water for irrigation. If additional water resources are needed then water consumption should be monitored by the installation of water meters or measured observation.

Table 8-1: Proposed Surface, Groundwater, and Effluent Discharge Monitoring Parameters.

Water Resources	*Monitoring Indicator parameters*	*On-Site*	*Off-Site*[18]
Surface water	• Temperature	NA	√
	• pH	NA	√
	• Electrical Conductivity (EC)	NA	√
	• Ammonia	NA	√
	• Nitrate	NA	√
	• Manganese	NA	√
	• Total Phosphorous	NA	√
	• Total Suspended Solids (TSS)	NA	√
	• Biochemical oxygen demand (BOD)/Dissolved oxygen (DO)	NA	√
	• Total Organic Carbon (TOC)	NA	√
	• Total Coliform, Salmonellae	NA	√
	Metals (Chromium, Cadmium, Copper, Zinc, Nickel, Mercury, Lead)	NA	√
Groundwater (drinking)	• Temperature	√	√
	• pH	√	√
	• Electrical Conductivity (EC)	√	√
	• Ammonia	√	√
	• Nitrate	√	√
	• Nitrite	√	√
	• Manganese	√	√
	• Phosphate	√	√
	• Total Coliform, Fecal Coliform, Escherichia coli.	√	√
	• Iron	√	√
	• Phenols	√	√
	• Metals (Cadmium, Copper, Zinc, Nickel, Mercury, Lead)	√	√
Effluent Discharge[19]	• pH	√	√
	• BOD_5	√	√

[18] Off-Site includes port area.
[19] Effluent Discharge mainly applies for on-site activities as well as storm water at the port. Effluent discharge is not anticipated at off-site locations other than the port.

Water Resources	*Monitoring Indicator parameters*	*On-Site*	*Off-Site*[18]
	• Chemical Oxidation Demand (COD)	√	√
	• Total Suspended Solids (TSS)	√	√
	• Oil and Grease	√	√
	• Ammonia Nitrogen (NH_4-N)	√	√
	• Phosphorous (P)	√	√
	• Temperature increase	√	√

8.3.1 Criteria

The standards or criteria against which surface water and groundwater quality will be assessed are presented in Table 8-2 and Table 8-3.

Table 8-2: Standards for drinking water quality (WHO).

Type of Analysis	*Guideline Value*
pH	6.5 – 8.5
TDS	1000.00
Turbidity (NTU)	5.00
Colour	15.00
Fecal Coliform/ 100ml	0.000
E. Coli /100ml	0.000
Iron	0.30
Manganese	0.30
Sulphate	400.00
Nitrate	10.0
Arsenic	0.05
Cadmium	0.005
Chromium	0.050
Cyanide	0.050
Lead	0.050
Mercury	0.001
Selenium	0.010
Zinc	5.000

Table 8-3: Recommended effluent standards (US EPA).

Parameter	*Maximum value milligrams per liter (mg/L)*
pH	6-9
BOD_5	50
Chemical Oxidation Demand (COD)	250
Total Suspended Solids (TSS)	50
Oil and Grease	10

Parameter	Maximum value milligrams per liter (mg/L)
Ammonia nitrogen (NH_4-N)	10
Phosphorous (P)	5
Temperature increase	Less than or equal to 3°C[20]

8.3.2 Methodology

Surface, groundwater, and effluent discharge samples should be collected and placed in pre-cleaned (1 liter) glass bottles depending on the target analysis. After collection, the bottles should be properly sealed and placed in a cooler at a temperature below 40 °C and transported to the laboratory facility for analysis preferably within 24 hours after the sampling time. A Global Positioning System (GPS) should be used to approximate the geographic coordinates of each location. In addition, groundwater samples should clearly indicate the location of the well or water body and its corresponding depth. Relevant data including monitoring location/position, depth, time, weather conditions (wind speed and direction, ambient temperature, precipitation), and work progress should be recorded concurrently. In-situ monitoring instruments should be checked and calibrated prior to usage and as per manufacturer specifications. Responses of sensors and electrodes should be checked with standards solutions before each use. In addition to on-site analysis samples from key sites (such as the main workshop area) will be sent to off-site laboratory facilities for quality assurance and quality control once per year.

8.3.3 Water Courses

Sampling should be conducted away from the water course banks in the main current and never conducted in stagnant water. In shallow stretches, carefully wade into the centre current to collect the sample. When collecting a water sample for analysis in the field follow the steps below:

[20] The effluent should result in a temperature increase of no more than 3 degrees Celsius at the edge of the zone where initial mixing and dilution takes place. Where the zone is not defined, use 100 meters from point of discharge.

1. Label the bottle with the site number, date, and time.
2. Remove the cap from the bottle just before sampling. Avoid touching the inside of the bottle of the cap. If you accidentally touch the inside of the bottle, use another one.
3. Try to disturb as little as possible the bottom sediment. In any case, be careful not to collect water that has sediment from bottom disturbance. Stand facing upstream. Collect the water sample on your upstream side, in front of you. You may also tape the bottle to an extension pole to sample from deeper water.
4. Hold the bottle near its base and plunge it (opening downward) below the water surface. If you are using an extension pole, remove the cap, turn the bottle upside down, and plunge it into the water, facing upstream. Collect a water sample 8 to 10 inches beneath the surface or midway between the surface and the bottom if the stream reach is shallow.
5. Turn the bottle underwater into the current and away from you. In slow-moving stream reaches, push the bottle underneath the surface and away from you in an upstream direction.
6. Do not fill the bottle completely, leaving approximately 1-inch air space so that the sample can be shaken just before analysis. Recap the bottle underwater, remembering not to touch the inside.
7. Fill in the appropriate information in the field data sheet.
8. Place samples in a cooler and immediately transport to the laboratory.

8.3.4 Wells

1. Label the bottle with the site number date and time.
2. Disinfect and flare the nozzle head of the well.
3. Allow the water to run for ten minutes before taking the sample.

4. Remove the cap from the bottle just before sampling. Avoid touching the inside of the bottle or the cap. If you accidentally touch the inside of the bottle, use another one.
5. Recap the bottle without touching the inside.
6. Fill in the appropriate information in the field data sheet.
7. Place samples in a cooler and immediately transport to the laboratory.
8. Measure the water level.

8.3.5 Location

Water quality of identified and existing drainage channels offsite should be monitored to identify chemical spills or soil erosion problems during the operation phases. Sampling should be conducted in the vicinity of the site as long as the drainage system carries water. Groundwater samples should be collected from the well(s) existing on site and from nearby wells that could be present around operational sites (offsite). Samples should also be taken from any well close to the septic tank to ensure the effectiveness of the liner system. Figure 8-1 and Figure 8-2 show the approximate locations of the three wells on-site and off-site on a sample farm, respectively. Table 8-4 lists the wells from which samples are to be collected and their respective location.

Table 8-4: Identified Wells for Water Quality Testing.

Well	*Location*	*Coordinates*	*Remarks*
Well 1	On-site (workshop)	29 N 389365 UTM 651501	Used for drinking and general purposes
Well 2	On-site (workshop)	29 N 389308 UTM 651548	Used for drinking and general purposes
Well 3	On-site (workshop)	29 N 389309 UTM 651564	Used for drinking and general purposes
Well 4	Off-site (Johnson Farm)	29 N 365476 UTM 678360	Used by local residents for drinking and general purposes
Well 5	Off-site (Johnson Farm)	29 N 365346 UTM 678412	Used by local residents for drinking and general purposes

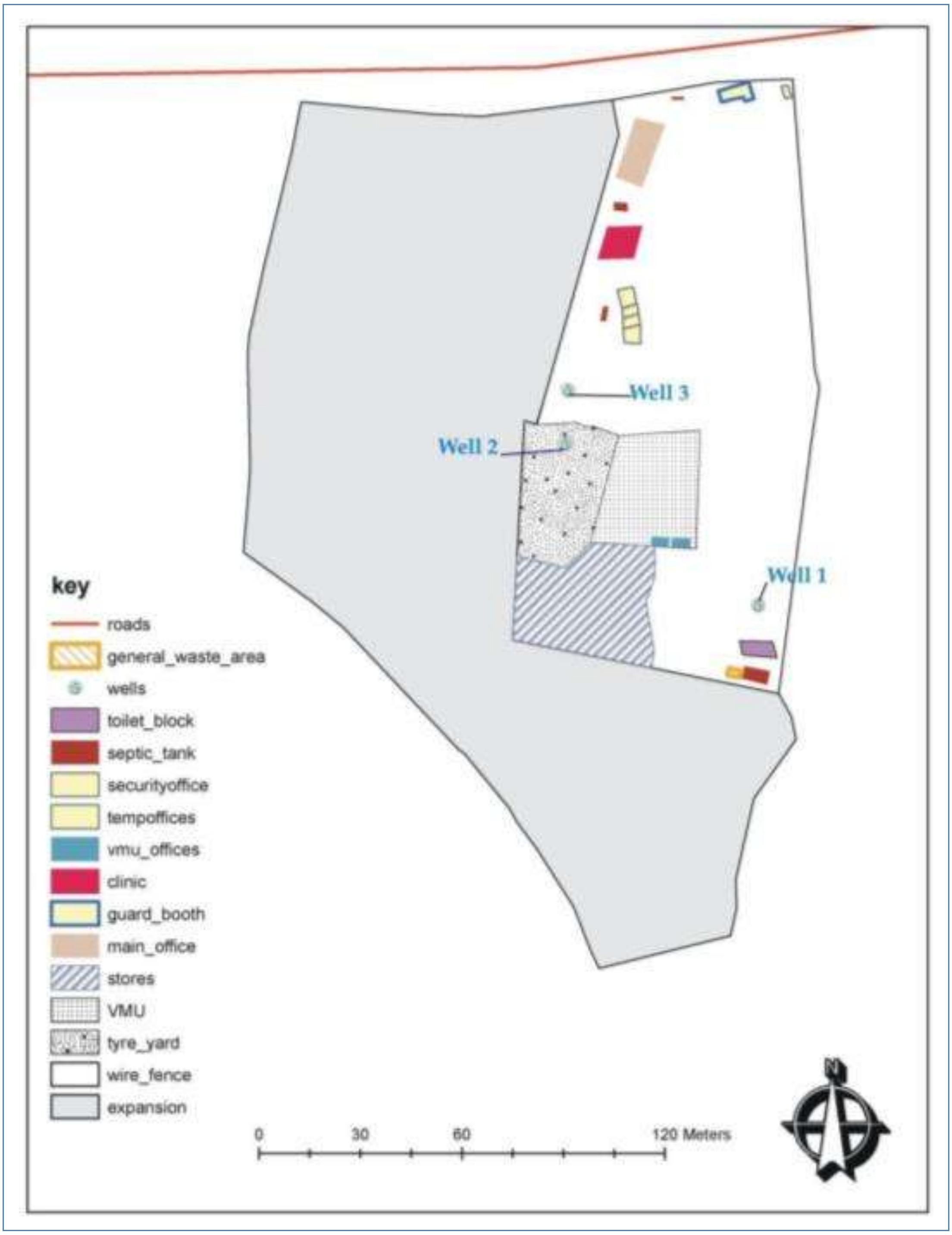


Figure 8-1: Approximate locations of wells on the workshop site.

In the sample off-site location, water samples are also to be collected from the nearby stream that crosses at the northern border to the farm. Periodic sampling according to Table 8-6 from this stream will take place at three different locations as indicated in Table 8-5 and Figure 8-2.

Table 8-5: Range of coordinates for sampling locations from stream located within the vicinity of the farm.

Location	Range of Coordinates
Upstream (Zone 1)	Between 29N 366631 UTM 678980 and 29N 365748 UTM 678648
On-site (Zone 2)	Between 29N 365468 UTM 678648 and 29N 365241 UTM 678561
Downstream (Zone 3)	Between 29 N 364541 UTM 678526 and 29 N 365101 UTM 678517
On-Site (Zone 4)	Between 29 N 365432 UTM 678645 and 29 N 365390 UTM 678706
On-Site (Zone 5)	Between 29 N 365351 UTM 678722 and 29 N 365058 UTM 678930
On-Site (Zone 6)	Between 29 N 364958 UTM 678895 and 29 N 364815 UTM 678892

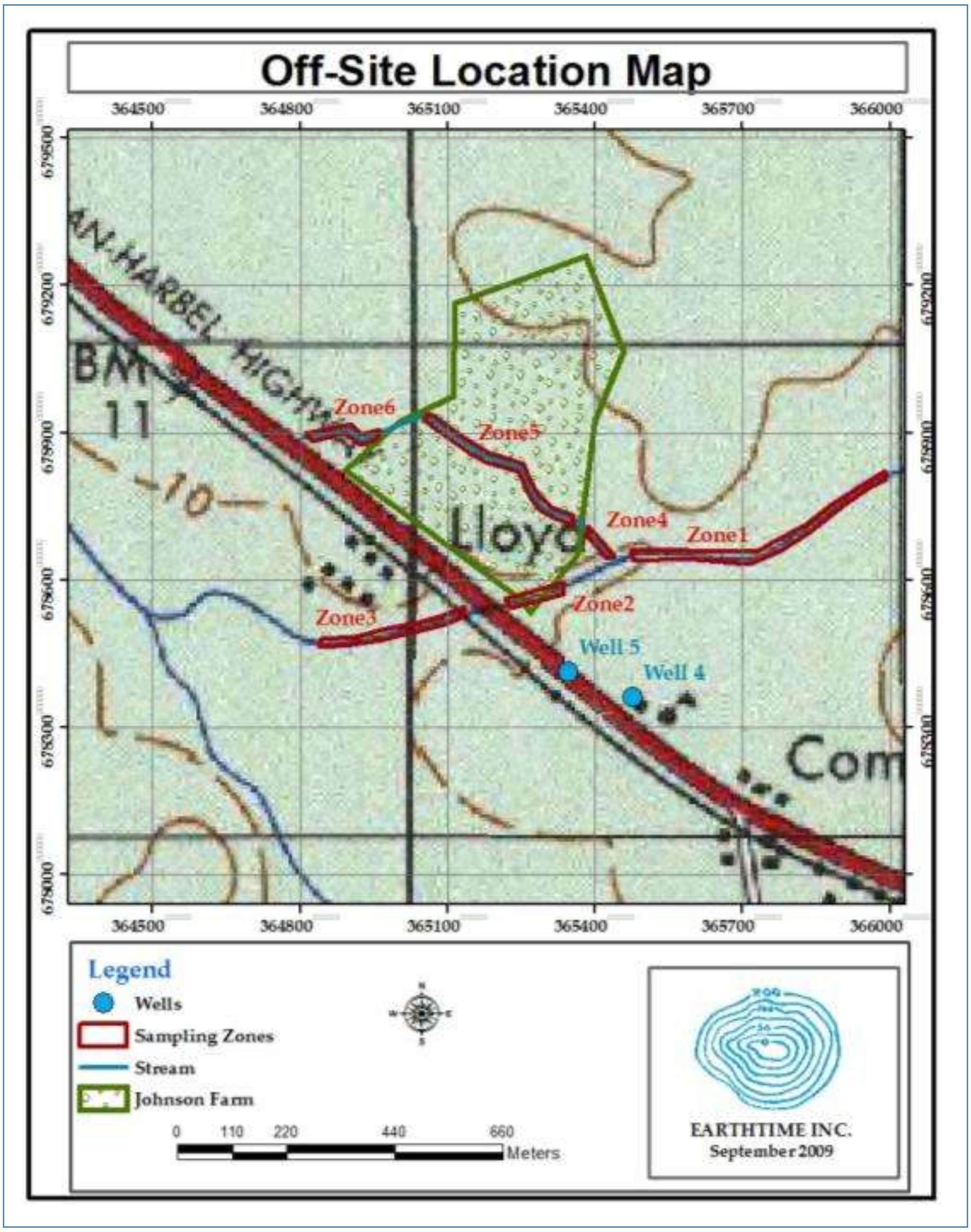


Figure 8-2: Location map for zones of sampling for water quality monitoring.

8.3.6 Frequency

The testing frequency of surface, groundwater and effluent discharge that should be followed is defined in Table 8-6.

Table 8-6: Surface, groundwater and effluent sampling frequency.

Stage	*Frequency*	*Off-Site*	*On-Site*
Pre Works	Once	√	NA
Operational	Monthly	√	√

8.4 SOIL EROSION

Soil erosion and monitoring plans will include a pre-harvest geomorphologic assessment and field survey with terrain mapping including contours, slope lengths and steepness, to assess erosion risk as well as a pre-harvest vegetation cover and map.

Stratified soil sampling to provide 10 random samples per site will be undertaken to study soil type, texture, moisture content, topsoil depth and susceptibility to erosion. Preexisting soil compaction conditions will also be assessed.

Table 8-7: Soil Erosion Susceptibility [21]

Surface Soil Texture	*Susceptibility to Erosion (1=highest)*
Silt, silt loam, loam, very fine sandy loam	1
Sandy clay loam, silty clay loam, clay loam	2
fine loamy sand	3
Clay, silty clay, sandy clay, very Sandy loams, loamy sands	4

Site areas predicted to be at highest risk for erosion will have topsoil pins inserted to monitor soil loss during and post harvest operations at one week intervals and after heavy rainfall events.

[21] *Courtesy of the Minnesota Forest Resources Council.*

The sample harvesting site (Johnson Farm) covers an area of 52 acres (21.04 ha). Sandy clay soil covers most of the site changing to clay as it approaches the highway on the southwestern border of the site, and becoming sandy loam around the stream which crosses the site in an east/south-easterly direction (Figure 8-3).

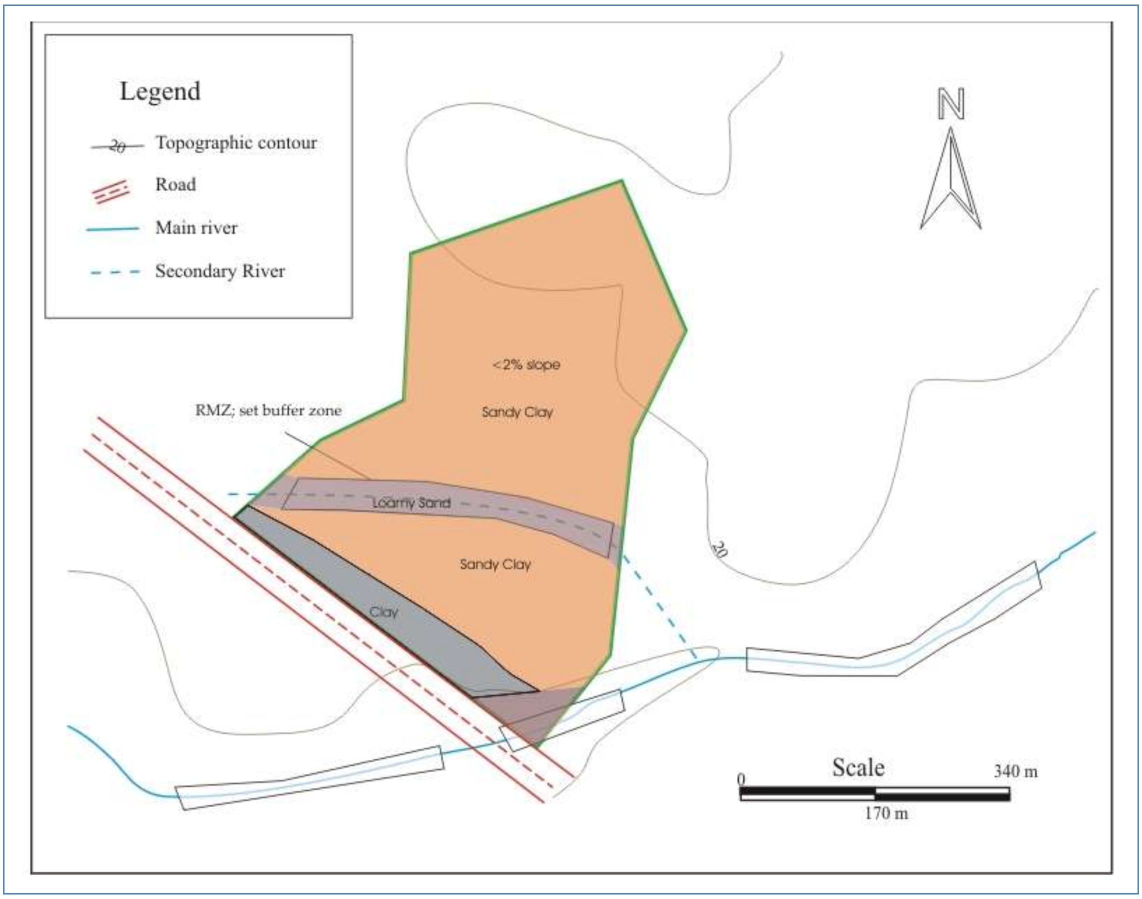


Figure 8-3: Topographic map showing current site.

