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MONROVIA CITY CORPORATION (MCC)

EMERGENCY MONROVIA URBAN SANITATION PROJECT (EMUS)

ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT CHEESEMANBURG URBAN SANITATION PROJECT

MAY 2017

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Disclaimer

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LIST OF ABBREVIATIONS

%	Percent
°C	Degrees centigrade
°F	Degrees Fahrenheit
asl	Above Sea Level
BOD	Biochemical Oxygen Demand
C_2H_4	Ethene
$CaCo_3$	Calcium Carbonate
CDM	Clean Development Mechanism
CEC	Cation Exchange Capacity
CH_4	Methane
cm	centimeter
CO	Carbon Monoxide
CO_2	Carbon Dioxide
COD	Chemical Oxygen Demand
CR	Critically Endangered
dBA	Decibel Adjusted
DO	Dissolved Oxygen
EC	Electrical Conductivity
EHS	Environmental Health and Safety
EMMP	Environmental Management and Monitoring Plan
EMUS	Emergency Monrovia Urban Sanitation Project
EN	Endangered
EPA	Environment Protection Agency
EPML	Environmental Protection and Management Law
EPRP	Emergency Preparedness and Response Plan
ESIA	Environmental and Social Impact Assessment
ESMP	Environmental and Social Management Plan
FDA	Forestry Development Authority
FHWA	Federal Highway Administration
GIIP	Good International Industry Practice
GOL	Government of Liberia
GPS	Global Positioning System
H_2S	Hydrogen Sulphide
HC	Hydrocarbon
HDPE	High Density Polyethylene
IDA	International Developing Agency
Kg	Kilogram
Km	Kilometer
Km/m^3	Kilometer per Cubic meter
l	Liter
LC	Least Concern
Leq	Equivalent Sound level
LRTF	The Liberia Reconstruction Trust Fund
m	Meter
m^3	Cubic meter
mBG	Meter Below Ground
MCC	Monrovia City Corporation
mg	milligram
mg/l	Milligram per liter

MHSW	Ministry of Health and Social Welfare
ml	milliliter
MLME	Ministry of Lands Mines and Energy
MOA	Ministry of Agriculture
MPW	Ministry of Public Works
MRF	Material Recovery Facility
n	count
n.d.	non detectable
NMOC	Non-Methane Organic Compounds
NO_2	Nitrogen Dioxide
NOI	Notice of Intent
NO_x	Nitrogen Oxides
NT	Near Threatened
OSHA	Occupational Safety and Health Administration
PM	Particulate Matter
PP	Polypropylene
PPE	Personal Protective Equipment
PVC	Polyvinyl chloride
QA/QC	Quality Assurance / Quality Control
SO_2	Sulphur Dioxide
SS	Suspended Solids
SW	Solid Waste
SWM	Solid Waste Management
SWMP	Solid Waste Management Plan
TDS	Total Dissolve Solids
TOC	Total Organic Carbon
TOR	Terms of Reference
TSP	Total Suspended Particles
TSS	Total Suspended Solids
TVA	Total Volatile Acids
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
USEPA	United States Environmental Protection Agency
UTM	Universal Transverse Mercator
VOC	Volatile Organic Compound
VU	Vulnerable
WGS	World Geodetic System
WHO	World Health Organization
Yr	Year

EXECUTIVE SUMMARY

INTRODUCTION

This report presents an Environmental and Social Impact Assessment (ESIA) for the proposed Cheesemanburg Urban Sanitation Project. The Cheesemanburg facility will accommodate sorting and a sanitary landfill. This facility is situated at the boundary between Montserrado and Bomi Counties and falls within the solid waste management plan of Liberia. The main objective of this ESIA is to ensure environmental protection and management in addition to providing assistance in the design, facility construction, site preparation, operation and post closure of the proposed facility. This ESIA will target landfilling activities as well as highlight various facility management plans to be implemented by the contractor during all phases of the project.

This ESIA report is structured in eight (8) main sections. Whereas Section 1 provides a brief background on the project, Section 2 provides the legislative framework. Section 3 describes the proposed plan. Analysis of alternatives is included in Section 4. Section 5 presents the environmental setting surrounding the site. Section 6 assesses the impacts of the deployment of the plant. Section 7 proposes Environmental Management and Monitoring Plan (EMMP) to assist facility managers to monitor the activities of the landfill in order to ensure process efficiency and environmental safety during the entire project lifetime.

PROJECT COMPONENT

The proposed design for the MRF includes the following technical management and administrative components:

- Guard room and weighbridge
- Unloading area
- Receiving area
- Sorting line
- Administrative area
- Worker's facility

IMPACTS

Analysis of impacts that may be incurred due to implementation of the facility revealed that limited adverse environmental impacts would occur during the short-termed facility construction and site preparation phase. During the operation and post closure phases, the facility may be associated with negative impacts due mainly to leachate/liquid waste generation with potential surface and/or groundwater contamination, visual/landscape intrusion, biodiversity, air quality, traffic as well as health and safety. Other less serious impacts of concern include odorous emissions, soil contamination, landfill stability/settlement and socio-economics.

All identified impacts can either be avoided or minimized by careful planning of design construction activities as well as by adopting a proper environmental management plan including mitigation and monitoring measures during the facility construction and site preparation phase, the operation phase, and post closure phase of the proposed facility.

ALTERNATIVES

The alternatives explored for this project included various solid waste management options.

ENVIRONMENTAL MANAGEMENT AND MONITORING PLAN

Table 0-1 and Table 0-2 present a summary of proposed mitigation measures during both the facility construction and site preparation phase and operation and post-closure phase. The cost of the implementation of mitigation measures will be part of the cost allocated for the facility design, construction, site preparation as well as the cost of the operation activities during the operation phase. The implementation of the mitigation measures will be the reasonability of the contractor under supervision of a consultant, EPA, and concerned local authorities.

Table 0-1 Summary of facility construction and site preparation phase mitigation measures

Impact	Facility construction and site preparation phase mitigation measures

Impact	Facility construction and site preparation phase mitigation measures
Surface and Groundwater Quality	**Landfill proper design** • Install a combined impermeable liner system consisting of the following components: (1) 2 layers of compacted clay (2) geomembrane (3) drainage layer (4) geotextile and (5) soil layer. **MRF plants proper design** • Minimize the amount of precipitation coming into contact with the waste during all stages. • Enclose all facility units with roofed structures and all curing areas shall utilize permanent roof structures to control moisture and minimize liquid waste generation. • Adopt designs for the MRF that accommodate for slightly inclined ground surface to ensure proper liquid waste drainage. • Provide the facility with an adequate Solid Waste storage area (roofed, impermeable paving, proper drainage and ventilation) with a capacity of at least two consecutive days throughput. • Retain a sufficient unsaturated zone to provide liquid waste attenuation in case of a leakage. **Effective facility drainage** • Divert surface and storm water away from the facility • Direct all site runoff into site storm drains along with adequately designed sand/silt/debris removal techniques such as sand traps, silt traps and sediment basins. • Regularly maintain silt/debris removal facilities. • Discharge rainwater pumped out from trenches or foundation excavations into storm drains via silt removal units. **Facility construction and site preparation activities** • Cover open stockpiles of construction materials with tarpaulin or similar fabric during rainstorms events. • Compact earthworks as soon as the final surfaces are formed to prevent erosion. • Contain domestic wastewater from the construction site's toilets, kitchens and similar facilities in sanitary septic tanks before being transported by trucks to the wastewater treatment station or to a wastewater disposal site. • Clean up immediately any accidental spillage of oil, fuel or chemical.
Air Quality	**Facility construction and site preparation activities** • Install windbreaks or source enclosures (such as trees, fences, plastic mesh, etc.) to reduce surface wind speed. • Maintain good housekeeping practices including elimination of mud/dirt carried out on paved roads at the construction site, periodic removal of dust-producing materials. • Minimize PM emissions by regular watering of surfaces. **Equipment & machinery** • Ensure good quality of diesel fuel used with on-site equipment. • Turn off all equipment when not in use. **Transportation** • Cover the road surface with a new material of lower silt content. • Maintain roads regularly. • Maintain trucks and on-site equipment. • Adopt a traffic management plan while avoiding congested and sensitive routes.
Odour	• Removed existing waste to a temporary lined area. • Conduct initial screening and floor sorting for existing waste. • Cover existing waste with a top soil layer.
Health and Safety	• Restrict access to the construction site by proper fencing. • Establish buffering areas around the site. • Provide guards on entrances and exits to the site.