The highest risk at the current site would be where the land inclination slopes at 10 degrees towards the stream. In this area three randomly selected 10x10m pin plots will be installed parallel to the slope. The rows of pins in each plot are to be set two meters apart and the pins separated by one meter. Erosion rates are predicted to be less than 5% as operations progress with the aim of achieving above requirement of less than two cm over a five year period. The Environmental Manager will be responsible for overall oversight of erosion monitoring and sediment control measures and will work with the Site Supervisors to ensure proper assessments and monitoring is being undertaken.

8.4.1 Soil Quality

To ensure that soil quality does not deteriorate due to project activities, baseline random soil sampling will be undertaken followed by sampling at regular intervals during and post harvesting. In addition, added soil testing will take place should there be any accidental incidents such as oil spill.

Chemical studies conducted on soil samples will include soil

- pH;
- Cation Exchange Capacity;
- soil organic matter content;
- nitrogen supply capacity;
- phosphorus content and supply capacity; and
- salinity.

Testing of physical features will include onsite testing for depth, texture, soil structure, and degree of compaction.

Additionally soil will be tested for pesticide residues at baseline (preharvest), and at intervals after replanting. After a period of three to five years, key harvesting sites would be revisited for repeat soil sample collection and testing, to ensure the maintenance of soil quality and productivity potential in the long term.

8.5 Soil Cover

Soil cover should be monitored at every cleared land. The preservation of soil cover will be continuously monitored by field investigations. Field visits are important after heavy rains to ensure that the mitigation measures are still efficient. It is also required to designate three locations with measuring tools to check to soil cover losses. During field visits, it is important to perform the following:

- Ensure that the planted vegetation are still resistant to the water erosion
- Check the water channels if they are filled and if the vegetation within them is still alive.

- Clean-up water channels during dry weathers from any debris
- Replace any dead vegetation and crops by new ones to maintain natural barriers against erosion action
- Check for mulch spreading and add new material as required
- Ensure vegetation at lands contours
- Ensure less than 500 trees per hectare
- Ensure replanting occurs within the replanting (rainy) season following felling
- Ensure cover crops planted
- Ensure Riparian Management Zones being observed
- Soil monitoring frequency should be before and after operations.

8.5.1 Detailed Sedimentation Control and Monitoring Plans

Pre-harvest water quality assessment will include an assessment of baseline turbidity (NTU), transparency (%) upstream and downstream from the site area in duplicate samples. The samples will be taken from the main centre current. This is to be followed by weekly sampling during and post harvest. Daily sampling is triggered by NTU>250 until NTU drops to <25 or to baseline levels, whichever is highest. Water quality monitoring documentation will be kept by the Environmental Manager and made available as requested.

In addition the soil erosion monitoring procedures (detailed in the above section on soil erosion monitoring), filters will be placed at several locations along the drainage ditches to collect the sediments in order to decrease sediment contamination of downstream watercourses. The sediments will be cleared regularly depending on the need and will be re-scattered in the fields. The filter will be either made artificially from twigs and grass bundled together or by use of native plants which will be allowed to grow in specific areas to act as natural filters.

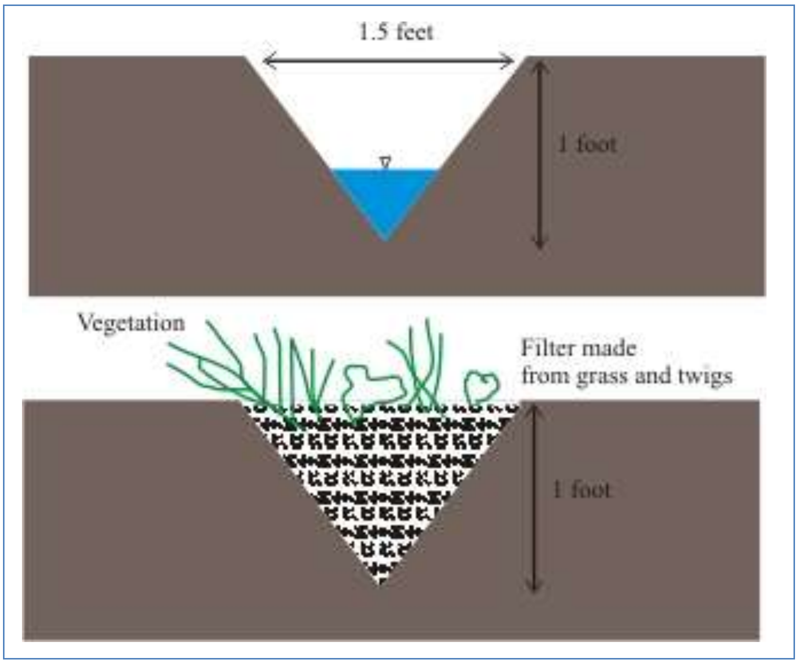


Figure 8-4: Design of the ditch a) Open ditch b) ditch with filter made from grass and twigs and possible vegetation growth.

8.6 SOLID WASTE GENERATION

During the operation phase, site audits on the general refuse streams should be conducted to examine existing waste management and handling procedures that include storage, segregation, recycling, transport, as well as disposal. The objectives of the audit are to ensure that the generated wastes are accounted for and to ascertain that they are handled in an environmentally sound manner that complies with proposed mitigation measures. Quantities, photographic documentation, and interviews are essential elements of the audits.

During operation, it is necessary to implement waste consignment notes indicating source/dates/quantities of generation along with periodic analysis of constituents. Monitoring should also include:

- Disposal route;
- Visual inspection of waste storage, collection and disposal areas. Records to be maintained for inspection.

8.7 AIR QUALITY MONITORING

During operations off-site, air quality should be monitored in terms of fugitive dust particles or PM-10. Whereas the main sources of air pollution on the main site will be the generated gases resulting from the combustion of fuel for the production of energy both in the form of heat and electric power. These emissions mainly include NOx, SOx, CO, PM, VOC and CO_2.

8.7.1 Methodology

The 1-hr and 24-hr Total Suspended particles (TSP) /PM-10 levels should be measured to delineate the temporary impact of dust emitted off-site. Both measurements should be conducted by drawing air through a high volume sampler fitted with a conditioned pre-weighed filtered paper, at a controlled rate. After sampling for 1 hour (or 24 hours), the filter paper with retained particles is collected and returned to a laboratory for drying in an oven at 110 °C followed by accurate weighing. The average TSP/PM-10 level is calculated from the ratio of mass of the particulates retained on the filter paper to the total volume of air sampled. When positioning the sampler, the following points should be noted:

- A horizontal platform with appropriate support should be provided to secure the samples against gusty winds; airflow around the sampler should be unrestricted (a portable high-volume sampler can also be used).
- Any wire fence or gate to protect the sampler should not obstruct airflow.
- The distance between the sampler and an obstacle (i.e. building) should be at least twice the height that the obstacle protrudes above the sampler.
- No furnace or generator should be nearby.
- A secured supply of electricity is needed to operate the sampler.

An alternative means of measuring 1-hr averaged TSP/PM-10 concentrations is through a hand-held particle counter (capable of sampling in the range of 0.1-100 mg/m3). This method does not require laboratory analysis and gives instant

TSP/PM-10 readings. Air samples are drawn for a period of one hour and the device provides the time-averaged TSP/MP-10 level. Calibration of the monitoring equipment should be conducted prior to implementation of the monitoring program and as specified by the manufacturer.

Wind speed and direction should also be recorded at monitoring locations. Wind sensors should be installed on masts at an elevation of 2 and 10 meter above ground so that they are clear of obstruction or turbulence. The wind monitoring equipment should be calibrated once every six months. In the case of unavailability of elevated wind sensors, it might be possible to use calibrated hand-held anemometers on the condition that no obstructions are present. All relevant data including temperature, pressure, weather conditions, elapsed-time meter reading for the start and stop of the sampler, identification, and weight of the filter paper, date, and time of sampling, and work progress at the concerned area should be recorded in detail.

8.7.2 Monitoring Locations and frequency

During operations off-site, a sampling frequency of once a month will be observed at rubber trees lands next to houses for 24-hour TSP/PM-10 monitoring. In case of complaints or whenever the highest impacts are likely to occur; 1-hr TSP/PM-10 monitoring could be conducted on a weekly basis.

8.8 Noise Level Monitoring

Noise levels will be monitored at sensitive receptors during off-site operations.

8.8.1 Criteria

During the ground preparation phase and off-site operations, the standards or criteria against which noise (measured as A-weighted equivalent sound pressure level, Leq, in dBA) monitoring will be assessed are the WHO & World Bank noise guidelines in different zones (Table 8-8), as well as the Federal Highway Administration (FHWA) noise abatement criteria (Table 8-9). In addition, occupational noise exposure should be assessed with respect to the standards promulgated by Occupational Safety and Health Administration (OSHA) (Table 8-10).

Table 8-8: Noise level guidelines. Source: WHO 1999 & World Bank, 2007.

Area Classification	*One Hour LAeq (dBA)*	
	Daytime 07:00 – 22:00	*Nighttime 22:00 – 7:00*
Residential; institutional; educational	55	45
Industrial; commercial	70	70

Table 8-9: Summary of FHWA noise Abatement Criteria (FHWA, 1997)

Land Use Category	*FHWA Standard Leq (dBA)*	*Description of Land Use Category*
A	57 (exterior)	Land where serenity and quite are of extraordinary importance and serve an important public need and where the preservation of those quantities is essential if the area is to continue to serve its intended purpose.
B	67 (exterior)	Residencies, motels, hotels, public meeting rooms, schools, churches, libraries, hospitals, picnic areas, recreational areas, playground and parks.
C	72 (exterior)	Developed lands, properties or activities not included in A and B.
D	-	Undeveloped land.
E	52 (interior)	Residencies, motels, hotels, public meeting rooms, schools, churches, libraries, hospitals and auditoriums.

Table 8-10: Permissible Noise Exposure (OSHA)

Duration (hours per day)	*Sound Level (dbA) slow response*
8	90
6	92
4	95
3	97
2	100
1½	102
1	105
½	110
¼ or less	115

8.8.2 Methodology

Sound level meters should be used to measure noise levels in terms of Leq, in dBA. Calibration of the meters should be conducted before and after each monitoring round, using a portable calibrator or similar. Calibrated hand-held anemometers should be used for the measurement of wind speed during noise monitoring periods. Noise monitoring should be carried out for at least one hour in order to determine the average noise level.

Noise measurements should not be made in the presence of fog, rain, and wind with a steady speed exceeding 5 m/s or wind gusts exceeding 10 m/s. The monitoring locations should be at a point located 1m from the exterior of the sensitive receiver building façade and at a height of approximately 1.2 m above ground or at a height that has the least obstructed view of the construction activity in relation to the receiver. Relevant data including temperature, pressure, weather conditions, elapsed-time meter reading for the start and stop of the sampler, data and time of sampling, and work progress of the concerned area should be recorded concurrently with noise measurements.

8.8.3 Monitoring locations

During the ground preparation phase, off-site operations as well as on-site operations, noise monitoring will be conducted at: 1) facility site to determine any impact on facility workers and 2) three monitoring stations selected around the perimeter of the site at varying distances to examine noise propagation and dissipation in relation to potential impacts on residential or sensitive areas. In addition, noise measurements should be readily conducted whenever any complaints are filed.

8.8.4 Frequency

A sampling frequency of once a month during operations both on-site and off-site will be observed at all monitoring stations for 1-hour noise monitoring. In case of complaints or whenever the highest impacts are likely to occur, 1-hr noise monitoring will be conducted on a weekly basis.

8.9 Safety

Continuous monitoring of health and safety indicators should be conducted to ascertain the application of mitigation measures and health and safety guidelines.

The safety measures indicated in this section are to be applied both off-site and at the main site. Operators and supervisors on-site and off-site have to provide and maintain safe systems of work to ensure the safety of their workers who could be affected by the operational activities. The following monitoring scheme should be implemented by the environmental officer and Human Resource Department on a daily basis:

- Safety signs including signs of helmets, goggles, gloves, boots, masks, earphones, wet floor, etc. should be available at the different operating buildings.
- Signs prohibiting unauthorized entrances without the management's permission, and signs or SOPs prohibiting gunning of engines and horn blowing should also be installed.
- Emergency exits should be available in each building.
- The workers should be aware of the use of fire extinguishers and should know all emergency exits.
- The workers should be aware of the location of emergency phone numbers and their use in case of accident.
- All vehicles must be provided with fire extinguishers and drivers should know how to use them.
- Vehicle maintenance should be regularly done to prevent risks of accidents. Lights, reflectors, brakes, horns should be revised.
- The proper use of PPE should be checked in addition to presence of signs, first aid kits, fire fighting devices, etc.

In case of accident occurrence, a mechanism for proper reporting should be maintained. The description of the accident occurrence, duration for clearing the risk, and final conclusions should be written down. Proper corrective actions should be studied and implemented to reduce the probability of the accident re-occurrence.

Continuous awareness lectures are important to be given to all workers. This would help them know why safety measures should be taken and inform them on all safety measures and their locations. Workers would know how to act faster in case of any accident occurrence.

8.10 BIOLOGICAL ENVIRONMENT

Field investigation and surveys with photographic documentation should be conducted within the site and its surrounding environment during all phases of the project. This would ensure the use of recommended plant species on site as well as provide a visual assessment of the overall site status (physical and biological aspects) and highlight indicator/ sensitive species to be monitored. Field surveys should be conducted once before and during facility construction and site preparation phase, and annually during operation phase. As a result of the field survey the following points should be ensured:

- Identify any significant flora species than the rubber trees and delineate it with barrier strips in order to maintain vegetation that provides habitat to animals
- Ensure that vegetation is preserved and proceed with plantation of vegetation and crops that help in enhance local ecological habitats
- Perform quarterly control of planted vegetation and replace dead ones by new vegetation in order to maintain an even distribution of plantation

8.11 LANDSCAPE AND VISUAL INTRUSION

Visual inspection and photographic documentation will be undertaken to ensure the effective implementation of mitigation measures related to landscaping and visual resources during all phases of the project. Field surveys should be conducted on a monthly basis during off-site operations and bi-annually during operations on-site. The results from the field visits should be used to continuously refine and calibrate the output of the predictive imaging methods used in the EMP process, if any.

8.12 SOCIO-ECONOMIC

Monitoring of socio-economic indicators such as employment generation should be conducted on a regular basis through employment records. Monitoring of social indicators such as population perception, should be conducted regularly during off-site operations operation and annually during on-site operations through field questionnaires, interviews, and public meetings.

BR Fuel will monitor the implementation of the social management plan through a dedicated staff and allocated resources. Table 8-11 indicates the monitoring plan during the operation of BR Fuel. The monitoring data will be compiled, document, and archived at the refinery.

Table 8-11: Social mitigation measures to be monitored during the operation of BR Fuel.

Social Management Element	*Mitigation measures*	*Responsibility*
Implementation of Social Management	BR Fuel is encouraged to engage local NGOs who will monitor the implementation of the social mitigation measures or management plan towards managing community expectation and addressing their concerns during the operational phase.	Environmental & Safety Officer
Child Labor	To ensure adherence to child labor laws and commitments BR Fuel will monitor on-site and off-site areas of activity on a regular basis. During these visits, the Environmental Safety Officers will observe site activity as well as interview staff to ensure that not only BR fuel operations are complaint but also those of their suppliers.	Environmental & Safety Officer
Social Investment Projects	BR Fuel to monitor social investment projects under the direction of an E&S Manager who appraises internal and external stakeholders regarding the status of projects and benefits/impacts to the communities.	Environmental & Safety Officer
Health Awareness	It is advisable to conduct an annual health surveillance assessment for workers & nearby	Environmental & Safety Officer

Social Management Element	Mitigation measures	Responsibility
	local community to ensure that there are no health effects, especially from water quality impacts, to local community due to the operations of BR Fuel & the application of fertilizers, herbicides & pesticides.	

Although some stakeholders revealed that operations are not expected to impact charcoal prices or availability in the near future, it is strongly recommended that BR Fuel works with the Forest Development Authority to gather more information and undertake research regarding potential long- term impacts of project activities especially with regards to impacts of expansion and increased scope of the project.

8.13 SUMMARY OF MONITORING PLAN

A summary of the monitoring parameters with corresponding location, and frequency is presented in Table 8-12. Figure 9-1 depicts an institutional framework for implementing environmental management plans. These plans must be updated and refined during the design phase and prior to initiating the construction activities.

Table 8-12: Summary of Proposed Monitoring Plan

Impact	*Monitoring Means*	*Parameters*	*Phase*	*Location*	*Frequency*	*App. Cost*
Air Quality	Portable sampling	• Total suspended particulates (TSP) • Particulates < 10 microns (PM10)	• Operation	• Offsite • On-site • Nearby receptors	Monthly	$7,000/portable sampling device
Noise levels	Sampling	• Leq (dBA)	• Operation	• Off-Site • On-Site • 3 monitoring locations around the perimeter of the site(s)	• Monthly • Upon Complaints	$5,000/ portable sampling device
Surface water quality	Sampling	• Temperature • pH • Conductivity (EC) • Ammonia, Nitrate, Manganese, Total Phosphorous, Total Suspended Solids (TSS), Biochemical oxygen demand (BOD) / Dissolved oxygen (DO), Total Organic Carbon (TOC) • Total Coliform • Metals (Chromium,	• Off-site Pre-works	• At least two sample locations should be conducted one upstream and Surface drainage recuperation canal • Exact location should be determined prior to work in collaboration with local	Once	
			• Off-site operation		Monthly	

Impact	*Monitoring Means*	*Parameters*	*Phase*	*Location*	*Frequency*	*App. Cost*
		Cadmium, Copper, Zinc, Nickel, Mercury, Lead)		authorities		
Groundwater (drinking)	Sampling	***Wells used for drinking*** • Temperature, pH, Electrical Conductivity (EC) • Total Alkalinity • Ammonia, Nitrate, Nitrite, Phosphate, Manganese, Iron, Phenols • Total Coliform, Fecal Coliform, Escherichia Coli, • Metals (Cadmium, Copper, Zinc, Nickel, Mercury, Lead)	• Off-site Pre works	• Wells existing within the vicinity of the main site and close to the septic tank. • Exact location should be determined prior to work initiation by in collaboration with local authorities	Once	

Impact	*Monitoring Means*	*Parameters*	*Phase*	*Location*	*Frequency*	*App. Cost*
			• Off-site and On-site operations		Monthly	
Effluent Discharge	Sampling & Measurement	• pH • Ammonia Nitrogen (NH_4-N), Manganese, • Phosphorous, • Total Suspended Solids (TSS), • Biochemical oxygen demand (BOD_5) • Chemical Oxidation Demand (COD) • Oil & Grease • Temperature Increase	• Off-Site • On-Site	• Port storm water • On-site septic tanks	Monthly	
Waste generation	Generated waste checklist	• Visual inspection of waste storage, collection and disposal areas; • Maintains records of quantities of waste generated	• Off-site site preparations	Entire area of operation	Monthly	Priced within off-site operations

Impact	*Monitoring Means*	*Parameters*	*Phase*	*Location*	*Frequency*	*App. Cost*
	Generated waste checklist	• Source/dates/quantities; • Disposal route; • Visual inspection • Install monitoring wells	• Off-site and On-site Operations	Entire area of operation	Monthly	Priced within operation
Health and safety	Health and safety surveys, documentation of injuries and accidents	Proper use of PPE, presence of signs, first aid kit, and firefighting devices	• Site preparation • Operation on-site and off-site	Entire area of operation	Continuous	$ 10,000/year
Socio-economics	Field questionnaires and interviews	• Population perception • Employment record • Reported cases of affected psychological stresses	Pre-works	Region of influence	Once	$500/visit
			Off-site preparation		Once	
			On-site Operation		Annually	

Impact	*Monitoring Means*	*Parameters*	*Phase*	*Location*	*Frequency*	*App. Cost*
Biological environment	Field investigation, survey and photographic documentation	• Pre-works basic assessment • Ensure use of recommended plant species on site • Visual assessment of overall site status (physical and biological aspects) • Highlighting indicator / sensitive species to be monitored • Development of a monitoring schedule • Monitoring indicator, sensitive specie(s) • Photographic documentation of present species	• Pre-works • • Off-site operation • On-Site operation	• Facility site • Surrounding habitats	• Once • • Continuous • Annually	$500/visit
Soil cover	Field investigation, profile measurement, survey and photographic	• Soil profile • Vegetative cover • Water ditches • Sediment control basins	• Off-site land preparation	• Entire area of Operation	• weekly	$500/visit

Impact	*Monitoring Means*	*Parameters*	*Phase*	*Location*	*Frequency*	*App. Cost*
	documentation					
Soil Quality	Sampling	• pH; • Cation Exchange Capacity; • soil organic matter content; • nitrogen supply capacity; • phosphorus content and supply capacity; and • salinity • depth, texture, soil structure, and degree of compaction	• Off-site land preparation	• Entire area of operation	• Preharvest and at intervals after replanting	
Landscape and visual intrusion	Visual inspection and photographic documentation	• Ensure the effective implementation of mitigation measures	• Off-site preparations	• Entire area	• Once	$500/visit
			• Off-site and On-site Operations		• Annually	

9 OPERATIONAL PHASE MANAGEMENT

9.1 ORGANIZATION AND RESPONSIBILITIES

It is recommended that BR Fuel appoints an Environmental and Safety Manager/Officer during the operational phase of the project in order to manage and implement the EMP. The proposed organizational structure for the operational phase is presented in Figure 9-1.

The E&S Manager will develop an ESMS document detailing the objectives, organizational structure, responsibilities, resources, mitigation and control measures, monitoring and auditing plans, review systems, provisions for implementing corrective actions for deviations from EMP, and training systems for the operational phase of the project. The E&S Manager will ensure effective implementation of ESMS on a day-today basis with the support of the various managers such as the general manager, technical managers, administrative managers, etc.

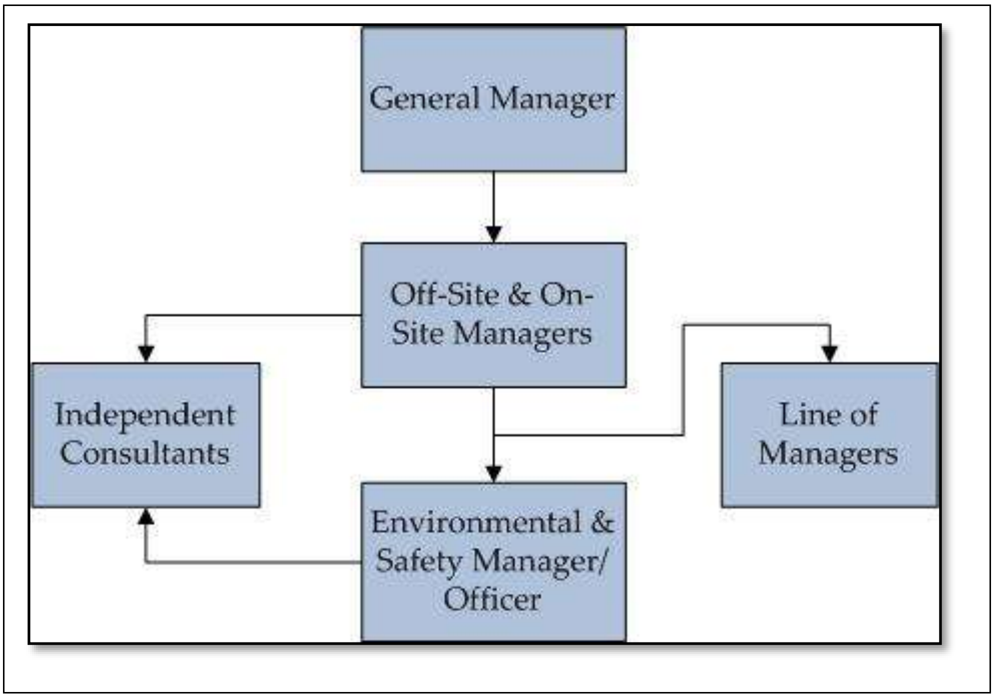


Figure 9-1: Organizational diagram for environmental and safety management during operation of BR Fuel.

9.2 Record Keeping

Monitoring efforts would be in vain in the absence of an organized record keeping practice. It is the responsibility of the environmental officer and the BR Fuel administration to ensure the development of a database that includes a systematic tabulation of process indicators, performed computations, maintenance schedules and logbook, and process control and performance monitoring outcomes. Such a historical database benefits both the plant operator and design engineers.

Such database can also be used to assess the effectiveness of the mitigation measures and to correct or to update these whenever necessary to maintain lowest negative impacts of BR Fuel.

9.3 Capacity Building

The proper implantation of environmental and social management plan is highly dependent on the available existing capacity and awareness of the facility staff, surrounding community and concerned stakeholders. The capacity-building program consists of Specialized Training Workshops (STW).

9.4 Specialized Training Workshops

STWs consist of a combination of theoretical lectures, focused training sessions, and field demonstrations that are believed to maximize workshop impacts. Activity specific technical training manuals will be developed and distributed to the participants to serve as a basis for future reference and application of proper environmental guidelines. In addition to safety and health issues, the manual should provide the trained staff with remedies for potential problems that could be encountered during operation.

9.5 Environmental Awareness Workshop

The personnel involved in the operations of BR Fuel, and the mitigation and monitoring plans will be required to attend environmental and social training workshops throughout the project activities. The objective of these workshops is to ensure appropriate environmental and social awareness, knowledge, and skills for the implementation of environmental and social mitigation and monitoring measures. They will be conducted at least twice a year during the actual operation phase. The workshops will increase environmental and social awareness of the participants by covering at least the following topics:

- Environmental laws, regulations and standards.
- Labor laws, regulations and standards.
- Pollution health impacts.
- Pollution prevention and mitigation measures.
- Sampling techniques and environmental and social monitoring guidelines.
- Integrated solid waste management (source reduction, separation, processing, etc).
- Health and safety measures.

9.6 Facility Operation Training Workshop

Facility operators should receive appropriate training to assume the duties of managing the facilities and operations of BR Fuel, implementing the suggested mitigation measures, and monitoring potential impacts. The training workshop should cover the following issues:

- *Negative impacts:* to prevent the occurrence of negative impacts, workers should be aware of all potential impacts, their causes, and mitigation measures.
- *Environmental awareness:* workers should have a sense of environmental awareness in order to understand the importance of environmental protection.
- *Health and safety regulations:* BR Fuel should resume responsibility for ensuring adequate training of all operators. This could be achieved by small

workshops conducted, in the facility, mainly during the operation phase for one day on a quarterly basis.

9.7 CONTINGENCY PLAN

The environmental management plan for BR Fuel's various activities both on-site and off-site has been developed in order to minimize and mitigate the effects of potential impacts that might arise during the preparation, operation and post closure phases. However, unexpected accidents and emergencies might occur that require additional measures during transportation, and handling of the oil and lubricants. In this case, a contingency plan should be developed.

The contingency plan includes the identification of likely accidents and emergencies, outlining response scenarios, delegating responsibilities, and co-ordination with the proper authorities. Furthermore, the plan would serve as a reference for risk assessment and employee training.

The following are potential emergencies that may occur thereby requiring effective contingency planning:

- Accidental leakage and/or spillage of solid waste, and liquid waste (including oil, lubricants, and other chemicals).
- Vehicle/truck breakdown
- Fire events.

In the case of any accidents and emergencies, the required response should be implemented in a timely fashion in order to minimize the impacts of the accident and it must be undertaken by qualified individuals, experienced in emergency response actions. Table 9-1 outlines the main components for the operation of BR Fuel.

Table 9-1: BR Fuel Contingency Plan.

Potential emergencies	*Response*
Accidental leakage and/or spillage of the solid waste, liquid waste (during transportation), discovery of hazardous or infectious wastes	**Isolation** • When safe to do so, isolate the contaminants to prevent further dispersion of any contaminates • **Spill Clean-up and Disposal** • Clean-up and disposal of spilled material must be undertaken in a timely fashion with due regard for potential adverse environmental impacts, health and safety and regulatory requirements • In consultation with local EPA authorities and the facility's environmental management & monitoring consultant, the following steps shall be taken: o Locate and quantify the contamination o Assess the site conditions and environmental impacts o Assess potential for contamination, collection and repair o Deploy immediately the required personnel, materials and machinery to contain and clean-up the spilled material o Call in specialized spill response contractor or appropriate personnel and machinery as required **Spill Notification** • Contact local EPA authorities to notify them of accident and many potential risks related to the percolation into groundwater or flow into surface water **Monitoring as a Follow up** • A monitoring program shall be developed and implemented to confirm the effectiveness of any required clean-up **Root cause Assessment and Corrective Action** • An investigation will be undertaken to determine the root cause(s) of the incident and to identify, if feasible, corrective actions that can be undertaken to ensure that the incident does not re-occur **Documentation** • Incident report, including photographs, clean-up documentation, including the results of analytical testing and root cause assessment and corrective actions
Vehicle/truck breakdown	• In case of truck breakdown, it should be possible to have the vehicle replaced if it requires maintenance/repair that would exceed few days • To avoid service disruption and the potential of a breakdown, BR Fuel should ensure that the vehicle meets strict performance and safety standards

Potential emergencies	Response
Fire events	• In case of fire event: immediately contact the fire brigade for assistance. Fire extinguishers should be readily available on site to directly limit fire extension. • A fire protection plan could include, but not necessarily be limited to the following: o Having a readily available, pressurized water supply, complete with standpipes, hose bibs, and in some cases either a sprinkler system or hydrants for connection to pumper trucks o A road design that permits easy access by fire-fighting equipment o Proving buffer distances between potentially combustible materials o Having a readily available stockpile of soil to smother fires (as an alternative to using water)

9.8 Statement of Compliance and Commitment

BR Fuel will confirm its adherence to the environmental requirements and obligations of this EMP during operations on-site and off-site. BR Fuel will also comply with the national regulations/standards stipulated and will adopt the proposed mitigation measures and monitoring plans of this environmental management plan (EMP). As in any project, flexibility must be maintained to enable adaptation to the given context. Any modifications of the mitigation measures and monitoring plan, however, will follow the spirit and principles of the existing plan. BR Fuel will coordinate and technically liaise with the EPA for the proper application of the proposed environmental management plan.

10 PUBLIC PARTICIPATION

Environmental and Social Impact Assessment (ESIA) is an instrument of environmental policy defined as a study to assess the environmental and social impact of planned activity as well as a tool for decision making about the perceived feasibility of the planned activity. The purpose of ESIA should not be just to assess impacts and complete an environmental and social impact statement (ESIS); it is to improve the quality of decisions and to inform the public of the projects objectives and components and potential impacts.

Public involvement and consultations are important components in projects such as the described woodchip biomass production project by Buchanan Renewables Fuel, in order to ensure information is properly conveyed and that cooperation and acceptance from the public is secured. Public participation should also aim to increase general environmental and social awareness among the public and various stakeholders in regards to the proposed project and thereby addressing their concerns. Additional reasons for involving the public in the ESIA process include:

- Public participation is regarded as proper and fair conduct in public decision-making activities.
- Public participation is widely accepted as a way to ensure that projects meet the stakeholders' needs and are suitable to the affected public.
- The project carries more legitimacy, and less hostility, if potentially affected parties can influence the decision-making process.
- The final decision is 'better' when local knowledge and values are included and when expert knowledge is publicly examined.

The effectiveness of public participation is measured by the degree of communication, the intensity of contact and the degree of influence for decision making.

Table 10-1 represents some example of effective public participation techniques that can be utilized by the contractor.

Table 10-1: Recommend techniques for public participation.

Technique	*Objective(s)*	*Scope*	*Participants*
Public Displays	• To inform about the project	• Informative	Affected people and other relevant interests
Public Meetings	• To identify issues and to solicit feedback	• Consultative	Affected people consisting of village officials, informal leaders and local people as well as rubber farmers associations
Focus Group / Discussion	• To identify issues and to solicit feedback • To get ideas for environmental and social management	• Informative • Consultative • Environmental & Social Management	Affected people

Moreover, in accordance with the requirements of the Environmental Protection and Management Law and the EPA for public consultation on major development projects' related activities and disclosure of the findings of the ESIA report, Earthtime and BR Fuel as well as Vattenfall have recognized the need for an effective public consultation and disclosure program. As such, consultation with relevant stakeholders commenced during the preparation of the ESIA report.

It is strongly recommended that BR Fuel holds consultation sessions as part of the public consultation and disclosure program prior to and during harvesting activities

This section describes the consultation process that took place during the preparation of this ESIA report and identifies stakeholders that have an interest and/or influence on the project.

10.1 Regulations and Requirements

Sections 17 and 18 of the Environmental Protection and Management Law require that the project sponsor should disclose the findings of the ESIA to the relevant stakeholders when the draft ESIA has been completed. This requirement is also in line with the Guidelines for ESIA Administrative Procedures set by the EPA.

10.2 PUBLIC PARTICIPATION PROGRAM

The public participation was carried out during the preparation of the ESIA, where several stakeholder meetings were organized and held in Monrovia and Buchanan. The sessions were held on September 21, 22, 24, and 28 2010. The aim was to provide information on the project, its expected environmental and socio-economic impacts and the proposed mitigation measures and monitoring plan in addition to obtaining and documenting recommendations, opinions and concerns by the various stakeholders. The meeting included:

- An introduction about BR Fuel and its project and related activities in Liberia
- A presentation of the ESIA report;
- Engagement of stakeholders from rubber farmers associations, government officials (such as Environmental Protection Agency, Forestry Development Authority, Ministry of Internal Affairs, National Port Authority and Rural and Renewable Energy Agency of the Ministry of Lands Mines and Energy) as well as NGOs (Such as Flora & Fauna International, ACDI/VOCA, Sustainable Development Institute and others). Consultations with communities and workers associations in Buchanan were also held.
- Detailed discussion with the stakeholders on the proposed Environmental Management Plan as well as the Environmental Monitoring Plan;
- Highlighting the importance of the participation of the local people in the decision making process.

The list of participants the public consultation meetings is presented in Appendix D.

The forum provided a platform for all the relevant stakeholders to raise their concerns, highlight project related social, environmental and economical issues of significance and reach a common understanding on the way forward to address all significant issues of concern. These concerns are discussed in the following section. The relevant feedback from the public consulting meeting has been incorporated in the Environmental Management Plan (EMP) to the extent possible.

It is recommended that stakeholder engagement with the local communities directly affected by the project should continue throughout the project life cycle.

10.3 ISSUES ARTICULATED DURING THE CONSULTATION

Concerns, questions, comments and suggestions regarding many of the aspects of the project were raised by the different participants to the consultation meetings.

On the environmental side, an important concern was raised about monoculture and its negative effects. In many of the meetings held, intercropping rubber trees with some short-term fast growing species (pineapple, beans, pepper, etc.) was discussed as a major mitigation measure to the problem of monoculture that can also benefit the farmers by the time the replanted rubber trees grow.

Another common concern was the impact of noise resulting from the different operations on-site and off-site on the workers and the local residents. Proposed mitigation measures were presented and discussed in details in order to address those concerns. The measures were approved by the participants.

There were also some worries from the NGOs about the possibility for BR Fuel to seek new lands to plant more rubber trees. Another worry of the NGOs was about using genetically modified rubber for replanting. Both concerns were addressed by BR Fuel representatives who stressed the fact that BR Fuel works on existing rubber farms and has its own nursery where the company is producing natural rubber clones with the support of the Todee Rubber Farmers.

The NPA managing director and team had concerns about the environmental aspects of the project both in the port of Buchanan and off-site. They raised their worries about fire accidents due to the presence of woodpiles and stressed the necessity for BR Fuel to own fire fighting trucks and equipments as well as to have a trained team of fire-fighters which should be available around the clock. The Managing Director of NPA indicated that on several visits to the Port of Buchanan, the fire-fighting trucks were seen on site, but fire-fighters were not seen. BR Fuel's response was that they have fire equipment and a fire service at their woodchip site 24 hours a day (three 8 hour shifts); if not seen, it was likely because they were in the shade on their property. BR Fuel also indicated that their fire service is run by a Canadian volunteer fire fighter and conducts training on a regular basis. The county fire team is invited to the training. The team has supported the county and ArcelorMittal's fire service on a number of occasions. Furthermore, the likelihood of internal combustion is extremely low.

They also expressed their concern regarding the spillage of woodchips during loading operation both on the port quay and in the water. They showed evidence of this spillage (Figure 10-1) and urged BR Fuel to take action to prevent it from happening again. Moreover, the NPA team was worried about the soil conditions after operations and suggested monitoring the soil quality. It was important here to mention the absence of accredited soil testing laboratories in Liberia and that, if soil testing is to be done, samples should be transported for testing abroad or BR Fuel should have trained expert(s) among its environmental team to carry on soil testing. They also expressed concerns on the degradation of water quality due to the excessive use of fertilizers and pesticides. Here again, it was important to recall that the EMP mentioned the use of chemicals is to be minimized and substitution of chemicals by biological practices should be applied whenever possible.