Impact	Facility construction and site preparation phase mitigation measures
	• Install warning signs at the entrance of the site to prohibit public access. • Provide training to staff about the fundamentals of occupational health and safety procedures. • Provide appropriate personal protective equipment, and personal handheld gas detectors. • Keep uniforms and PPE clean and in good condition and replace them at least on a semi-annual basis. • Provide personal ID cards for all employees. • Monitor explosive and flammable gas buildup. • Provide adequate loading and off-loading space. • Develop an emergency response plan. • Provide on-site medical facility/first aid. • Provide appropriate lighting during night-time works. • Implement speed limits for trucks entering and exiting the site and from the highway. • Installing retaining nets to hold falling debris during, site clearing. excavation, and construction. • Provide environmental friendly fire-fighting equipment such as dry powder extinguishers within the premises of the facility. • Conduct annual fire-fighting and leak checks training drills for the operating staff. • Prohibit smoking as well as liter or weed build-up in the area as these may pose fire risks.
Noise	• Erect noise barriers along active work sites and along sensitive route roadside. • Operate only well-maintained equipment and machinery. • Shut down equipment that may be intermitted in use between work periods or throttle them silencers or minimum. • Utilize silencers or mufflers on construction equipment. • Use material stockpiles and other structures to screen noise from on-facility construction and site preparation activities. • Schedule noisy activities during daytime periods. • Install noise reducing road surfaces such as quiet pavements. • Select quieter equipment and machinery whenever possible.
Waste Generation	• Use to the extent possible the generated construction debris in filling activities or stockpile and store for future use as daily cover within the landfill. • Reduce or eliminate over-ordering of construction material. • Arrange for the recycling of any chemical waste generated on-site. • Hazardous waste should be properly contained. • Store general refuse generated on-site in enclosed bins or compaction units separate from construction and chemical wastes. • Prohibit burning of general refuse. • Promote reusable rather than disposable dishware. • Fence the construction site to intercept litter scattering.
Landscape and Visual Intrusion	• Select construction materials, architectural designs and colour schemes that will naturally blend into the landscape for all project facilities including buildings, fencing, and signs. • Incorporate underground utilities (to the extent possible) to house electrical, storage, and operational equipment. • Minimize apparent height and mass of the facility through careful choice of design, layout and colour scheme. • Enclose active site with non-transparent fencing to minimize visual impacts. • Prohibit vehicles from packing outside the fenced boundary of the site. • Preserve existing flora cover when feasible. • Initiate tree planting around sorting units to ensure proper installation of wind breaks and green belt screen using indigenous species whenever possible.
Biological Environment	• Secure fencing of areas not required for land-take prior to commencement of work. • Minimize the outward light emissions at the facility. • Maintain a buffer zone around the site to minimize disturbance to animals.

Impact	Facility construction and site preparation phase mitigation measures
	• Minimize litter blow by good cover, fencing and hand-picking. • Avoid any alteration of the physical and chemical components of the habitat surrounding the facility site.
Socio-Economics	• Give priority to the local community in the immediate vicinity of the site in terms of providing job opportunities. • The scavengers are employed/registered under an entity specialised in MSW management facilities that are registered and certified by the various agencies of the Government of Liberia especially MCC and EPA. • These entities should also be equipped with the appropriate infrastructure and scavenging tools (such as shoes, gloves, protection gear, etc.) • Only adults should are to be employed/registered with such entities. • Water supply for washing and areas for changing clothes are provided. • Implementation of health surveillance for workers as well as regular vaccination and health examinations. • Provide educational programs with regard to sanitation and hygiene.
Traffic	• Develop and implement a preliminary traffic plan with a detailed routing scheme that takes into consideration the possibility of night-time activities, congested areas as well as sensitive areas so as not disturb residents and commuter. • Provide and independent access road to the site accommodating for heavy duty vehicles of up to 40 tons weight and sufficient width for two moving trucks (approximately 8 m). • Disseminate information regarding the construction schedule and traffic plan. • Provide alternate routes when needed and when feasible. • Install adequate warning, signing, delineation and channelling at least 500 m down and up-gradient from the construction site. • Restrict movement and transportation of construction machinery outside the site to off-peak traffic hours and during nighttime.
Cultural Heritage	• Adopt chance-find procedures. • In the event where archaeological remains are found, construction activities should be suspended and notice should be given to the concerned authorities.

Table 0-2 Summary of facility construction and site preparation phase mitigation measures

Impact	Operation and post-closure phase mitigation measures

Surface and groundwater quality	**Liquid waste management system at MRF**
	• Control, collect, store, treat and monitor the generated liquid waste on-site
	  o The recommended liquid waste barrier system is an impermeable flooring pad of properly mixed cement and adhesive liquid waste resistant material.
	  o The liquid waste collection system must include a drainage system independent from the wastewater collection system to collect the liquid waste and washwater generated from the different stages.
	  o Liquid waste must be collected and stored in a tank designed to cater for a volume of liquid waste and washwater generated over a period of 3 consecutive days. The tank should also be secured through an impermeable layer of properly mixed mix cement and adhesive liquid waste resistant material.
	
	Waste placement and daily cover at the landfill
	• Use intermediate/daily covers from soil with a thickness of at least 10 cm and a slope ranging between 2-5% (not to exceed a gradient of 1 in 3).
	• Install intermediate drainage layer.
	
	Top cover and surface runoff drainage at the landfill
	• Install a multi-layer top cover with low permeability cap.
	• Install a recuperation canal system to control and manage rainfall runoff from the surface of the closed landfill cells.
	
	Leachate management at the landfill
	• Implement a leachate management system that drains, collects and treats the generated leachate.
	• Install a combined leachate drainage system: sloped terrace and perforated pipes.
	• Treat leachate on-site in a leachate treatment plant.
	• Minimize the amount of precipitation coming into contact with the waste.
	• Control liquid waste inputs.
	• Retain a sufficient unsaturated zone to provide leachate attenuation in case of leakage.
	• Implement a rigorous monitoring plan.
	
	Domestic wastewater
	• Collect all domestic wastewater resulting from the administrative buildings and workers facilities and transfer them to the planned wastewater treatment station or to a wastewater disposal site, or discharge into the planned sewage network, if it complies with the national standards.
	