On the socio-economic forum, concerns of the different participants included questions about the type of support that BR Fuel is providing for the farmers and the possibility of resettlement of local residents where BR Fuel will have operations. In addition, a unanimous worry was that BR Fuel shall not in any case be involved in child labor. Here the BR Fuel representative explained that the company abides by the national and international laws and promised not to support child labor neither directly nor indirectly.

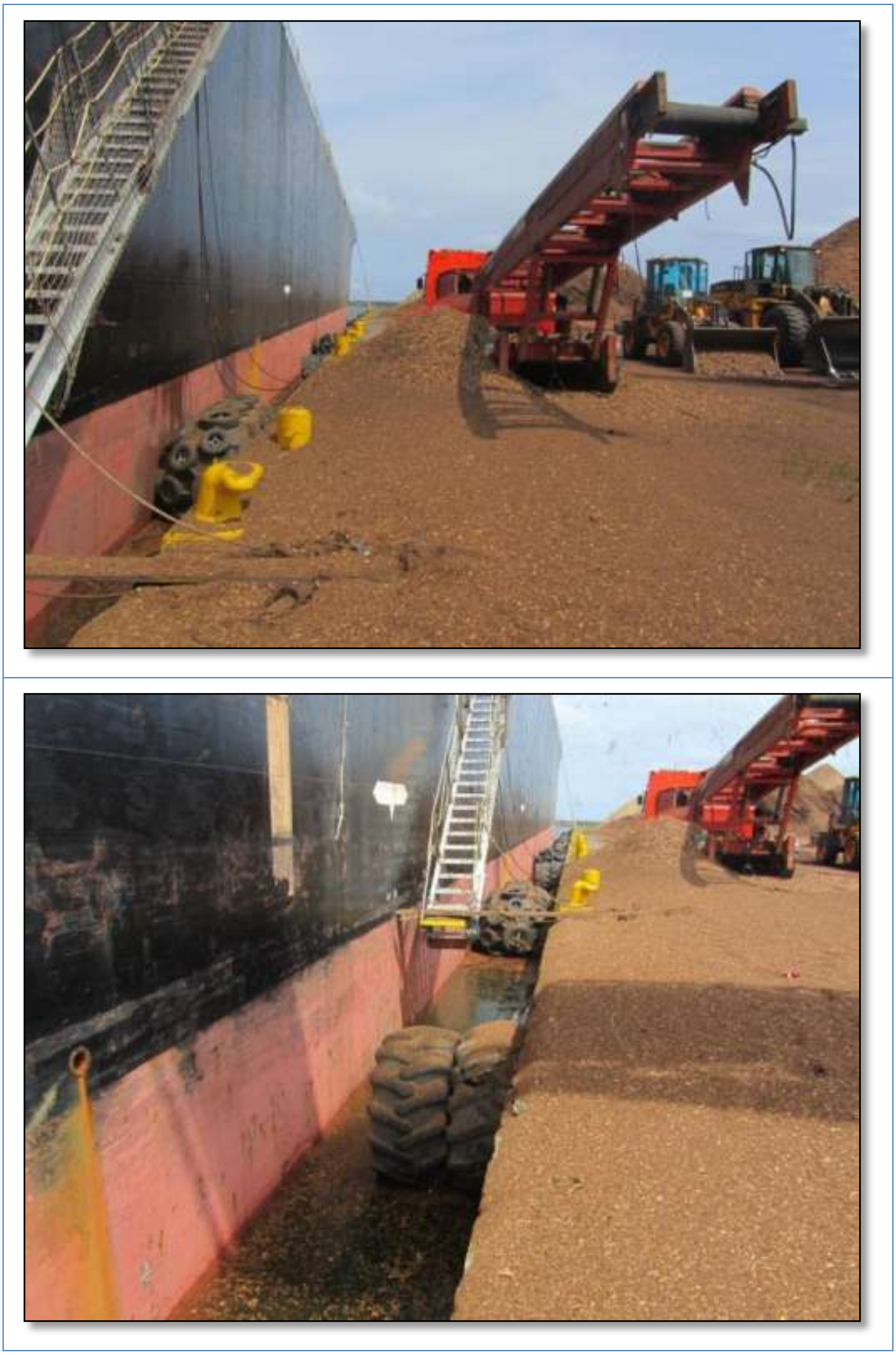


Figure 10-1: Woodchip spilled at Port of Buchanan during loading. ***Source:*** **National Port Authority.**

Potential negative impact of BR Fuel's project on charcoal production and price was long-discussed during the meetings. The discussions on charcoal production were raised by Earthtime in every meeting in order to get the input of all the groups on that matter. The result of this consultation was controversial and needs more investigations and follow-up. In fact, when asked, the rubber farmers associations did not think that BR Fuel's project would negatively affect the charcoal production and price. They mentioned that not all leftovers of roots and branches are currently being used by the farmers for charcoal production. They also explained that the charcoal price is only affected by the location and the road conditions (i.e. cost of transport).

Although BR Fuel recognizes the need to study the issue further, particularly in light of its expansion plans, it does not believe that it is currently having a negative impact on charcoal production because there are thousands of old rubber trees near all farms on which they are working. Furthermore, they leave the roots and branches of the trees in piles for charcoal producers, reducing the cost of accessing rubber wood for charcoal.

On the other hand, FDA indicated that the charcoal production might be negatively impacted by the project and expressed concerns that charcoal producers will seek other sources for their charcoal i.e. the natural forests and wetlands. They explained that normally, the charcoal producers negotiate with the rubber farmers for their old rubber trees. They pay them in cash and sometimes by providing one or two bags of coal they produce using the old trees. FDA fears that with the offer BR Fuel is giving to the rubber farmer, the latter will not be willing to sell his/her trees to the charcoal producers anymore and this will mean a higher cost of charcoal or shifting to natural forests as well as mangroves for charcoal production.

A discussion on the related alternatives was held with FDA. FDA said one alternative as planting some fast growing tree species that could be a good source of coal without having a heavy impact on the environment.

Finally, FDA indicated the lack of data and records on the charcoal production industry in Liberia and suggested working closely with BR Fuel to gather as much data as possible about the sector. BR Fuel also expressed interest in cooperating with FDA on gathering as much data as possible on how much charcoal is from rubber wood, how much rubber wood is used for charcoal, and how prices for charcoal have changed over past two years and why. Moreover, they demonstrated interest in working together to find the reality of the project's impact on charcoal production and to seek the necessary solutions.

Other issues addressed during the meetings included:

- Questions about the quantity of rubber that can be and is planned to be harvested;
- Questions about the projects' impacts on the health of the workers and local residents;
- Inquiry about the possibility of holding carbon credit agreements resulting from the project as an investment in renewable energy and in planting new trees;
- The need to invest in capacity building within Liberia to meet the EMP requirements;
- Discussions on the effectiveness of the replanting process and the time frame between harvesting and replanting;
- Discussion on the necessity of planting windbreakers around the harvested farms and the types of windbreakers that can be used;
- Discussion about the potential degradation of the woodchips quality due to their long exposure before loading.

Discussions with BR Fuel employees lead to the following comments and suggestions, they are listed by issue:

- Soil: the need to have a harvest management plan that mitigates soil compression and erosion, and mitigation that varies between rainy and dry season.
- Biodiversity: sometimes farm owners insist on clearing all the trees, but the company needs to safeguard biodiversity. This should be clarified in the farmer contract. Another issue is the difficulty of preventing the owners from selling trees in the riparian zone to charcoal producers.
- Water quality: necessity to conduct both pre- and post-testing of water
- Safety awareness: for some employees, safety materials, equipment and knowledge are insufficient. More materials should be available and a better safety plan should be developed. (BR Fuel's Environmental Health and Safety officer is performing his review and will take on this responsibility)
- Noise: employees recommended that the generator, which produces most of the noise at the compound be relocated
- Moths in Woodchip pile: in the dry season, there are often moths around the woodchip pile causing a general nuisance to workers.
- Education: employees were appreciative of the in-service training program established at the college of Buchanan, but some hope the program can be extended. Buchanan College cannot provide all relevant skills, thus they suggested that the in-service training program should be extended to other schools.
- Transportation: workers cited lack of transportation as a major impediment in their ability to get to work and even to conduct work related activities. Employees requested that management invest in buses
- Medical benefits: employees asked that the company help them provide healthcare for their children.
- Other: employees said this sort of consultation should happen more often.

Other discussions where held with community members and stakeholders in Buchanan. The main issues addressed were:

- Air quality: concerns about the woodchip piles catching on fire; other concerns about dust emitted by the company's trucks along the road getting into people's houses. One proposed solution was to have signs for the trucks to slow down at certain points of dense population.
- Socio-economic: some communities through which the company's trucks drive did not feel they benefited from jobs from BR Fuel; one idea was to organize local road crews to fix the roads as an employment attempt for these affected communities.
- Water: concerns about the woodchips getting into the port waters while loading vessels. BR Fuel has addressed this problem by purchasing a longer conveyor.
- Socio-economic: one concern was that by cutting down rubber farms BR Fuel was taking away the latrines used by villagers; mitigation would be providing latrines to these affected people.
- Other: Some stakeholders expressed concern about woodchips coming out of BR Fuel's trucks onto the roads and suggested not overloading the trucks. There were also several appeals for the company to help the various communities by providing jobs and helping schools and clinics. BR Fuel asked that these appeals be sent to the company's relevant staff who will respond to them individually.
- There was a warm and sincere appreciation of BR Fuel's work by nearly everyone there and the impact the investment was having on the county. The stakeholders were impressed by BR Fuel employing women, as well as helping the orphanage and now the community college.
- The community stakeholders suggested holding more regular meetings to promote dialogue.

All concerns were discussed and solutions provided, some of which are detailed in the environmental management plan. It is important to highlight the unanimity of the concern of the long-term sustainability of the environmental management plan (especially from the NGOs side). This highlights the necessity for BR Fuel to competently implement the environmental management plan all along the project's life-cycle and in the various areas of the project's operations.

10.4 STAKEHOLDER ENGAGEMENT DURING ON-SITE AND OFF-SITE OPERATION

It is strongly recommended to update and communicate with the various stakeholders during the operational phase on-site (workshop facilities) and off-site (harvesting location). The main objective of this communication is to maintain continued positive community relations and ensure that all interested stakeholders/parties are kept informed on all project activities that may have a positive or negative impact. This section describes the framework under which national, governorate and community level liaison activities will be conducted. It also defines the roles and responsibilities of the Community Relations Officer (CRO), identifies stakeholders to be engaged and timing of engagement.

10.4.1 Objectives of the Stakeholder Engagement Program

The main objective of the liaison activities is to ensure a systematic stakeholder engagement process is in place throughout the project life cycle in the various areas of operation. At the national and local level, liaison activities will constitute formal meetings to discuss economic, environmental and social aspects of the project and associated permitting and planning issues. At the community level, liaison activities will focus on communication with local communities to establish and maintain an appropriate relationship with the people dwelling in the areas where BR Fuel will have operations. The overall objective of the community liaison activities will be to:

- Inform local communities of project-related development activities in their area;
- Ensure local communities are made aware of the hazards associated with the operational activities;
- Minimize the potential for disputes arising between the workers and local communities;
- Respond to community concerns regarding issues such as disruption to daily life, safety issues, disturbances due to noise, dust, etc; and
- Better understand the development needs of the communities in which BR Fuel is operating.

10.4.2 Roles and Responsibilities

Community relations and social impact management (CRSIM) will be the responsibility of BR Fuel. BR Fuel shall have in place a dedicated team for implementation of CRSIM. The team will have pre-defined roles and responsibilities that will complement each other and ensure effective implementation of the program.

10.4.3 Community Liaison Team

BR Fuel shall be responsible for maintaining community relations and liaison. The main responsibilities of the CRO are outlined in the following sections. It is recommended that BR FUEL have dedicated teams for community liaison. In addition, women Community Relations Assistants (CRAs) could be sought from the local communities; this would ensure that women in the various surrounding communities are kept informed and assist in development and implementation of capacity building programs for the village women. The primary responsibility of the CROs and CRAs shall be to build positive relationships with the communities that will be directly impacted by the project activities in the various areas of operation. The CROs and CRAs will act on behalf of BR FUEL and will report to their corresponding managers. Below is a description of the responsibilities of community relation officers.

10.4.4 BR Fuel CRO

- Organize and attend meetings with community representatives and local communities prior to arrival of BR Fuel workers to a given locality;
- Regularly meet with community members to ensure that there are no outstanding community issues during the project activities in their locality;
- Hold meetings with national and regional authorities on project related issues;
- Provide weekly updates to his/her corresponding manager(s) on arising community issues;
- Maintain records of all consultations and communications with local communities;
- Maintain records of complaints and grievances and immediately report to corresponding manager(s);
- Focal point for resolution of community complaints and grievances; assist in grievances resolution;
- Identify potentially significant social and community issues that may arise and report to corresponding manager(s); and
- Identify potential opportunities to leverage BR Fuel's expertise and resources to support community development needs.

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Appendix A: Noise Level Readings

Plate A1 (Excavator 330)

Date Time=06/17/09 11:20:00
Sampling Time=5
Record Num= 60
Leq Value=81.7 SEL Value=106.5
MAX Value=93.2
MIN Value=72.6
Freq Weighting=A Time Weighting=Fast
82.6,11:20:00,
82.5,11:20:05,
85.1,11:20:10,
78.4,11:20:15,
83.2,11:20:20,
81.8,11:20:25,
81.6,11:20:30,
83.8,11:20:35,
81.3,11:20:40,
82.8,11:20:45,
78.9,11:20:50,
75.4,11:20:55,
76.8,11:21:00,
76.4,11:21:05,
75.4,11:21:10,
80.2,11:21:15,
81.6,11:21:20,
81.9,11:21:25,
80.3,11:21:30,
79.0,11:21:35,
80.1,11:21:40,
83.8,11:21:45,
83.2,11:21:50,
83.7,11:21:55,
82.7,11:22:00,
84.1,11:22:05,
83.8,11:22:10,
84.0,11:22:15,
82.4,11:22:20,
79.7,11:22:25,
79.9,11:22:30,
80.8,11:22:35,
83.5,11:22:40,
82.4,11:22:45,
81.9,11:22:50,
78.5,11:22:55,

83.1,11:23:00,
79.0,11:23:05,
81.1,11:23:10,
78.9,11:23:15,
83.0,11:23:20,
81.7,11:23:25,
85.0,11:23:30,
79.9,11:23:35,
78.8,11:23:40,
80.1,11:23:45,
79.9,11:23:50,
78.0,11:23:55,
78.3,11:24:00,
81.5,11:24:05,
77.6,11:24:10,
77.8,11:24:15,
78.0,11:24:20,
77.5,11:24:25,
81.4,11:24:30,
83.2,11:24:35,
81.3,11:24:40,
81.1,11:24:45,
80.1,11:24:50,
82.4,11:24:55,

Plate A2 (Power Saw)

Date Time=06/17/09 11:34:00
Sampling Time=5
Record Num= 12
Leq Value=96.3 SEL Value=114.1
MAX Value=101.8
MIN Value=75.0
Freq Weighting=A Time Weighting=Fast
92.1,11:34:00,
95.4,11:34:05,
93.2,11:34:10,
93.5,11:34:15,
95.8,11:34:20,
95.9,11:34:25,
95.4,11:34:30,
96.1,11:34:35,
96.3,11:34:40,
96.3,11:34:45,
96.4,11:34:50,
96.4,11:34:55,

Plate A3 (Peterson 5000H Chipper)

Date Time=06/17/09 11:41:00
Sampling Time=5
Record Num= 60
Leq Value=96.6 SEL Value=121.3
MAX Value=105.2
MIN Value=73.5
Freq Weighting=A Time Weighting=Fast
74.6,11:41:00,
77.0,11:41:05,
84.4,11:41:10,
90.1,11:41:15,
96.1,11:41:20,
97.6,11:41:25,
98.4,11:41:30,
98.8,11:41:35,
99.1,11:41:40,
99.3,11:41:45,
99.5,11:41:50,
100.1,11:41:55,
100.6,11:42:00,
100.7,11:42:05,
100.5,11:42:10,
100.4,11:42:15,
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100.1,11:42:25,
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98.5,11:43:55,

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97.7,11:44:35,
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97.5,11:44:45,
97.5,11:44:50,
97.4,11:44:55,
97.3,11:45:00,
97.2,11:45:05,
97.1,11:45:10,
97.1,11:45:15,
97.0,11:45:20,
96.9,11:45:25,
96.9,11:45:30,
96.8,11:45:35,
96.7,11:45:40,
96.7,11:45:45,
96.6,11:45:50,
96.6,11:45:55,

Plate A4 (CAT Generator 100KVA)

Date Time=06/17/09 13:11:00
Sampling Time=5
Record Num= 60
Leq Value=81.4 SEL Value=106.1
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Plate A5 (CAR 322 Grabber)

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Plate A6 (Grinder)

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Plate A7 (Conveyor McClosky)

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Appendix B (Procedure for the handling of fuel)

1. PROCEDURE FOR THE STORAGE OF FUEL

1.1. Storage of Fuel

1.1.1. All oil, fuel chemicals and waste material that could result in the risk of uncontrolled discharge of pollutants into the surrounding environment will be contained in secondary containment structures adequately designed to prevent any releases or spills on the land and subsequently to groundwater. The vehicle refueling station and generator supply fuel tank will also be equipped with secondary containment structures. These secondary containment structures will be in accordance with IFC guidelines and standards or the EPA's Spill Prevention, Control, and Countermeasure (SPCC) Rule.

1.1.2. Where the circumstances require, fuel may be stored in an approved mobile refueling tank.

1.1.3. Storage of mobile fuelling tanks when not in use shall be within an area where there is no exposure to damage by vehicular movement.

1.1.4. The fuel storage area will be located as far away as possible from drainage channels.

1.1.5. All tank vehicles and mobile refueling tanks are to be properly labeled.

1.1.6. Approved fire extinguishers will be located near the fuel storage areas.

1.1.7. Smoking will not be permitted in the area of the fuel storage facility and "No Smoking" signs will be posted. No smoking will be allowed during any fuelling operations. "No Smoking" signs are to be maintained in good condition.

1.1.8. Waste oils, lubricants, greasy and oily rags or other materials subject to spontaneous combustion will be retained in a labeled container used for that purpose exclusively and will be properly disposed of at frequent intervals.

1.1.9. Appropriate emergency spill equipment will be available in the fuel storage area and in mobile tanker (see Section 6).

1.1.10. No "hot work" shall take place within at least 5 meters of fuel storage zone.

1.1.1. In cases where fuel is being stored on site, this Procedure shall be posted or available on site and a copy shall be incorporated in the company safety policies and procedures.

1.2. INSPECTION AND MAINTENANCE

1.2.1. ***Daily:*** fuel truck tanks and associated pumps, hoses and connections.

1.2.2. ***Weekly:*** secondary containment areas in accordance with IFC guidelines or SPCC Rules

1.2.3. ***Monthly:*** Bulk storage tanks, secondary containment structures, associated valves and connections.

1.2.4. ***Quarterly:*** spill response equipment will be inventoried and maintained in good working order on a quarterly basis.