	Facilities cleaning, maintenance and waste transportation
	• Manage any contaminated cleaning and drainage water from vehicle and plant serving areas, as well as oil and lubricants generated from maintenance workshops on-site.
	• Minimize water use during cleaning of working areas and vehicles (e.g. adopting dry cleaning practices prior to water cleaning.
	• Collect, store and treat the generated wash water “liquid waste” from facility operations and the liquid waste from storage tanks of the vehicles transporting waste with the leachate.
	• Contain and clean up any oil leakage or spillage.
	• Equip the facility with a wheelwash.
	• Equip all vehicles transporting waste or materials that could leak-with drainage tanks.

<table>
<tr><th>Impact</th><th>Operation and post-closure phase mitigation measures</th></tr>
<tr><td>Odor</td><td>Proper design-MRF
Ensure enclosed storage and processing area which are mechanical ventilated.
• Ensure that all active area should be under a negative atmospheric pressure and the location of facility entrance should be oriented opposite the wind direction in order to avoid the migration of any generated odors into the surrounding environment.

Waste handling and processing
• Ensure that all sorting activities are conducted within 12 hours following waste delivery.

Leachate/Liquid waste management
• Collect, properly store and treat on-site all generated leachate and liquid waste.

Facility operation-Landfill
• Implement the gas management system to collect and flare the gas in an enclosed facility.
• Use of an intermediate/daily cover.
• Deploy good housekeeping practices.

Waste transportation
• Sheet of vehicles delivering wastes and removing residues.
• Ensure that vehicles and containers are adequate for the quantity of waste transported and that they are properly maintained.</td></tr>
<tr><td>Air quality</td><td>Proper design-MRF
• Ensure enclosed storage and processing area which are mechanical ventilated.

Landfill operation
• Implement the gas management system to collect and flare the gas in an enclosed facility.
• Use of intermediate/daily cover.
• Deploy good housekeeping measures.
• Pave or use of suppressants to mitigate dust emissions.

Waste transportation
• Sheet of vehicles delivering wastes and removing residues.
• Ensure that vehicles and containers are adequate for quantity of waste transported and that they are properly maintained.
• Use collection trucks that are no more than 10 years of age.</td></tr>
<tr><td>Health and safety</td><td>• Site security.
• Site safety.
• Site facilities.
• Environmental controls.
• Waste transportation.
• Waste trucking system.
• Emergency/contingency plans.
• Workers hygiene.
• Personnel protection.
• Firefighting.</td></tr>
<tr><td>Noise</td><td>• Schedule collection and transport of the solid wastes either in the early morning hours or late in the afternoon.
• Install mufflers and noise barriers around air blowers and pumps.
• Enclose noisy equipment.
• Erect noise barriers along active work sites
• Implement and rigorous inspection and maintenance program applicable to all equipment and machinery.</td></tr>
</table>

Impact	Operation and post-closure phase mitigation measures
Waste Generation	• Store collection recyclables in a dedicated area within the facility unit purchase. • Provide the facility with an adequate Solid Waste storage area (roofed, impermeable paving, proper drainage and ventilation) with a capacity of at least two consecutive days throughput. • Clean continuously litter within closed facilities as well as on all roads within the site including access roads. • No medical waste, industrial wastes, animal carcasses, fish waste, or other obnoxious and environmentally hazardous materials shall be accepted at the landfill. • Conduct regular inspection of incoming wastes at weighbridges. • Record daily quantities of incoming wastes at the entrance of the facility. • Maintain fences constructed to intercept litter scattering.
Landscape and visual intrusion	**Structures and planting** • Maintain the buildings within the site to preserve their architectural and visual appeal. • Use appropriate gradients to ensure soil stability and prevent soil erosion. • Ensure compatibility of final landform with surrounding ground levels and topography. • Ensure storage of waste and equipment in proper location. • Planting trees throughout facility site is recommended to ensure optimum visual integration of the facility especially from top viewers while avoiding straight lines trees species. **Landfilling** • Conduct landfilling activities in small, well defined cells (covered daily) to minimize the areas of waste exposed visually. • Use appropriate gradients to ensure soil stability and prevent soil erosion. **Final landfill form** • Using appropriate gradients to ensure soil stability and prevent soil erosion. • Ensuring compatibility of final landform with surrounding ground levels and topography. • Prompt seeding of reclaimed areas within the landfill to prevent soil erosion and desiccation as well as enhance the aesthetic property of the affected area. • Ensuring optimum visual integration of the final landfill form into the surrounding landscape through trees/shrub planting. o Planting should be conducted in a natural and random planting layout rather than straight line planting. o Planted species should be compatible with the surrounding flora
Biological environment	• Avoiding any alternation of the physical and chemical components of the habitat surrounding the facility site. • Lay top soil with minimum compaction to provide a satisfactory growing medium for final restoration of the entire site. • Maintain a buffer zone around the site to minimize disturbance to animals. • Minimize litter blow by good cover, fencing and hand-packing. • Minimize the outward light emissions at the facility. • Replant groundcover and trees on affected areas and/or around site boundaries using native species whenever possible. • Using topsoil for final restoration of the entire site.
Landfill stability	• Ensure the necessary compaction and uniform placement of the waste. • Ensure that the final cover slope does not exceed 1 to 3 (rise: run).
Socio-Economics	• Instigate a formal complaints system which responds in a timely fashion to complaints about nuisances. • Publish data and reports on environmental performance of the facility. • Provide economic incentives to communities by adopting policies to recruit locally and to hire local sub-contractors when possible.

Impact	Operation and post-closure phase mitigation measures
Traffic	• Develop and implement a site-specific waste transport plan to ensure safe transportation of solid waste to the site as well as minimize traffic and congestion impacts that may incur from the operation of the facility. • Provide maximum turning space and sight lines for vehicles at both the entrance and exit. • Ensure vehicle movement in the direction of predominant traffic flow. • Ensure adequate off-loading and loading space to allow vehicles sufficient area to wait on-site. • Ensure adequate off-street parking for employees. • Maintain one-way traffic within the site to prevent obstruction to vehicles entering and leaving. • Implement speed restrictions on vehicles entering and leaving the site.

ENVIRONMENTAL MONITORING PLAN

Impact and compliance monitoring are necessary during the construction and site preparation phase and the operation and post closure phases of the Cheesemanburg landfill facility with the main objectives being to:

- Monitor 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.

Monitoring of air quality, surface water quality, noise levels, groundwater quality, leachate quality, soil quality, odors, waste management practices, traffic, health and safety, landscape, and socio-economic indicators is outlined below for the Cheesemanburg facility. 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 personal 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 contractor or consultant as necessary and according to the final design of the Cheesemanburg sanitary landfill. Equivalent procedures, methods, and equipment are acceptable pending approval of concerned authorities. Flexibility in implementation is essential as long as the objectives are met.

A summary of the monitoring parameters with corresponding location, and frequency is presented in Table 0-3. It is recommended that the monitoring plan be implemented by an entity independent of but in coordination with the contractor and consultant involved in any component or task of the project to ensure quality control and uniformity.

Table 0-3: Summary of the proposed monitoring plan

Impact	Monitoring means	Parameters	Phase	Location	Frequency	App. Cost
Local climatic conditions	Permanent weather monitoring station	• Temperature, humidity, rainfall and wind speed and direction • Volume of precipitation • Evaporation (lysimeter) • Atmospheric humidity	• Pre-works • Facility construction & site preparation • Operation • Post-closure	• Facility site	• Daily	• $7,000/ weather station
Ambient Air Quality	Portable sampling	• Total suspended particulates (TSP) • Particulates < 10 microns (PM10)	• Facility construction & site preparation	• Facility site • Nearby receptors	• Once	• $7,000/portable sampling device
	Gas analyzer and flow meter	• Methane (CH_4) • Carbon monoxide (CO) • Sulfur dioxide (SO_2) • Nitrogen oxide (NO_2) • Total suspended particulates (TSP) • Particulates < 10 microns (PM10)	• Operation phase	• Facility site • Landfill, MRF plant • Nearby receptors	• Monthly • Upon Complaint	• $25,000/unit
			• Post-closure	• Facility site • Landfill • Nearby receptors	• Bi-Annually for 10 years • Upon complaint	
Landfill surface gas emissions	Portable sampling	• Methane (CH_4)	• Operation phase	• Filled areas in the landfill	• Monthly	• Included in the above portable device
			• Post-closure		• Bi-Annually for 10 years	
Subsurface (Soil gas)	Permanent morning stations	• Methane (CH_4) • Carbon dioxide (CO_2) • Nitrogen (N) • Sulfides • NMOC's	• Facility construction & site preparation	• Monitoring wells perimeter of the site • Exact location should be determined prior to work initiation by the contractor collaboration with the Ministry of Environment and local authorities	• Once	• Included in above portable device
			• Operation phase		• Monthly	
			• Post-closure		• Bi-Annually for 10 years	

Impact	Monitoring means	Parameters	Phase	Location	Frequency	App. Cost
Air emissions	Gas analyzer and flow meter	• Pre-flaring (CH_4, CO_2, N, O_2, NH_4, NMOC's, sulfides, CO) • Post-flaring (O_2, dust, CO, NO_2, SO_2)	• Operation phase	• Gas flaring unit	• Monthly	• $25,000/unit
			• Post-closure		• Bi-Annually for 10 years	
Noise levels	Sampling	• Leq (dBA)	• Facility construction & site preparation	• Facility site • 3 monitoring locations around the perimeter of the site	• Monthly • Upon Complaints	• $15,000/ portable sampling device
			• Operation			
Surface water quality	Sampling	• Temperature • pH • Electrical Conductivity (EC) • Ammonia • Nitrate • Nitrite • Phosphate • Manganese • Total Phosphorous • Total Suspended Solids (TSS) • Biochemical oxygen demand (BOD) • Dissolved oxygen (DO) • Total Organic Carbon (TOC) • Total Coliform, Salmonellae, Fecal Coliform, Escherichia coli, Fecal Stretococus • Iron • Phenols • Metals (Chromium,	• Pre-works	• On the Po river upstream and downstream of the landfill site • On the Dima creek upstream and downstream of the landfill site • From the creeks and swamp areas surrounding the landfill site • From the surface drainage recuperation canal • Exact location will be determined prior to work initiation by the contractor in collaboration with local authorities	• Once	• $675/sample
			• Operation		• Monthly	

Impact	Monitoring means	Parameters	Phase	Location	Frequency	App. Cost
		Cadmium, Copper, Zinc, Nickel, Mercury, Lead)	• Post Closure		• Bi-Annually for 10 years	
Surface water Level and Flow	• level probes • Flow meter	• Water Level • Water Flow	• Pre works	• Po River ad Dima Creek	• Continuous • Monthly	• $1800/ level troll • $ 11,000 / flow meter
Groundwater Level	• Permanent monitoring wells • Level Probes	• Water Level	• Pre works	• Drilling of at least 4 wells on site (One well should be installed on the highest elevation onsite and at least three other wells on different sides of the site)	• Continuous	• $1800/ level troll • $6000/ well (actual final cost depends on well depth)
Groundwater quality	Sampling	• Temperature • pH • Electrical Conductivity (EC) • Ammonia • Nitrate • Nitrite • Phosphate • Manganese • Total Phosphorous • Total Suspended Solids (TSS) • Biochemical oxygen demand (BOD) • Dissolved oxygen (DO) • Total Organic Carbon (TOC) • Total Coliform, Salmonellae, Fecal Coliform, Escherichia coli, Fecal Stretococus	• Pre works • Operation	• Permanent monitoring wells • Exact location should be determined prior to work initiation by the contractor in collaboration with local authorities • Wells in the surrounding communities	• Once • Monthly	• $675/sample

Impact	Monitoring means	Parameters	Phase	Location	Frequency	App. Cost
		• Iron • Phenols • Metals (Chromium, Cadmium, Copper, Zinc, Nickel, Mercury, Lead))	• Post-closure		• Bi-Annually for 10 years	
Leachate Quality (before and after on-site treatment)	Sampling & Measurement	• Volume • Temperature • pH • Ammonia • Nitrate • Manganese • Total Phosphorous • Total Suspended Solids (TSS) • Biochemical oxygen demand (BOD) • Dissolved oxygen (DO) • Total Coliform, Fecal Streptococcus, Salmonellae • Phenols • Metals (Chromium, Cadmium, copper, Zinc, Mercury, Lead)	• Operation • Post-closure	• Leachate collection tank	• Weekly	• $675/sample
				• Leachate extraction wells	• Monthly	
				• After treatment	• Weekly	
Waste generation	Generated waste checklist	• Quantity and composition	• Facility construction & site preparation	• Facility site	• Quarterly	• Priced within construction
	Incoming waste assessment	• Quantity	• Operation	• Incoming wastes (Weighbridge)	• Daily	

Impact	Monitoring means	Parameters	Phase	Location	Frequency	App. Cost
	Incoming waste assessment (upon need)	• Categorization: quantity and percent composition by weight and volume of organic waste, paper, cardboard, plastic products, glass, fabrics/textiles, metals	• Operation	• Uploading area	• Quarterly	
Odor emissions	Olfactory test	• Unpleasant/noxious smells	• Operation	• Facility site • Sensitive receivers	• Daily • Upon complaints	
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	• Facility construction & site preparation • Operation	• Facility site	• Continuous	
Socio-economics	Field questionnaires and interviews	• Population perception • Employment record • Reported cases of affected psychological stresses	• Pre-works	• Region of influence	• Once	• $500/visit
			• Facility construction & site preparation		• Once	
			• Operation		• Annually	
			• Post-closure		• Annually for 5 years	
Biological environment	Field investigation, survey and photographic documentation	• Pre-works basic assessment • Ensure use of recommended plant species on site • Visual assessment of	• Pre-works	• Facility site • Surrounding habitats	• Once	• $500/visit
			• Facility construction & site preparation		• Once	
			• Operation		• Annually	

Impact	Monitoring means	Parameters	Phase	Location	Frequency	App. Cost
		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	• Post-closure		• Annually for 5 years	
Landscape and visual intrusion	Visual inspection and photographic documentation	• Ensure the effective implementation of mitigation measures	• Pre-works	• Entire area	• Once	• $500/visit
			• Facility construction & site preparation		• Once	
			• Operation		• Annually	
			• Post-closure		• Bi-Annually for 5 years	
Landfill settlement	Topographic surveys and settlement plates	• Monitor decomposition process and rate of settlement graphically • Quantity additional capacity gained in active cells by accelerated settlement	• Operation	• Entire Landfill	• Quarterly (active cells) • Bi-Annually (closed cells)	
			• Post-closure		• Annually for 10 years	

INSTITUTIONAL STRENGTHENING AND FRAMEWORK

The proper operation of the Cheesemanburg facility is 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.