1.2.5. During all inspections, depleted inventories will be restocked and any mechanical problems will be scheduled for repairs. Logs for inspection will be kept by the Environmental Manager/Office on site.

1.2.6. A procedural review will be conducted annually by the environmental manager/officer to assure that the SPCC remains consistent with changing operational practices, regulations, and other factors.

1.2.7. The review will evaluate the locations of response cashes, the adequacy of cache inventories, and the operational facility of the site including notification and reporting procedures, training efforts, spill history recording, and other factors important to the effectiveness of the plan.

Appendix C (Solid Waste Contract)

Plate C1 (Contract between BR and Libra Sanitation)

Buchanan
Renewables

J. Abraham Dees
Operation Manager
Libra Sanitation Incorporated
Perry Street, Capitol Bye-Pass
Monrovia, Liberia

December 2, 2008

Dear Mr. Dees,

Re: Appointment of Libra Sanitation Inc. as waste collector for Buchanan Renewables (BR)

We hereby appoint Libra Sanitation Inc. to collect and dispose of garbage (used oil and fuel filters, used tires and other domestic and office wastes) for Buchanan Renewables in both Monrovia (BR House and Office) and Buchanan (BR Compound, BR Port Facility and BR Residences). The scope of work, frequency of collection, and service charge are as defined in the attached invoice.

Either party may terminate this agreement at anytime by giving the other party one months notice.

Sincerely,

Alexandra Baillie
Buchanan Renewables

J. Abraham Dees
Libra Sanitation Incorporated

Dec 3rd, 2008
Date

Buchanan Renewables BV
Congo Town, Monrovia, Liberia
Tel: +231 777 98 4 17/18

Plate C2 (Frequency of Collection)

DISPOSAL OF GARBAGE FROM THE COMPOUNDS OF THE
BUCHANAN RENEWABLES IN MONROVIA AND BUCHANAN

SCOPE OF WORK:
To collect and dispose of garbage (used oil and fuel filters, used tires and other domestic and office wastes) from the compounds of the Buchanan Renewable in Congo Town, Monrovia and Buchanan City, Grand Bassa County and dispose of same at the approved disposal sites.

FREQUENCY OF COLLECTION
The selection for the frequency of collection shall be made by the Management of Buchanan Renewables and for the given agreement is defined below. Collection will take place on Mondays and Fridays in both Buchanan and Monrovia.

SERVICE CHARGE

FREQUENCY OF COLLECTION	LOCATION	MONTHLY COST
Two Days Per Week	Monrovia	US$ 75.00
Two Days Per Week (Residence)	Buchanan	US$ 75.00
Two Days Per Week (Compound)	Buchanan	US$ 325.00
Two Days Per Week (Port Area)	Buchanan	US$ 75.00
Grand Total Cost Per Month for all		US$550.00

Note: One time cost for removing of stock pile of wastes.....$100.00
Payable upfront before work start: but job have been done
Base upon client's request.

Signed:____________________
J. Abraham Dees
OPERATION MANAGER

Plate C3 (Collection Point)

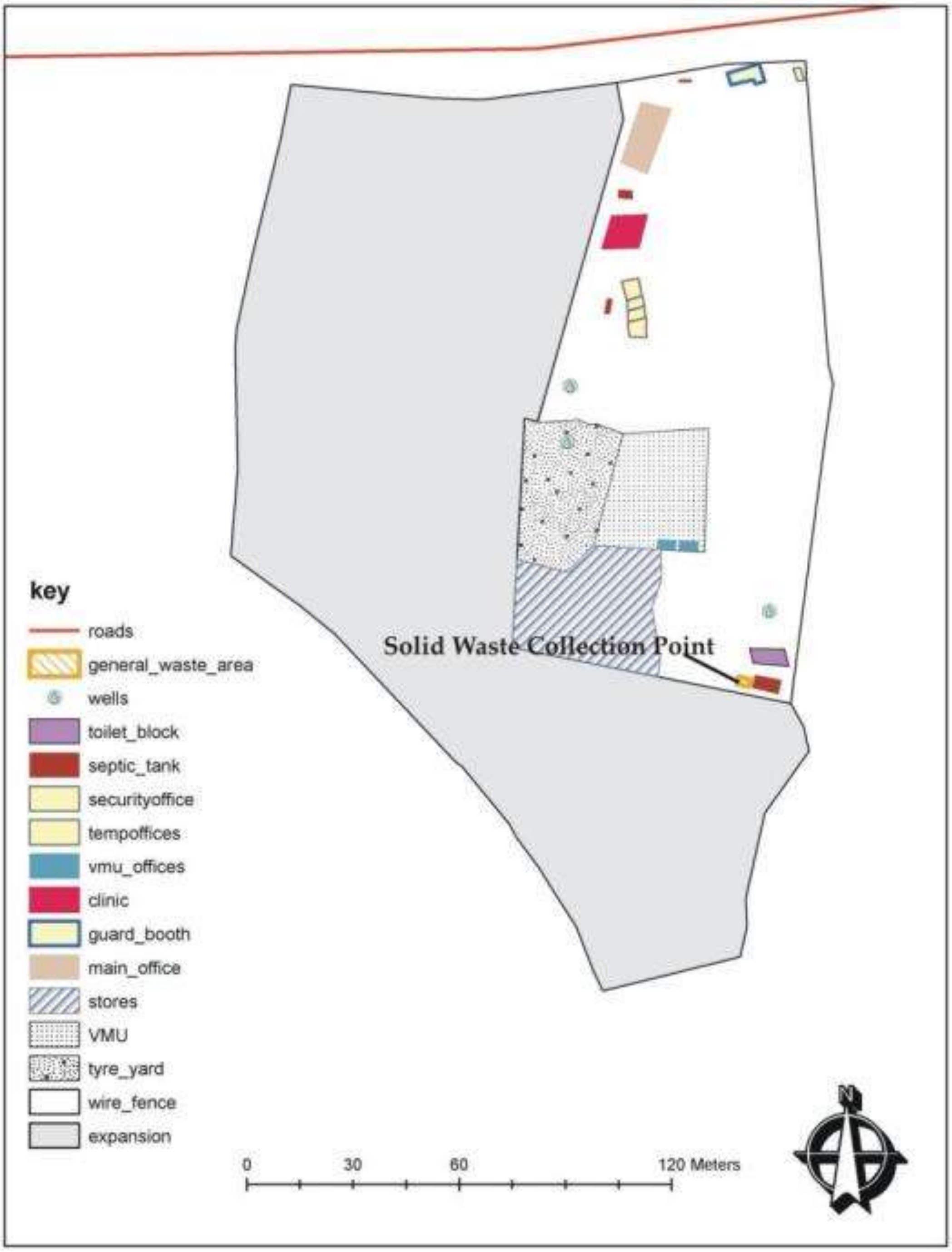


Plate C4 (EPA letter of approval of the dump site in Buchanan)

ENVIRONMENTAL PROTECTION AGENCY
P. O. Box 4024
4th Street, Tubman Blvd., Sinkor
1000 Monrovia 10, Liberia

August 15, 2008

Mr. Abraham Dees
Operation Manager Libra Sanitation
Buchanan, Grand Bassa County, Liberia

Dear Manager:

In view of your August 10, 2008 request for a dump site to dump solid waste collected from the compound of the Arcelor Mittal, I am pleased to inform you of our acceptance.

Regarding the above, the dump site along the OWN YOUR OWN road has been properly inspected and approved by EPA with the knowledge of the Buchanan City Corporation for your disposer from this date to November 30, 2008.

Please note that inspection of this dump site shall be done subsequently and failure to establish good waste management practices shall warrant the cancellation of this document.

Best regards.

Truly yours,

Kou M. Queia
Inspector EPA, Buchanan,
Grand Bassa County

Plate C5 (Letter of permit by Buchanan City Corporation to Libra Sanitation)

REPUBLIC OF LIBERIA
MINISTRY OF INTERNAL AFFAIRS
BUCHANAN CITY CORPORATION
GRAND BASSA COUNTY

Office of the Lord Mayor
Cell #: 06-569-504

August 15, 2008

Management of LIBRA
Sanitation Inc. Monrovia Perry
Street Monsterrado County

Dear Management,

Per previous discussions, based on the collection of garbage which you have had a contract from Arcelor Mittal in the LIMCO Loop areas, the city government have deemed it necessary to grant you this permit.

This means that we have met with the (EPA) environmental protection agency, including other government ministries as well.

Furthermore, this document explains that you have to collect garbage and dispose same the designated area that we have shown you. Any violation besides the area you will be responsible.

Truly yours,

Hon. Obediah Y. Zamgar Sr.
Mayor, Buchanan City

Plate C6 (Letter of certification by EPA to Libra Sanitation)

Office of Executive Director

ENVIRONMENTAL PROTECTION AGENCY
P.O. Box 4024
4th Street, Tubman Blvd., Sinkor
1000 Monrovia 10, Liberia

EPA

ED/EPA-01/0257/08/RL

TO WHOM IT MAY CONCERN

This is to certify that the LIBRA SANITATION INC is fully recognized as a waste disposal entity by the Environmental Protection Agency of Liberia and is functioning in compliance with the Environment Protection and Management Law (EPML) of the Republic of Liberia.

Given at Monrovia, Liberia, on this 26th Day of December, in the year, Two Thousand and Eight.

Ben Turtur Donnie
EXECUTIVE DIRECTOR

ENVIRONMENTAL PROTECTION AGENCY OF LIBERIA
MONROVIA, LIBERIA

Mobile 231 6511387 Fax 231 77523432 E-mail:benturturdonnie@yahoo.com

Appendix D (Minutes of Public Hearing)

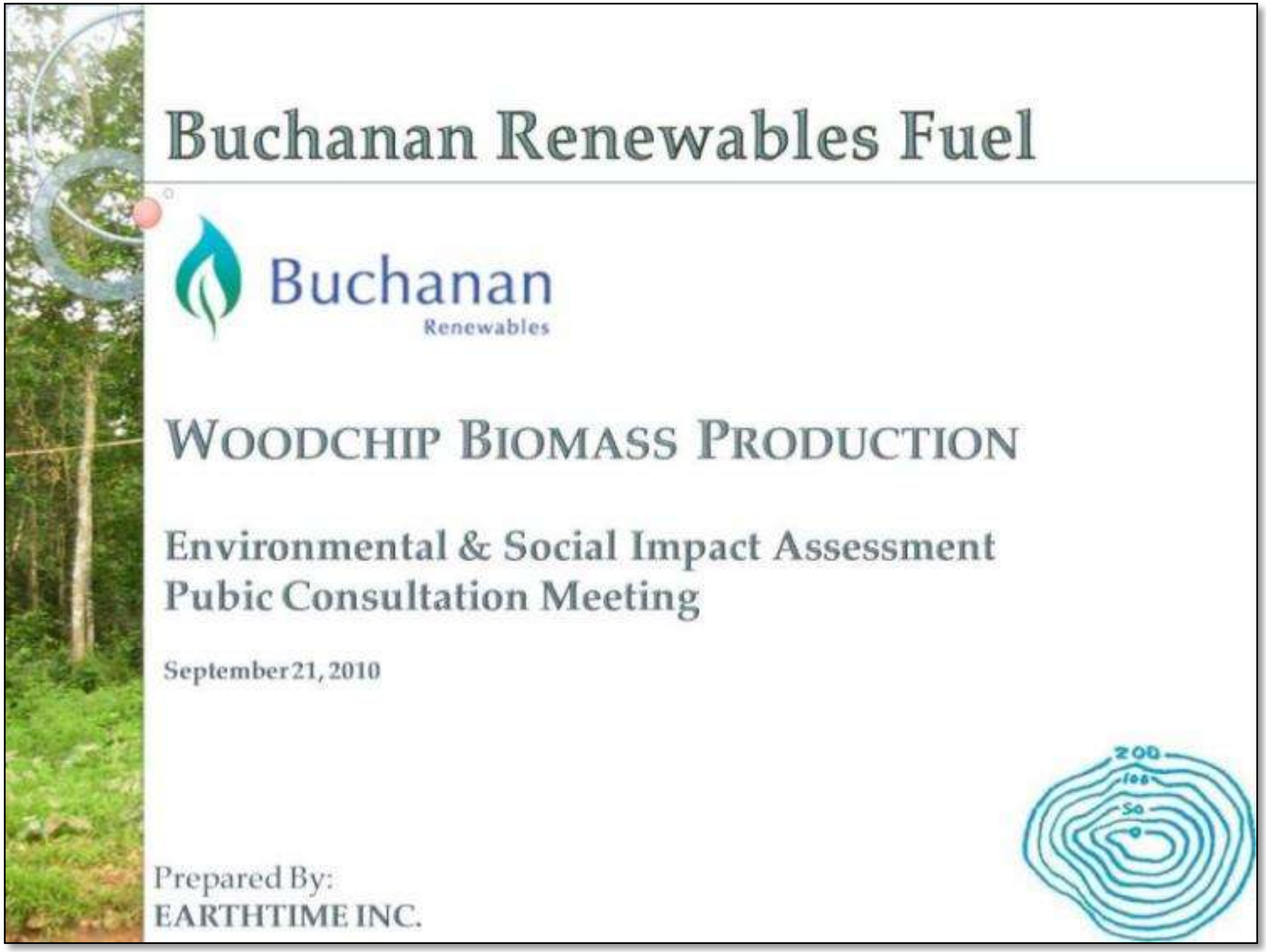
List of Public Consultation Participants

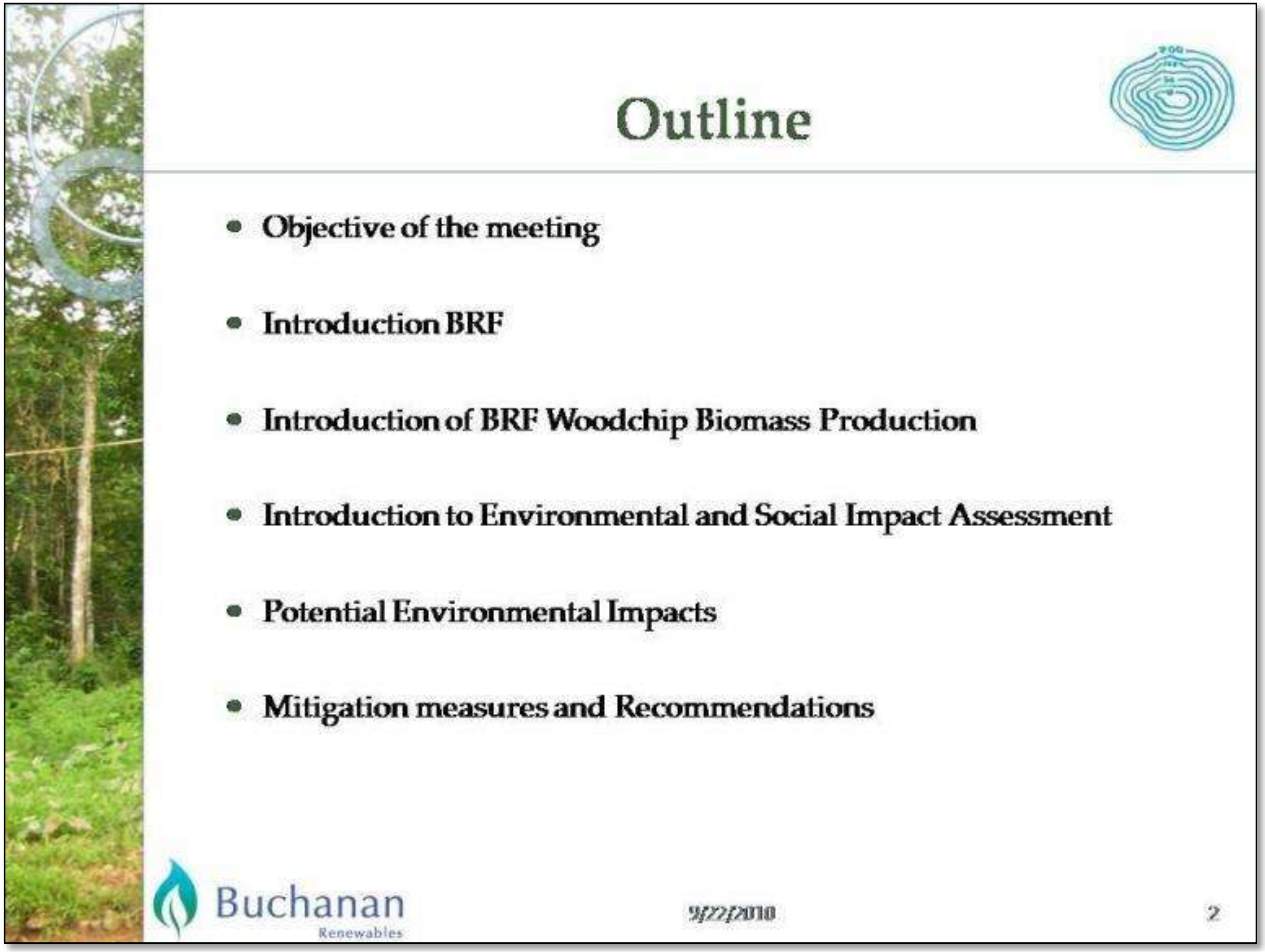
Name	Institution	Position	E-mail	Contact No.
Sept-21-2010				
Benjamin Karmorh Jr.	Environmental Protection Agency		benkarmorh@yahoo.com	
Teeko T. Yorlay	Ministry of Internal Affairs		ttyorlay@yahoo.com	06-412216
Matilda Parker	National Port Authority(NPA)		matildaparker@aol.com	
Roger Sherman	Rubber Planters Association of Liberia		rsherman2001@yahoo.com	
Robin Wheeler	ACDI/VOCA		rwheeler@acdivoca-lib.com	
Clinton Layweh	Rural and Renewable Energy Agency		cglayweh@yahoo.com	06-570719
Amare Tegbaw	Substainable Tree Crops Program		ategbaw@cgiar.or	
Dr. Nouhou Ndam	Flora & Fauna International		nouhou.ndam@yahoo.com	088-0541468
Jonathan W. Yiah	Sustainable Development Institute		jyiah@sdiliberia.org	06-426271
Sammuel J. Askie	Ministry of Internal Affairs		eekzmoo@yahoo.com	06-548073
H. Quiency Myers	Todee Rubber Farmer Association			06-594385
Joe Y. Gono	Todee Rubber Farmer Association			
Sept-22-2010				
Jeneba Kamamra	National Port Authority(NPA)	Technical Manager	jenebakamara@yahoo.com	06-387306
Matthew Snowea	National Port Authority(NPA)	Planning Manager	msnowea@yahoo.com	06-757524
Mohamed Lavalie	National Port Authority(NPA)	Chief of office Staff	calisolave@yahoo.com	06-356820
Matilda Parker	National Port Authority(NPA)	Managing Director	matildaparker@aol.com	06-997763
S. Gayah Karmo	National Port Authority(NPA)	Deputy Managing Director/Administration		06-205334
Jeffery George	National Port Authority(NPA)	Deputy Managing Director/Operation		06-511260
Christain kpelerpeala	National Port Authority(NPA)	Comptroller		06-762946
Jocob D.	National Port	PRO/CCS		06-553225