CAPACITY BUILDING AND MARKET PROVISIONS

The overall success of the proposed environmental management plan for the Cheesemanburg facility is interrelated with the contractors' provision of the proper and relevant trainings, local awareness campaigns.

PUBLIC PARTICIPATION

The main concerns raised by the stakeholders are listed below.

- Leakage of leachate and waste water into the ground and water system.
- The public is concerned regarding leakage of leachates from the liners and pipes used and are worried about the quality of material use and if it is trusted.
- They also emphasized on the monitoring aspect of the project that will allow the project owner to detect any impact caused by the project activities at early stages allowing enough time to address the problem.
- Relocation due to uncontrolled pollution from the project or to overfilling of the landfill before its expected closure time.
- The public suggested building clinics so that people would have direct access to health care in case of pollution caused by the project.
- Job opportunities and Health and safety and training of employees.
- Controlled Access to the site to prevent people from entering and dumping unauthorized material.
- Procedures to follow if there are complaints from the communities in case of pollution.
- What would happen to the site at closure?

RECOMMENDATIONS

In addition to mitigation measures and monitoring plan that are provided in the ESIA report, the following measures are strongly recommended the following:

1. A preliminary overall detailed design for the proposed sanitary landfill should be prepared. The design should be based on detailed geological, hydrogeological and geophysical conditions of the site.
2. Further hydrogeological investigation is required in order to identify the hydrogeological link between the proposed site and the existing water bodies in the vicinity. Data on depth and yield of aquifers, recharge basins, groundwater flow direction are necessary for a better understanding of the hydrogeological regime in the area. Moreover, the area is considered to be swampy where the water table in the rainy season is above the surface of the land. Further hydrogeological assessment will determine surface water and groundwater flow and direction and properties of subsurface conditions as well as possible contamination routes. This is a requirement that we strongly recommend prior to the construction of the landfill.
3. At least four multi-level monitoring wells should be established around the site to determine groundwater conditions prior to construction, during construction and operation.
4. Testing for transmissivity and permeability of wells should be conducted.
5. Installation of meteorological station at the site to monitor atmospheric indicators that are useful in refining the design of various landfill components particularly the liner system, the leachate collection and management system, the gas collection and management system, and the cover system. The station will also support the understanding of precipitation level at the site and its impact on nearby surface water bodies as well as recharge capacity of aquifers in the project area.
6. Continuous monitoring of local meteorological parameters coupled with a survey of wind circulation at the Cheesemanburg Landfill facility is essential prior to the construction and operation activities. Monitoring shall be initiated to assess the dispersion of potential gas and odour emissions at the facility using atmospheric dispersion modelling.

7. During the design phase of the landfill, and prior to initiation of construction activities, a proper drainage plan for the entire site should be designed. In addition, calculation of the capacity of the liner system to withstand the increased load should be conducted / ascertained. A risk and vulnerability assessment based on groundwater modelling, proper geophysical investigation and/or the hydrogeology characteristics of the site shall also be conducted to examine impacts on sub-surface aquifers in the event of unintended leakage and liner breakdown.
8. Initiation of proper geotechnical and laboratory investigation at the Cheesemanburg Landfill is essential prior to the construction and operation activities to determine physical characteristics of the soil as well as its composition.
9. Initiation of air quality monitoring prior to construction and expansion activities should be conducted at the Cheesemanburg landfill to assess the dispersion of potential gas and odour emissions at the surrounding agglomerations using atmospheric dispersion modelling.
10. A noise monitoring program should be adopted and implemented taking into consideration surrounding agglomerations, transportation activities and traffic schedule, whereby noise measurements are recorded prior to the construction phase as well as during construction of the disposal site, landfill expansion, operation, and post-closure.
11. The disposal of medical waste, industrial wastes, as well as slaughter-house and other hazardous waste without prior treatment may jeopardize the health and safety of workers and damage the landfill (corrosive leachate quality; degradation of liner system, leachate collection system, gas extraction wells; damaging leachate treatment plants; contamination; infection; etc. No medical wastes, industrial wastes, animal carcasses, fish waste, or other obnoxious and environmentally hazardous materials shall be accepted at the landfill.
12. During the post-closure phase, it is highly recommended to monitor the effects on plant and animal species and ensure that a long term mitigation plan be established.
13. In order to maximize the positive impact, it is recommended that qualified local residents be given the priority to employment opportunities. It should not only be restricted to qualified people but also people from the surrounding communities

should be trained to become qualified and allow them work in several processes form collection to sorting to organization etc. So, there should be a specific quota form local communities that should work in the factory and this will help improve their economic level and generate revenue for them as well as avoid them from becoming illegal scavengers.

14. Procedures for immediate cleanup actions following spillages of oil, fuel and chemicals should be prepared.
15. The contractor shall develop a site-specific waste transport plan to ensure safe transportation of solid wastes to the site.
16. It is strongly recommended that the contractor holds consultation sessions as part of the public consultation and disclosure program during the construction and the operation phase of the landfill.
17. A Grievance Mechanism should be prepared by contractor prior to construction activities.

1 INTRODUCTION

1.1 BACKGROUND

Liberia has made considerable progress since the civil war ended in 2003. The country has revived state administration and rebuilt some priority infrastructures but is yet to return to the economic standing and pre-war poverty levels. Before the war, Monrovia had a limited waste collection service in place, which discontinued at the onset of the conflict. Following the resolution of the internal conflict and the subsequent World Bank reengagement, the first, very simple, collection system was introduced on an emergency basis in 2008 with International Developing Agency (IDA) funding. Initially it captured 10 to 15 percent of the waste generated within the municipal boundary of the City of Monrovia which brought improvements but was insufficient. The Liberia Reconstruction Trust Fund (LRTF) supported the first waste-dedicated project – EMUS (Emergency Monrovia Urban Sanitation Project), which became effective in December 2009. The project was conceived as an emergency intervention with the main objective of designing a system that would collect about half of the waste generated within the municipal boundary of the City of Monrovia. The Whein Town Landfill, which is the only sanitary landfill in the Country, was developed under this emergency. The Whein Town Landfill is expected to reach the end of its life expectancy in 2 years and a new site has been identified in Cheesemanburg, approximately 20 km away from Monrovia City Center, for the development of a new landfill.

The solid waste sector in Monrovia and urban centers has gradually acquired great importance within the Government's development agenda. The Government of Liberia's Medium Term Economic Growth and Development Strategy (2013-2017) aim, among others, to increase access to sanitation and reduce disposal of solid waste in unmanaged sites. The Strategy also aims to develop a comprehensive policy on solid waste for Liberia and to support youth job creation replicating the solid waste community-based activities instituted under the EMUS at locations outside of Monrovia. The Government seeks to introduce a gradual but ambitious cost recovery mechanism where households will finance a substantial portion of the cost of keeping the city clean. However, from all economic indications, level of poverty, non-availability of jobs, the recent Ebola crisis and the projected higher costs of solid waste management (SWM) in Liberia as a result of too few private sector firms competing in the sector, and the increase in travel time for waste disposal due to city expansion and location of the new landfill 20 km away from the city center, Monrovia is not close to making huge inroads to self-sustaining regime of SWM –in the foreseeable future. The country will need substantial help from the development partners over a longer stretch than anticipated, as despite improvements in the collection services, and incipient recycling activities, the final disposal remains an important issue to be addressed.

1.1.1 Demographics and Waste Volumes

The population of Monrovia city is estimated at approximately 860,000, while that of Greater Monrovia is estimated at 1.2 million inhabitants with an annual growth rate of approximately 2.5%. Total domestic waste generated in Monrovia city is estimated at 542 tons/day (based on 0.63 kg/capita/day. Total domestic waste generated in greater Monrovia is 756 tons/day. Under EMUS, on average 330/tons/day was collected in 2012 and 2013, which is approximately 60% of the waste in Monrovia city and 45% of the waste in Greater Monrovia.

1.1.2 Current Waste Disposal

Monrovia City has a limitation in terms of size of the temporary landfill site situated at Whein town, identified and developed in 2012 as an emergency stop-gap measure since the earlier disposal site at Fiamah was filled to capacity before the Government could identify sufficiently large land for a new landfill. The Whein town landfill site will be fully filled and no more available for usage by end of 2016. By the end of 2011, the GoL and MCC were aware of the necessity to secure (fence) a sufficiently large plot of land for future development of the new landfill. The potential site has been identified in Cheesemanburg.

1.1.3 Waste Minimization

An important step to reduce or minimize waste in Monrovia is through recycling, reuse and composting. It will reduce the cost of transportation and final disposal as well as provide revenue from the sale of recyclable material and positive gain in environmental impact. Small scale recycling which was initiated in Monrovia five years ago has not been scaled up and remains a tiny portion of total waste disposed. The contracts for the operators of the two transfer stations have built-in incentives for recycling. However, it is estimated that the material currently recycled is far below the recycling potential estimated at around 40%. While this is the case, job opportunities that could have accrued mostly to unskilled labor, worst hit by the unemployment in Liberia, has remained untapped. Composting of organic matter, which could also be a part of a menu of programs to minimize the volume of waste has yet to crystallize and find utilization in Monrovia. It is estimated that organic material constitutes 40% of the waste composition on average, up to 80% at commercial agricultural markets. Even if the byproduct of composting is left unutilized, composting would lead to reduced transportation expense, since long haul is the main cost factor in the waste management system in Monrovia which will be exacerbated with the construction of the new landfill located at about 20 km away from the city center. Separation at source is the cheapest and most effective method of recycling. Some sensitization on separation at source has taken place under EMUS but is not being practiced by the population.

1.1.4 Public Health and Sanitation Hygiene

Data related to health and sanitation hygiene before and after the commencement of the waste collection system in Monrovia is not available and not has been collected. However, it is reasonable to assume that the impact of waste collection on public health has been significant. Under EMUS, a massive education campaign targeting communities and schools has been taking place, focusing on safe handling of waste.

1.2 THE ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT

All projects and activities, identified in Annex I of the Environmental Protection and Management Law of Liberia, dated November 26, 2002, are required to conduct an environmental impact assessment.

In accordance with Section 14 of the Environmental Protection and Management Law of The Republic of Liberia, the Republic of Liberia Environmental Protection Agency Environmental Impact Assessment Procedural Guidelines, dated 2006, and the World Bank's Safeguard Policies - the international lending organization –, the Monrovia City Corporation (MCC) is undertaking the Environmental and Social Impact Assessment (ESIA) for the Project.

The main objective of this ESIA is to ensure that the potential impacts from the construction, operation and closure of the landfill are identified, their significance is assessed, and appropriate mitigation measures are proposed to minimize or eliminate such impacts.

This ESIA/ESMP seeks to meet the following objectives:

- Ensure compliance with the local laws and regulations;
- Ensure compliance with the requirements of the funding agency;
- Determine the compatibility of the proposed Project with the surrounding environment;
- Generate baseline data that will be used to monitor and evaluate the mitigation measures implemented during the Project cycle;
- Identify and assess environmental and social impacts, both adverse and beneficial in the Projects' area of influence;
- Evaluate and select the best Project alternative from the various options;
- Manage by avoiding or at least minimizing potential environmental impacts and risks on the surrounding population and environment within acceptable limits;
- Assist decision makers in protecting, conserving and managing the surrounding environment as well as affected communities according to the principles of sustainable development;
- Incorporate environmental management plans and monitoring mechanisms during construction and operation phases of Project development.

1.3 THE PURPOSE AND NEED FOR THE PROJECT

The Project is envisaged to generate economic benefits from improved sanitary and environmental conditions. In addition to benefitting the population by reducing exposure to diseases, waste collection is expected to increase property values over the long term and will preserve existing urban infrastructure by preventing flooding of roads, houses and other infrastructure in low lying areas. The Project activities will also generate jobs through the primary collection, and contributing to the economy by transforming waste into fertilizer, energy and/or other useful by-products.

1.4 REPORT FORMAT

The current draft ESIA report is divided into nine sections which are summarized below:

Section 1 – Introduction

This section provides a brief description of Project background, the objectives of the ESIA, and the scope and organization of the study and format of this report.

Section 2 – Legislative and Institutional Framework

This section provides information on policy, legal and administrative framework applicable to the Project and defines major legal provisions required for the Project.

Section 3 – Project Description

This section presents a detailed description of the Project components, the various phases of the Project including the mobilization, construction, operation, and closure.

Section 4 – Project Alternatives

This section presents the project alternatives evaluated including selection of suitable sites for the implementation of the solid waste treatment and disposal facilities as well as a technical comparison between the various available solid waste management options and determination of the most suitable option.

Section 5 – Baseline Environmental Status

This section presents the methodology and findings of field studies undertaken with respect to geology, hydrology, meteorology, quality of ambient air, surface and groundwater, soils, sediments, noise levels, ecology, land use, and socioeconomics that define the existing environmental conditions of the Project area.

Section 6– Impact Assessment and Identification

This section identifies and discusses the potential environmental and socioeconomic impacts of the proposed landfill Project. This discussion will form the basis for the environmental management plan.

Section 7 – Mitigation Measures & Environmental Management and Monitoring Plan

This section identifies the mitigation measures to minimize, or eliminate the negative environmental impacts due to the construction and operation of the landfill. It also outlines the Environmental Management and Monitoring Plan (EMMP), taking into consideration identified impacts and mitigation measures, monitoring program, and the proposed organizational structure for the operational phase.

Section 8 – Public Consultation

This section presents the results of concerns, suggestions and other findings during consultation with people that could be affected by the Project's activities, together with appropriate regulations and requirements.

2 LEGISLATIVE AND INSTITUTIONAL FRAMEWORK

This Chapter describes the applicable international standards and relevant Liberia regulatory framework that set the context within which the Project will operate. The Environmental Protection Agency (EPA) is the environmental regulatory authority in charge of issuing environmental guidelines and reviewing the Environmental Impact Assessment process.

2.1 LIBERIAN ENVIRONMENTAL ADMINISTRATIVE FRAMEWORK

2.1.1 Government Organization

2.1.1.1 National Government

Liberia's government comprises popularly-elected executive and legislative branches, the latter being a bicameral National Assembly consisting of the Senate (30 seats with members elected by popular vote to serve nine-year terms) and the House of Representatives (64 seats; members elected by popular vote to serve six-year terms). The country operates a dual system of statutory law based on Anglo-American common law for the modern sector and customary law based on unwritten tribal practices for the indigenous sector.