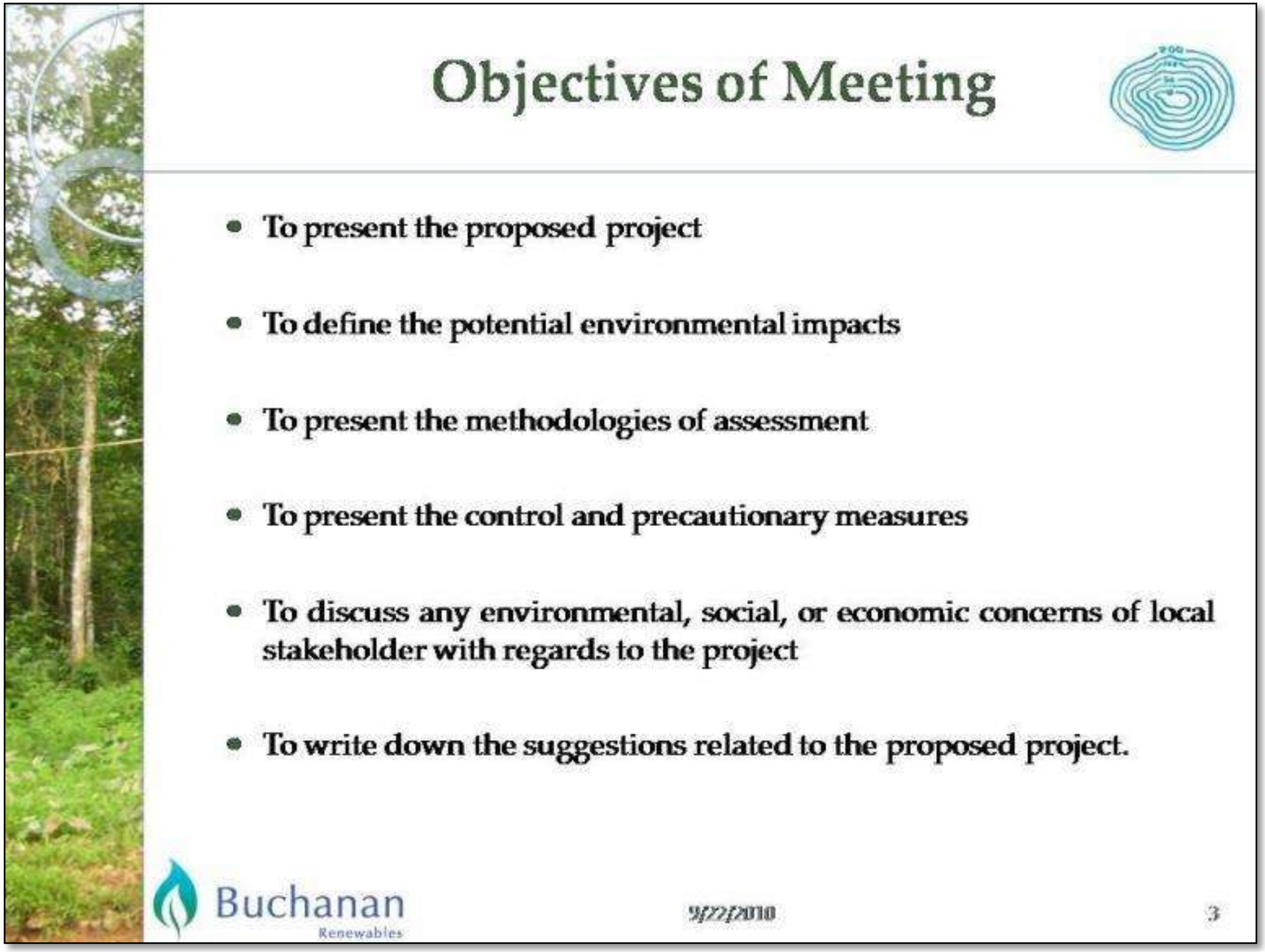
Walker	Authority(NPA)			
Sekou B. Korleh	National Port Authority(NPA)	Director/Procurement	skorleh@yahoo.com	06-492300
Capt. Armett E. Hill	National Port Authority(NPA)	Harbor Master	armetth@yahoo.com	06-697316
Patrick M. Darquare	National Port Authority(NPA)	Assistant Income Manager		06-527417
Augustus M. Paasewe	National Port Authority(NPA)	Account Manager	apaasewe2007@yahoo.com	06-540820
Herbert K. Mensah	National Port Authority(NPA)	Director	herbmensah@yahoo.com	06-557398
S. Eric Allison	National Port Authority(NPA)	Chief Accountant		06-512662
Momolu S. Johnson	National Port Authority(NPA)	Expenditure Manager	MomoluJohnson@yahoo.com	06-513561
Cllr. Peater Tiah	National Port Authority(NPA)	Legal Counsel	attydexter-2007@yahoo.com	
Baunabas Kasor	National Port Authority(NPA)	Operation Manager		06-51105
Sept-24-2010				
Jame Kpadehyea	Forestry Development Authority(FDA)	Manager	kpadehyeajames@yahoo.com	06-599715
Mulbah	Forestry Development Authority(FDA)	Forester		077-348254
Franklin W. Philips	Forestry Development Authority(FDA)	Forester	fphilips2006@yahoo.com	06-496251
Konikay A. Nimely	Forestry Development Authority(FDA)	Forester	Konikaya.nimely@yahoo.com	06-562134
Gayfior Kemah	Forestry Development Authority(FDA)	Forester		
Evans M. Kiatamba	Forestry Development Authority(FDA)	EIA Officer		06-410274
Ruth K. Varney	Forestry Development Authority(FDA)		Konahvarney@yahoo.com	06-518393
Fabian N. Kieh	Forestry Development Authority(FDA)	EIA Officer	fabiannkieh@yahoo.com	077-712789
Jangar S. Kamara	Forestry Development Authority(FDA)	Technical Manager	jangerskamara@yahoo.com	
Sept-28-2010				
Justin Barkon	BR Fuel	Warehouse Administrator		

P. Martins Zayzay	BR Fuel	Fuel Dept. Administrator		
Larry T. Kanwee	BR Fuel	GIS/IT Technician		
Edmund S. Korpu	BR Fuel	Fuel Supervisor		
Sam B. Reeves	BR Fuel	Artist Supervisor		
Ben Pawa	BR Fuel	Transport Coordinator		
Stephen Monday	BR Fuel	Environmental Officer		
Marvin M. Sokomou	BR Fuel	General Supervisor(Port Compound)		
Nelson Hill	BR Fuel	Agriculture Manager		
Emphyx Yarker	BR Fuel	Data Entry Clark		
Joshua Gabbidon	BR Fuel	Warehouse		
Marttia Killen	BR Fuel	Clinic Supervisor		
Victor Jarplah	BR Fuel			
Levi B. Zangai	Grand Bassa Community College			06-722-389
Dehsaywren C.T Colnie	G-Bag			06-845-340
Obediah G. Goffa	Bowaside			077-943-740
Christoplier Neufville	Commissioner Office			077-421-452
Elaine Jackson	Zone Six(6) Leader			06-699134
Richard T. Mason	Own Your Own			077-626-161
Stephen Monday	BRE			06-410-752
Emmanuel D. Nyema	USIRWUL, S.G			06-713-825
Nelson Hill	BRE			06-582-264
Kou M. Queia	EPA			06-594-122
Obediah Andrews	BRE			06-877-527
Obediah Zouyor		Major		06-569-504
T.-Wah Bedell Sr.	GoL	Council Man		06-524-045
Joe Lawson	BR			077-316-737
Abraham Kollie	Civil Society Org.			077-069-773
Eoans L. Stevesnon	YMCA			06-110-585
Martha F.	Ban Women Dev.			06-845-349

Karnga	Association			


Buchanan Renewables Fuel
Buchanan
Renewables
WOODCHIP BIOMASS PRODUCTION
Environmental & Social Impact Assessment
Pubic Consultation Meeting
September 21, 2010
Prepared By:
EARTHTIME INC.


Outline
Objective of the meeting
Introduction BRF
Introduction of BRF Woodchip Biomass Production
Introduction to Environmental and Social Impact Assessment
Potential Environmental Impacts
Mitigation measures and Recommendations
Buchanan
Renewables
9/22/2010
2

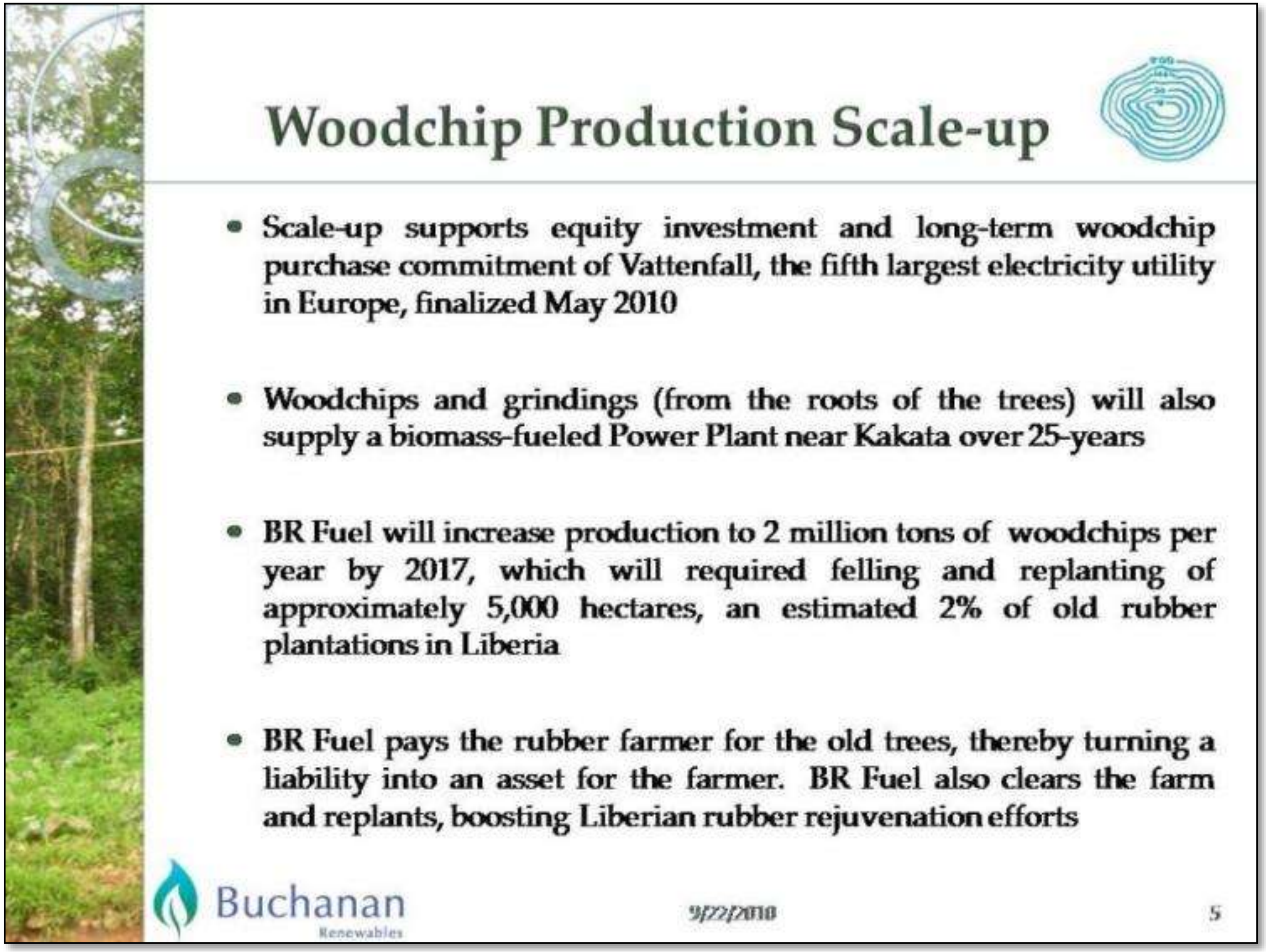

Objectives of Meeting
To present the proposed project
To define the potential environmental impacts
To present the methodologies of assessment
To present the control and precautionary measures
To discuss any environmental, social, or economic concerns of local stakeholder with regards to the project
To write down the suggestions related to the proposed project.
Buchanan
Renewables
9/22/2010
3

Buchanan Renewables Fuel

- BR Fuel produces and supplies end-of-life rubber wood for export to Europe as well as a 36MW dedicated biomass power plant to be constructed near Monrovia.
- Since creation in 2007, BR Fuel and affiliate companies have invested US$90m in building and expanding the business
- BR Fuel has received support and endorsement by Greenpeace, the European Climate Foundation, and other international NGOs as well as awards from the Corporate Council for Africa and recognition from Time Magazine.
- BR Fuel is affiliated with the McCall MacBain Foundation and has a strong social development focus and is committed to helping build Liberia's emerging economy.

Buchanan Renewables

9/22/2010 4


Woodchip Production Scale-up
Scale-up supports equity investment and long-term woodchip purchase commitment of Vattenfall, the fifth largest electricity utility in Europe, finalized May 2010
Woodchips and grindings (from the roots of the trees) will also supply a biomass-fueled Power Plant near Kakata over 25-years
BR Fuel will increase production to 2 million tons of woodchips per year by 2017, which will required felling and replanting of approximately 5,000 hectares, an estimated 2% of old rubber plantations in Liberia
BR Fuel pays the rubber farmer for the old trees, thereby turning a liability into an asset for the farmer. BR Fuel also clears the farm and replants, boosting Liberian rubber rejuvenation efforts
Buchanan
Renewables
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BRF Project Activities
Cutting down rubber trees using excavators or feller-bunchers and skidders;
Sawing off the branches with chainsaws and chipping the trees in portable wood chippers and trucking them to the port of power plant site OR, in future, trucking logs to stationary chippers at the woodchip handling facility or power plant site;
Preparing the land, replanting or providing support to farmers to replant;
Rehabilitating some roads within and around plantations as required;
Maintaining the fleet of equipment;
Storing woodchips and logs, quality control tests; and
Loading and shipping the woodchips using a loading conveyor, some shovels and some trucks.
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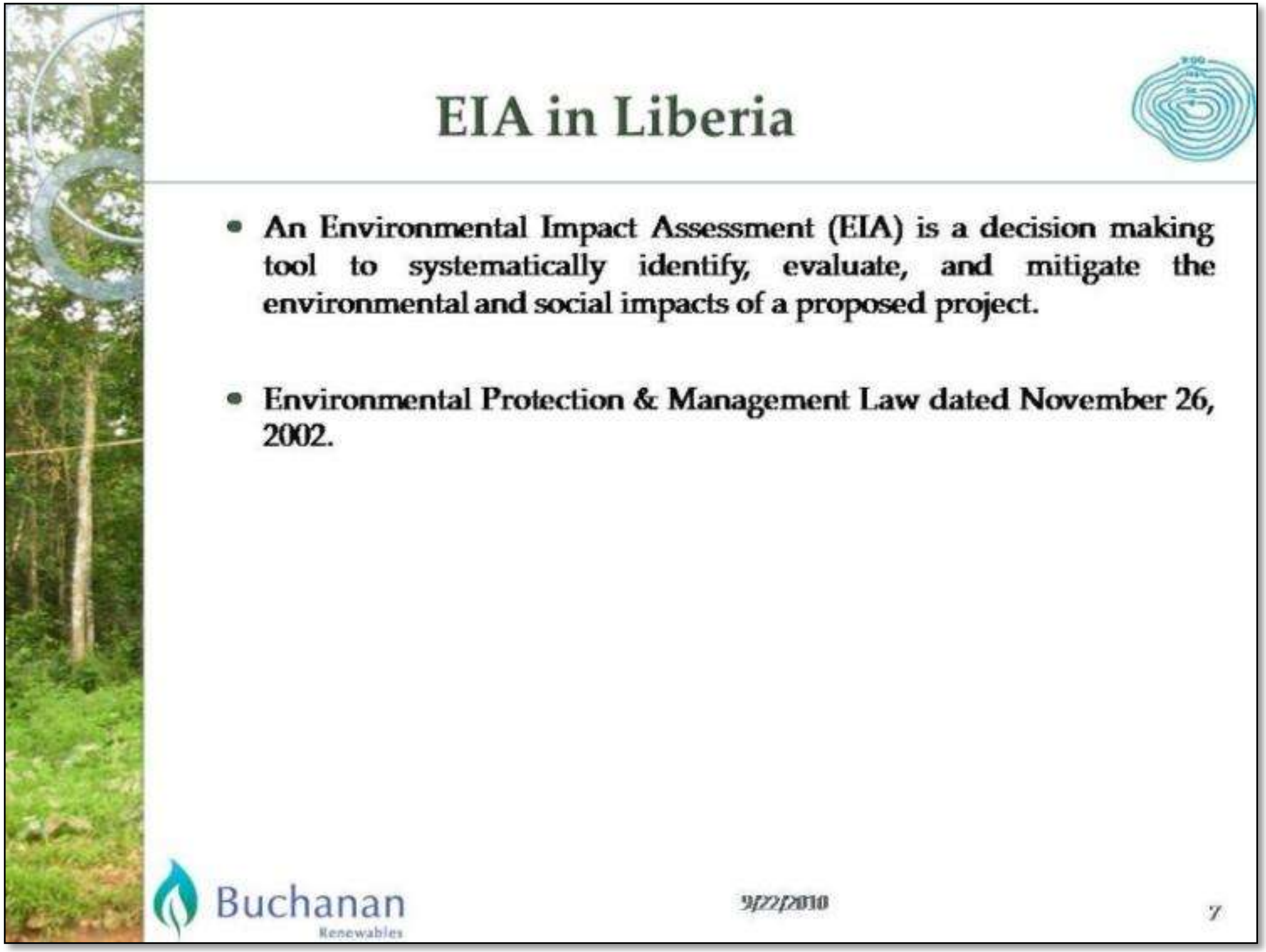
EIA in Liberia
• An Environmental Impact Assessment (EIA) is a decision making tool to systematically identify, evaluate, and mitigate the environmental and social impacts of a proposed project.
• Environmental Protection & Management Law dated November 26, 2002.
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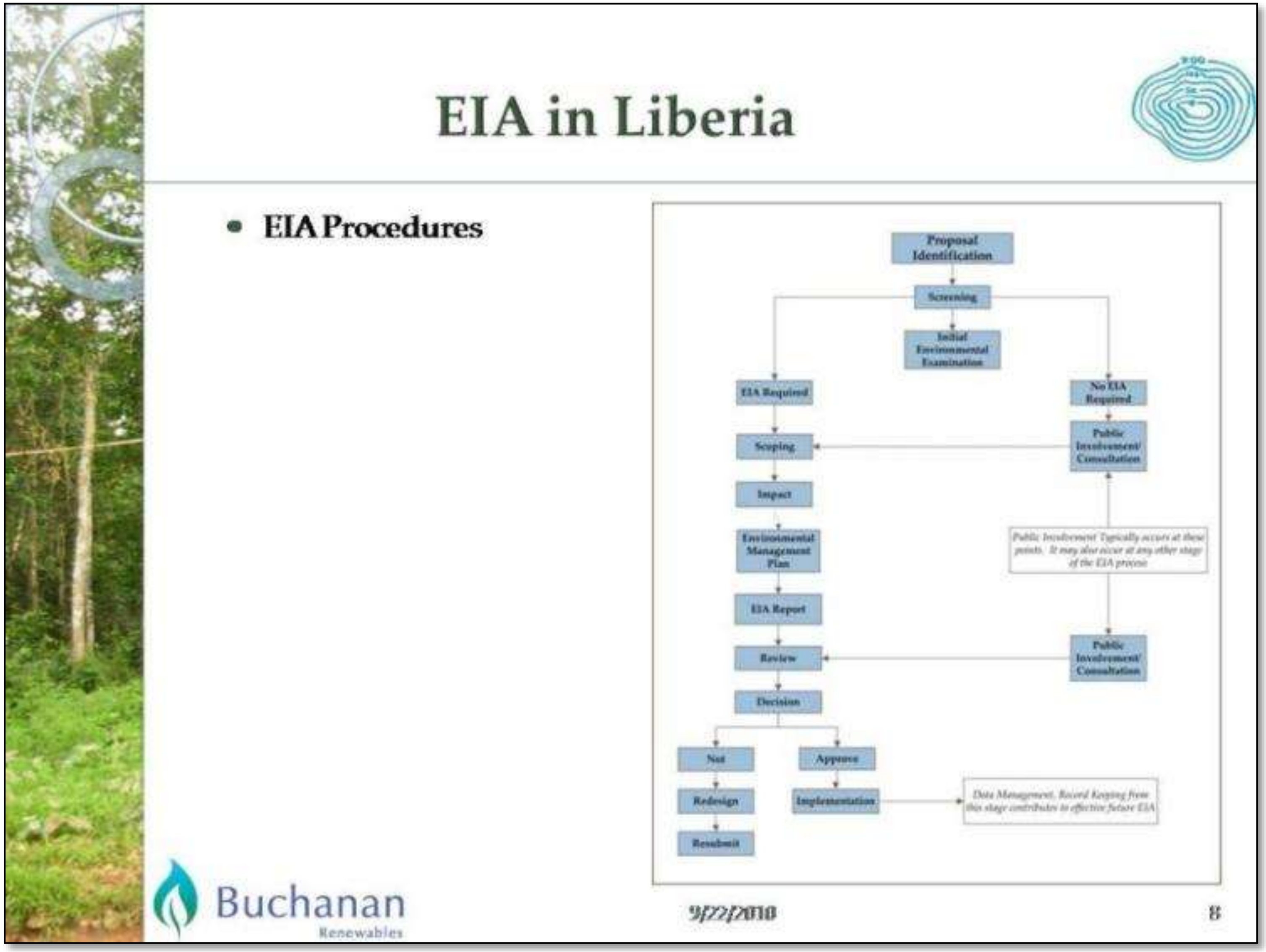
EIA in Liberia
EIA Procedures
Proposal Identification
Screening
Initial Environmental Examination
EIA Required
No EIA Required
Scoping
Public Involvement/ Consultation
Impact
Environmental Management Plan
Public Involvement Typically occurs at these points. It may also occur at any other stage of the EIA process
EIA Report
Review
Public Involvement/ Consultation
Decision
Not
Approve
Redesign
Implementation
Data Management, Record Keeping from this stage contributes to effective future EIA
Resubmit
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Environmental Components
Air Quality;
Soil;
Water Resources;
Biodiversity & Landscape;
Noise;
Socio-Economic Impact;
Human Health & Occupational Safety
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Impacts on Air Quality
• Sources of Air emissions:
➢ Machinery and vehicles;
➢ Power plants and combustion facilities
➢ cutting of trees,
➢ sawing of branches and
➢ chopping the wood
• Negative Impacts
➢ Reduction of Ambient Air Quality
➢ Health issues
Buchanan Renewables will commit to use the best available technologies in terms of dust and gaseous emissions controls. This will include performing regular maintenance of vehicles in addition to routes watering.
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Impacts on Soil