2.1.1.2 Local Government

Liberia comprises 15 administrative political subdivisions called counties, each headed by a Superintendent and further divided into Districts, each under a District Commissioner. Each District is sub-divided into Chiefdoms headed by a Paramount Chief, and each Chiefdom is divided into Clans headed by Clan Chiefs and towns headed by Town Chiefs. The clan areas were originally related to tribal sub-groupings and whilst this still largely applies, increasing urbanization and civil war has disrupted this pattern and Clans are now defined as administrative units.

2.1.2 Environmental Institutional Framework

2.1.2.1 National Level

2.1.2.1.1 Environmental Protection Agency

The Environmental Protection Agency (EPA) is an autonomous statutory body, established under the Act creating the Environmental Protection Agency of the Republic of Liberia 2003

(GOL, 2003a), and hereafter referred to as the EPA Act, to address the country's environmental problems. The EPA became a fully functioning entity in 2006, with the appointment of a board of directors and establishment of a Policy Council.

The EPA was established to "coordinate, monitor, supervise and consult with relevant stakeholders on all activities in the protection of the environment and sustainable use of natural resources" and as the lead national environmental agency is charged with executive authority for all environmental activities and programs relating to environmental management in Liberia. The EPA also has a key responsibility for matters relating to the issuing of an environmental impact assessment license and for compliance monitoring relating to environmental regulations and standards.

2.1.2.1.2 Monrovia City Corporation (MCC)

The Public Health Law of 1975 granted the MCC the responsibility of ensuring clean and sanitary environmental conditions in Monrovia. The MCC is responsible for environmental management including sanitation primarily in the form of beautification, street cleaning, and solid waste collection and disposal.

The MCC as the project implementing agency will have primary responsibility for implementation of all project related safeguards instrument including the ESIA and the ARAP. The MCC is responsible to ensure all necessary permits required for the construction and operation of the landfill are obtained. Safeguards implementation capacity assessment of the MCC and the current PIU did reveal that none of these entities has the capacity to implement the safeguards instruments (ESIA and ARAP) developed for this project. The PIU does not have a safeguards specialist. The MCC has an Environmental Health Unit. The capacity of the unit is however very low, with no experience in safeguards implementation for World Bank-financed project. The Unit is mainly involved with inspection of illegal dumpsites, public and private latrines, and restaurants, while its staff have no formal training or qualification with regards to safeguards implementation. The PIU will be required to hire an Environmental and Social Safeguards Specialist to oversee the implementation of the safeguards instruments developed for the project. The safeguards specialist to be hired will also be responsible for mentoring designated MCC staff as part of the capacity building initiative of the MCC. An indicative budget for key mitigation and monitoring activities has been included in Chapter 7 of this report. This budget will need to be incorporated in the overall project cost to ensure implementation of key mitigation and monitoring measures provided in the ESMP.

2.1.2.1.3 Ministry of Health and Social Welfare (MHSW)

The Division of Environmental and Occupational Health of the MHSW is responsible for handling matters related to water and sanitation. The responsibility ranges from conducting sanitary inspections of public facilities including food hygiene and drinking ware surveillance. The Division's role also includes construction and/or supervision of water wells and pit latrines and the promotion of community health education. MHSW also provides for capacity building and training of environmental health technicians.

2.1.2.1.4 Ministry of Public Works (MPW)

The MPW is responsible for the design, construction and maintenance of roads and highways, bridges, storm sewers, public buildings and other civil works in the country. Additionally, it has responsibility for the administration of urban and town planning, as well as provision of architectural and engineering services for all ministries and agencies of government. The design of the landfill and other ancillary structures, including access roads and bridges will need the approval of the Ministry of Public Works.

2.1.2.1.5 Ministry of Lands Mines and Energy (MLME)

The Ministry of Lands, Mines and Energy has the statutory responsibility for the development of mineral, water and energy resources in Liberia; it is in charge of land surveys in all parts of the country and coordinates, administers and regulates the use of public and private lands in Liberia, including mineral resources through granting of operation licenses, and regulates beach sand mining. It works along with the Ministry of Agriculture and the University of Liberia to conduct training and research on land rehabilitation. Energy provision is administered through the same Ministry by the National Energy Committee, while water resources are the responsibility of the National Hydrological Service. The MCC will collaborate with the MLME to ensure that the hydrogeological and geotechnical investigations required for this project are carried out as required. It is not certain at this stage if the soil on site can be used as cover material. In case cover material will need to be extracted from elsewhere, the MLME will be responsible for issuing license for the establishment of borrow areas.

2.1.2.2 Local Level

2.1.2.2.1 County and District Environmental Committees

To decentralize environmental management, the Environmental Protection Agency Act authorizes the establishment of County and District Environmental Committees and directs the National Environmental Policy Council to provide guidelines for their establishment. Each County Committee is composed of county and district officials, traditional leaders, private citizens, and two local representatives to the national legislature. The Committee is staffed by a County Environment Officer, hired by the EPA, but responsible to the County Committee.

The District Environment Committees are to be established by and report to the relevant County Environment Committee. They are charged with promoting environmental awareness and mobilizing the public to manage and monitor activities within the district to ensure that they do not have any significant impact on the environment. The District Committees are composed of district officials, mayors, chiefs, and private citizens and are staffed by a District Environment Officer hired by the EPA.

In addition to assisting the County and District Committees in the fulfillment of their responsibilities, the County and District Environment Officers are responsible for compiling reports to the EPA, promoting environmental awareness, and conducting public hearings on environmental impact assessment in the County and the District.

At present, two County Environmental Committees have been established; One in Sinoe County and another in Nimba County. However, EPA has established outstation offices in eight counties. The offices are staffed by Environmental Inspectors. As the County Environment Committees are established, some of the Inspectors may be reassigned as County Environment Officers.

2.1.3 Environmental Inspectors and Courts

To provide for enforcement of environmental requirements and standards, the Environmental

Protection Agency Act provides for the appointment of Environmental Inspectors and the establishment of an Environmental Court system.

2.1.3.1 Environmental Inspectors

The Act authorizes the EPA to "designate its officers and duly qualified public officers/civil servants … to be environmental inspectors within such Counties and District limits." Thus, Environmental Inspectors do not have to be EPA employees, but can also be designated officers or civil servants in other branches of the government. Environmental Inspectors are authorized to enter premises, inspect activities, take samples, and review records to ensure compliance with environmental rules and regulations. The exact nature of the inspector's enforcement authority is not defined in the Act, but the Act does state that the EPA is to "…establish the conditions, rules and regulations governing the qualifications, performance, powers and duties of the Environmental Inspectors." The EPML confirms that Environmental Inspectors can write Restoration Orders to correct an activity deemed to be noncompliant with environmental rules and regulations.

2.1.3.2 Environmental Courts

The Environmental Protection Agency Act defines a two-tiered court system to hear and rule on compliance with environmental rules and regulations.

The first tier is the Environmental Administrative Court. This court is to hear and rule on complaints relating to the environment. The complaints may concern the actions or decisions of the EPA or an Environmental Inspector, or may be brought by a member of the public to stop activities they believe are damaging the environment.

The second tier is an Environmental Appeals Court, established at the Judicial Circuit level.

At present, the Environmental Court system has not been formally established. EPA's five-year strategic plan (starting July 2011) provides for an administrative court to handle environmental issues for an intermediate period before the full establishment of an environmental court under the judicial system.