- Activities may result in soil erosion, compaction as well as pollutants leaking into soil and groundwater.

- Soil samples will be taken from Fuel tanks site
- Stratified soil sampling to study soil type, texture, moisture content, topsoil depth and susceptibility to erosion.
- Preexisting soil compaction conditions will also be assessed.
- Pre-harvest water quality assessment will include an assessment of baseline turbidity (NTU), transparency (%) upstream and downstream from the site area.

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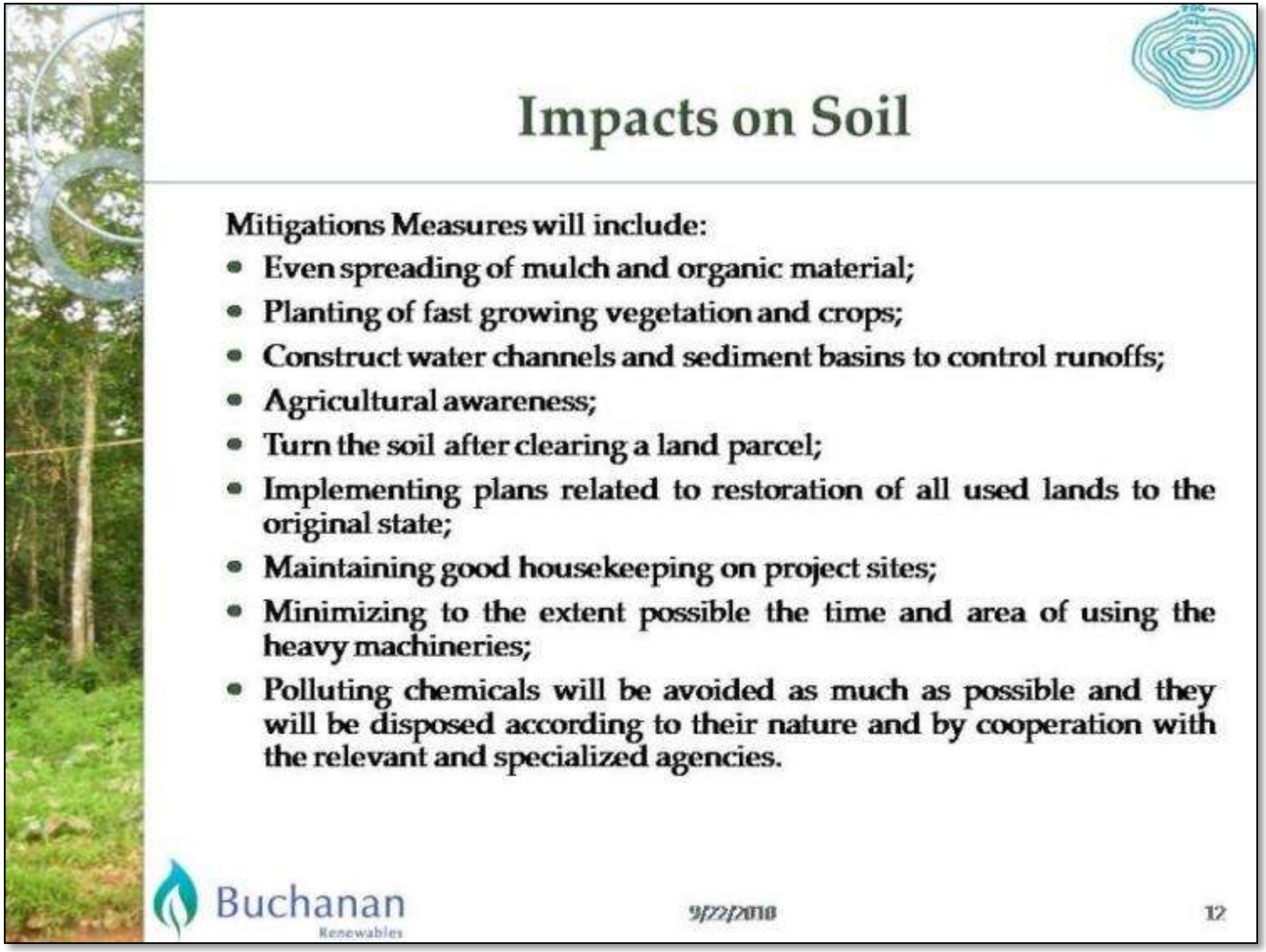
Impacts on Soil
Mitigations Measures will include:
Even spreading of mulch and organic material;
Planting of fast growing vegetation and crops;
Construct water channels and sediment basins to control runoffs;
Agricultural awareness;
Turn the soil after clearing a land parcel;
Implementing plans related to restoration of all used lands to the original state;
Maintaining good housekeeping on project sites;
Minimizing to the extent possible the time and area of using the heavy machineries;
Polluting chemicals will be avoided as much as possible and they will be disposed according to their nature and by cooperation with the relevant and specialized agencies.
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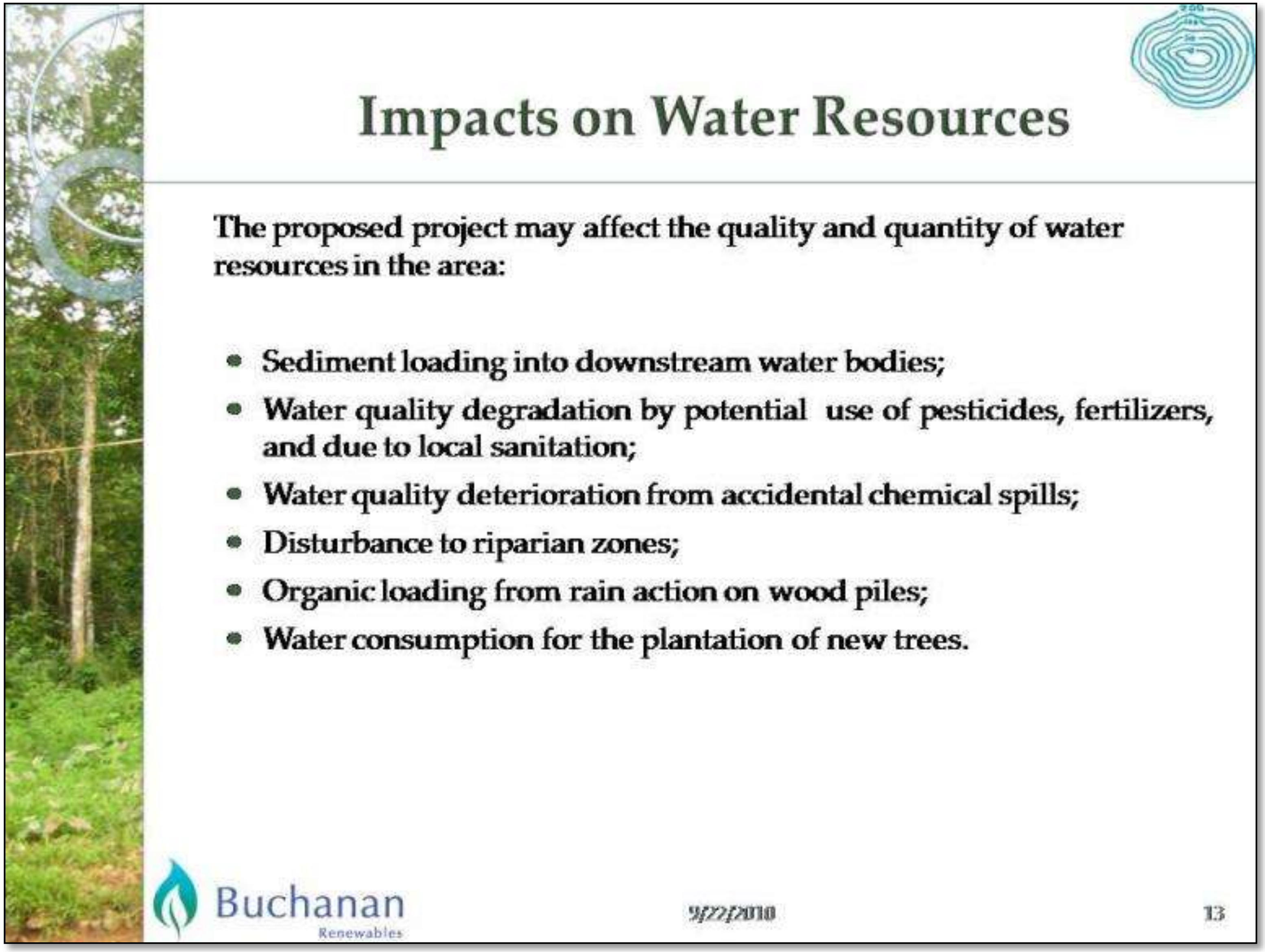
Impacts on Water Resources
The proposed project may affect the quality and quantity of water resources in the area:
• Sediment loading into downstream water bodies;
• Water quality degradation by potential use of pesticides, fertilizers, and due to local sanitation;
• Water quality deterioration from accidental chemical spills;
• Disturbance to riparian zones;
• Organic loading from rain action on wood piles;
• Water consumption for the plantation of new trees.
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Impacts on Water Resources

Mitigation Measures:

- Develop riparian management zone;
- Build natural embankment at water bodies;
- Avoid littering or discharge of any debris into nearby water bodies;
- Awareness on the application of biological fertilizers;
- Use chemical fertilizers in low doses;
- Provide preventative spill kits and absorbing material;
- Preserve any riparian zone detected;
- Ensure that workers use provided lavatories off-site;
- Empty lavatories wastewater tanks in any close wastewater treatment system or introduce a build up treatment plant.

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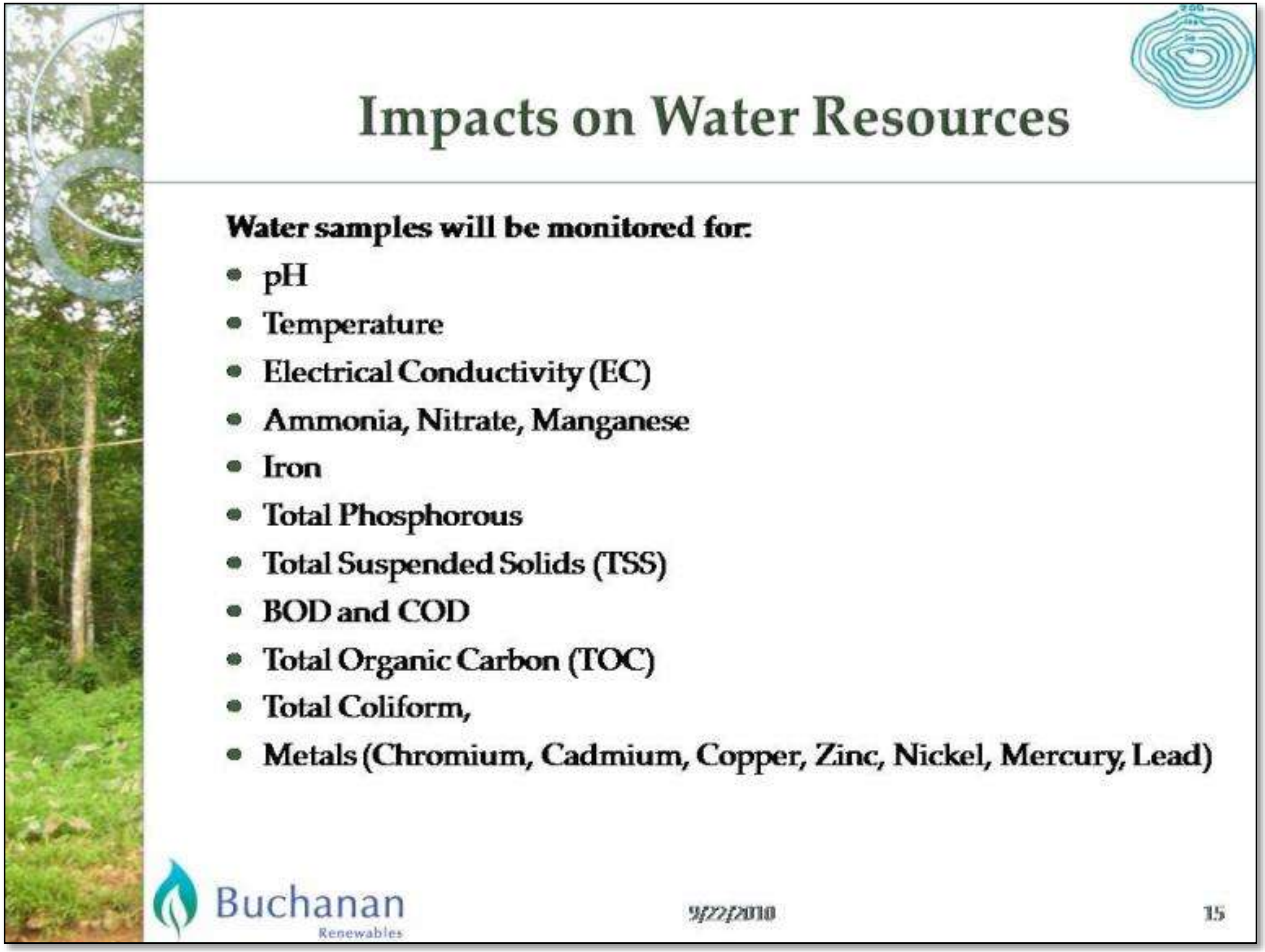
Impacts on Water Resources
Water samples will be monitored for:
• pH
• Temperature
• Electrical Conductivity (EC)
• Ammonia, Nitrate, Manganese
• Iron
• Total Phosphorous
• Total Suspended Solids (TSS)
• BOD and COD
• Total Organic Carbon (TOC)
• Total Coliform,
• Metals (Chromium, Cadmium, Copper, Zinc, Nickel, Mercury, Lead)
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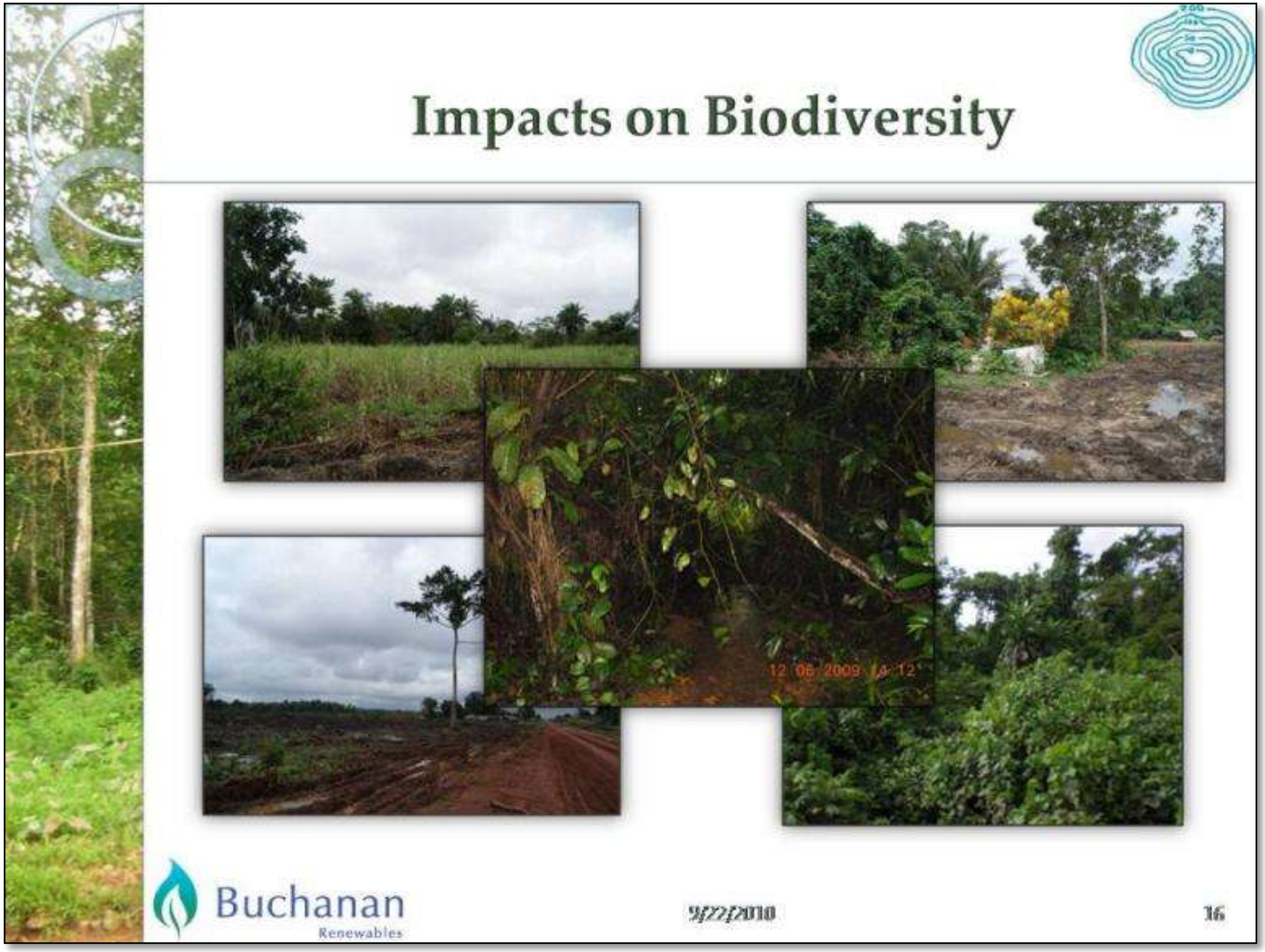
Impacts on Biodiversity
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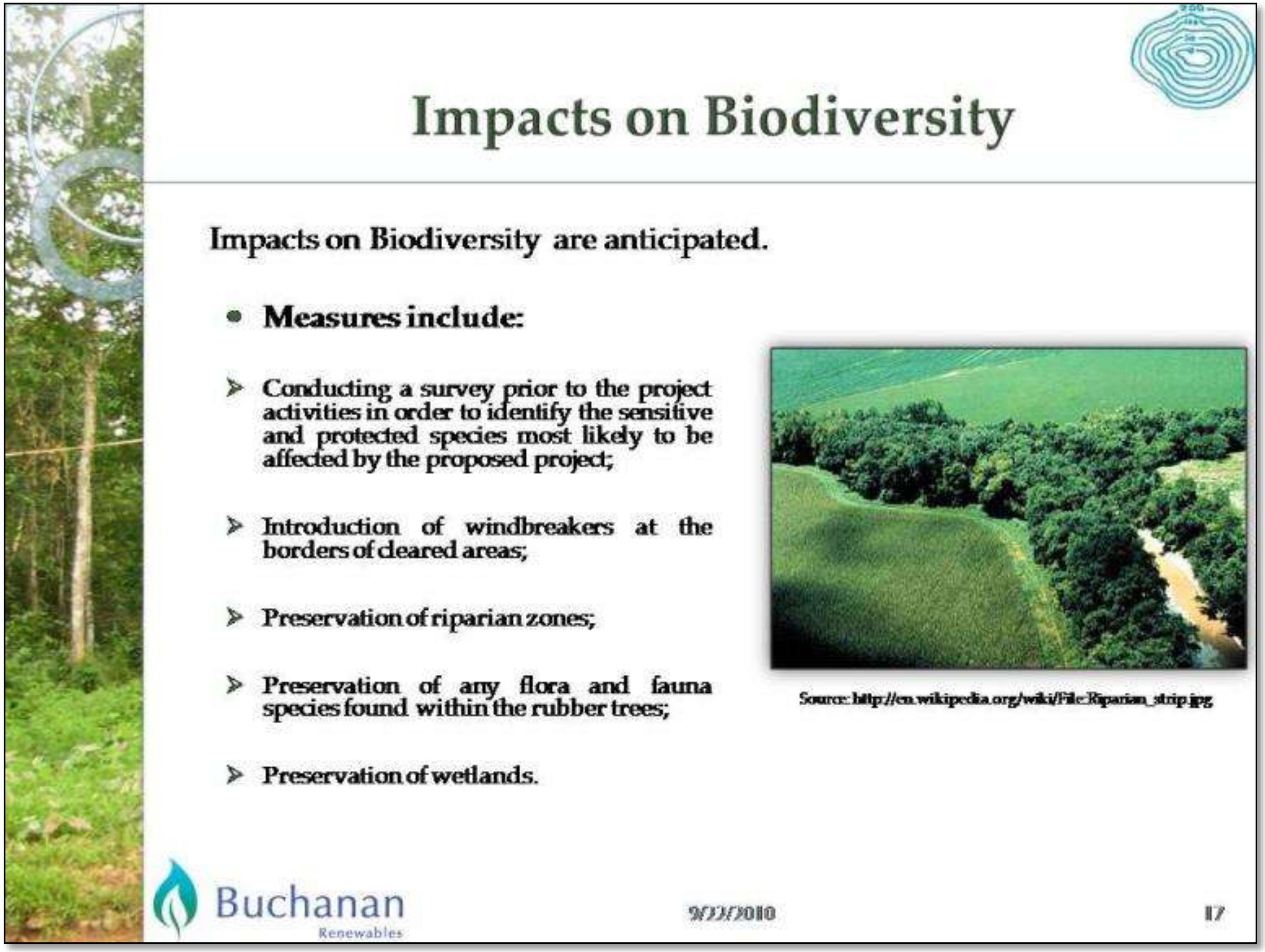
Impacts on Biodiversity
Impacts on Biodiversity are anticipated.
Measures include:
Conducting a survey prior to the project activities in order to identify the sensitive and protected species most likely to be affected by the proposed project;
Introduction of windbreakers at the borders of cleared areas;
Preservation of riparian zones;
Preservation of any flora and fauna species found within the rubber trees;
Preservation of wetlands.
Source: http://en.wikipedia.org/wiki/File:Riparian_strip.jpg
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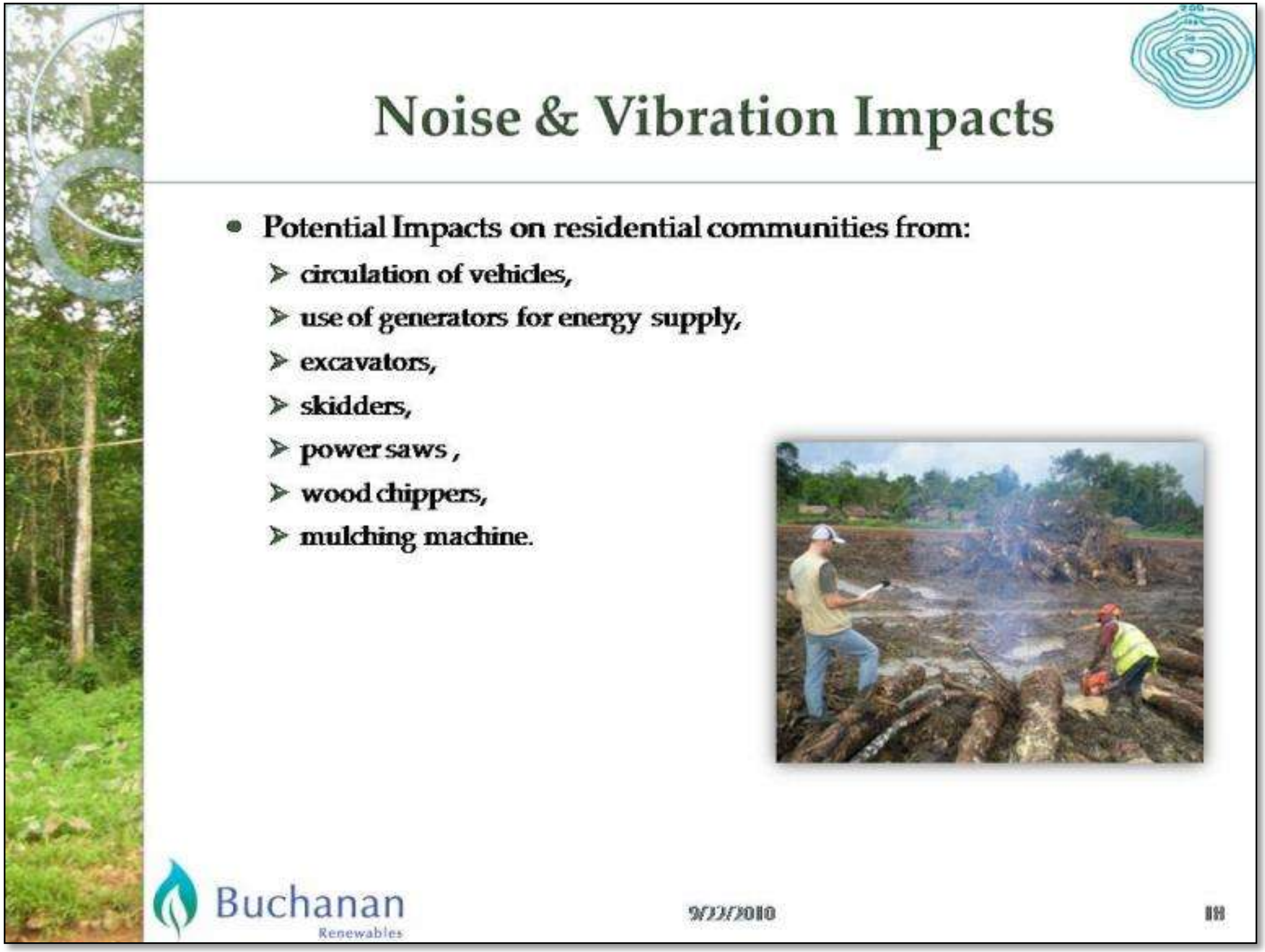
Noise & Vibration Impacts
Potential Impacts on residential communities from:
circulation of vehicles,
use of generators for energy supply,
excavators,
skidders,
power saws ,
wood chippers,
mulching machine.
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Noise & Vibration Impacts

- **Mitigation measures include:**
  - ➢ **Avoid cutting and sawing activities at early and late hours of the day at close residential areas;**
  - ➢ **Use of low-noise engines and installing noise mufflers;**
  - ➢ **Ensure that workers off-site employ personal sound proof devices;**
  - ➢ **Regular maintenance of heavy equipment and keep them away from the sensitive places;**
  - ➢ **Any machinery, which is intermittent in use, should be turned off in periods of non-use.**

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Socio-Economic Impacts
Impacts
Economic:
Employment generation;
Expenditure of wages in local area;
House purchase and rental;
Equipment and services procurement;
Local authority business tax/rates revenue;
Increase in agricultural income;
Increase in property value.
Adverse: Impact on charcoal producers
Mitigation would be leaving piles of wood not used for charcoal production
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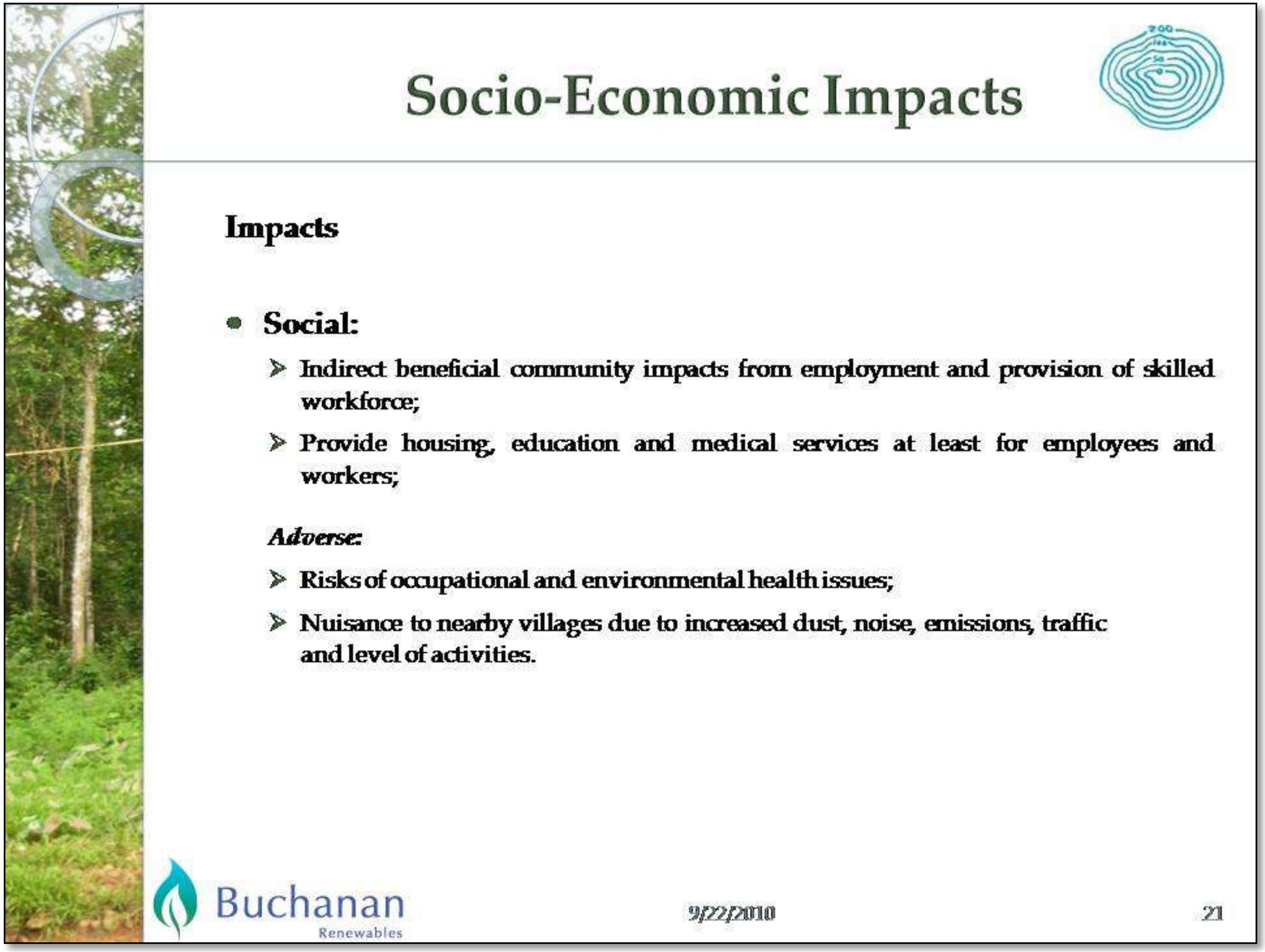
Socio-Economic Impacts
Impacts
Social:
Indirect beneficial community impacts from employment and provision of skilled workforce;
Provide housing, education and medical services at least for employees and workers;
Adverse:
Risks of occupational and environmental health issues;
Nuisance to nearby villages due to increased dust, noise, emissions, traffic and level of activities.
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Socio-Economic Impacts

Mitigation Measures:

- Promote jobs for local communities;
- Publicize data on environmental performances;
- Perform public consultations regarding new projects;
- Integrate local residents in different phases of the project;
- Provide proper awareness on proper practices and working instructions;
- Prohibit employment of children

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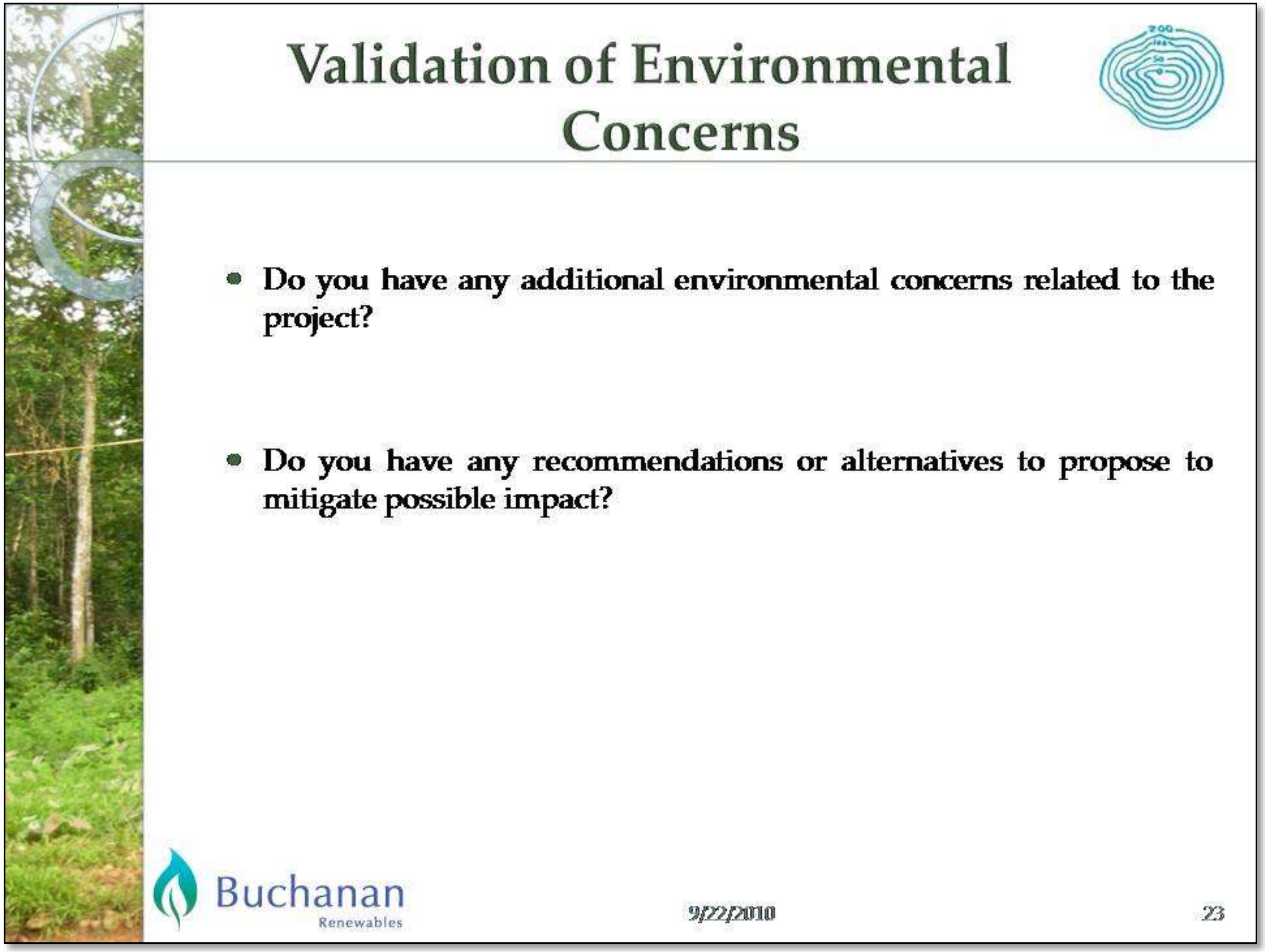
Validation of Environmental Concerns
Do you have any additional environmental concerns related to the project?
Do you have any recommendations or alternatives to propose to mitigate possible impact?
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Thank You
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