2.2 LEGISLATIVE FRAMEWORK

Table 2-1 describes the main categories of legislation in Liberia and Table 2-2 and Table 2-3 provide a summary of relevant Liberian environmental legislation and international environmental conventions signed/ratified by the Government of Liberia.

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 consistent with the statutory laws and the constitution of Liberia.

Table 2-2 Relevant Environmental Laws

Title	Year	Description
Conservation of the Forests of the Republic of Liberia	1953	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.
Supplementary Act for the Conservation of Forests	1957	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.
The Act that created the Forestry Development Authority (FDA)	1976	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.
Public Health Act	1976	It contains provision for the protection of drinking water resources and the inspection of potential sources of pollution.
The Natural Resources Law of Liberia	1979	This Law includes chapters on forests, fish, and wildlife, soil,

Title	Year	Description
		water, and minerals.
Wildlife and National Parks Act	1988	The Act identifies a number of protected areas; specifies policies and objectives regarding wildlife and conservation in the country.
The Environment Protection Agency (EPA) Act	2002	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.
The Environment Protection and Management Law	2002	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.
The National Environmental Policy Act	2002	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 natural resources.
National New Forestry Reform Law	2006	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.

Table 2-3 International Environmental Conventions Signed/Ratified by the Government of Liberia

Convention	Status	Year	Objectives
African Convention on Conservation of Nature and Natural Resources	Ratified	NA	To encourage individual and joint action for the conservation
Convention of International Trade in Endangered Species of Wild Fauna and Flora (CITES)	Ratified	1981	To prevent trade of endangered or threatened species
Convention Concerning the Protection of the World Cultural and Natural Heritage	Signed	2002	To recognize and protect cultural and natural heritage for future generations
Framework Convention on Climate Change and the Kyoto Protocol	Signed	2002	• To achieve stabilization of green house gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climatic system • To strengthen the commitment of developed country parties with a view to reduce their overall emissions
Stockholm Convention on Persistent Organic Pollutants (POP)	Signed	2002	• To strengthen National Capacity and to enhance knowledge and understanding Amongst decision makers, managers, industry and the public at large on POPs • To develop a National implementation Plan (NIP) to manage the elimination of POPs.
Ramsar Convention on Wetlands of International Importance	Signed	2003	• To manage wetland systems so that the human uses of these areas are undertaken in such a way as to retain their natural capital for future generations. • To encourage and support countries to develop and implement national policy and legislative frameworks, education and awareness raising programs, as well as inventory, research and training projects.
Convention on Biological Diversity (CBD)	Ratified	2000	• Promote Conservation of Biological Diversity. • Sustainable use of its components. • Fair and equitable sharing arising out of the utilization of genetic resources.
Convention on the Conservation of Migratory Species of Wild Animals	Ratified	2004	Aims to conserve terrestrial, marine and avian migratory species throughout their range
The Cartagena Protocol on Biosafety	Ratified	2003	To contribute to ensuring an adequate protection in the field of living modified organisms resulting from modern biotechnology
Convention on Desertification	Signed	1998	To combat desertification and mitigates the effect of drought in countries experiencing serious droughts and/or desertification
International Tropical Timber Agreement	Ratified	2008	Requires sustainable management of timber resource base, simultaneously encouraging the timber trade and the improved management of the forests
Vienna Convention for the Protection of the Ozone Layer	Signed	1996	States agreed to cooperate in scientific research on the ozone problem, to exchange information, and to adopt "appropriate measures" to prevent activities that harm the ozone layer. The obligations are general and contain no specific limits on chemicals that deplete the ozone layer.

Convention	Status	Year	Objectives
Montréal Protocol on Substances that Deplete the Ozone Layer	Signed	1996	A protocol to the Vienna Convention for the Protection of the Ozone Layer, it is designed to protect the ozone layer by phasing out the production of numerous substances believed to be responsible for ozone depletion
International Convention on Oil Pollution Preparedness, Response, and Cooperation(OPRC), London, 1990	Signed	1995	To strengthen the legal framework for the control of environmental pollution by oil, in general, and marine pollution by oil in particular.
International Covenant on Economic, Social and Cultural Rights	Ratified	2004	ICESCR commits to work toward the granting of economic, social, and cultural rights to individuals, including labor rights and rights to health, education, and an adequate standard of living. ICESCR is part of the International Bill of Human Rights, along with the Universal Declaration of Human Rights (UDHR) and the International Covenant on Civil and Political Rights (ICCPR)

2.2.1 Constitution of the Republic of Liberia

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.

2.2.2 The Environmental Protection Agency Act

"An Act to establish a monitoring, coordinating and supervisory authority for the sustainable management of the environment in partnership with regulated Ministries and organizations and in a close and responsive relationship with the people of Liberia; and to provide high quality information and advice on the state of the environment and for matters connected therewith".[1]

Thus, the Environment Protection Agency of Liberia (EPA) was created by the Act creating the Environment Protection Agency of the Republic of Liberia, known as the Environment Protection Agency Act. The Act was approved on November 26, 2002 and published on April 30, 2003. The establishment of the EPA marked a significant step forward in the protection and management of the environment of Liberia.

Section 5 of the Act designates the EPA as the principal Liberian authority for environmental management which shall co-ordinate, monitor, supervise, and consult with relevant stakeholders on all the 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. Moreover, the EPA is empowered to carry out, among other things, 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

[1] Ministry of Foreign Affairs. Monrovia, Liberia. April 30, 2003. Act Creating the Environment Protection agency of the Republic of Liberia. Section 1

for the welfare of the future generations;

- Identify projects, activities, and programs for which environmental impact assessment must be conducted under this Law
- 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.

2.2.3 Act Adopting the Environment Protection and Management Law of the Republic of Liberia

"An Act to establish a legal framework for the sustainable development, management and protection of the environment by the Environment Protection Agency in partnership with regulated Ministries and organizations and in a close and responsive relationship with the people of Liberia; and to provide high quality information and advice on the state of the environment and for matters connected therewith".[2]

Section 15 of the EPML states that business investors should present an environmental mitigation plan to the EPA, which should include the following sections:

[2] Ministry of Foreign affairs. Monrovia, Liberia. April 30, 2003. Act adopting the Environment Protection and Management Law of the Republic of Liberia. Section 1.

- 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

Section 12 of the EPML requires environmental review for projects 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.

Section 6 of EPML 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.

Section 24 of the EPML requires that the EPA should ensure that projects comply with their environmental mitigation plan through monitoring of its operations. Where evidence of non-compliance occurs, the EPA shall impose remedial measures and may bring action before the Environmental Court or through the Ministry of Justice to enforce compliance.

Section 25 of the EPML gives responsibility to the EPA carrying out periodic environmental audit of activities or projects that are likely to have adverse effects on the environment

Section 58 of the EPML requires that a license must be obtained from the EPA for any type of effluent discharge into the sewage system, also in case of operation of a sewage system. This license is provided by the EPA for a period that does not exceed 1 year.

Section 61 of the EPML prohibits pollution of all Liberian Waters. In case of water pollution, a sentence and/or a fine is/are imposed on the polluting party. The latter is also responsible for the cost of the removal of the pollutant and the restoration, restitution or compensation as determined by a law court.

Section 62 of the EPML bans pollution by solid waste of any land, coastal zone or water surface, street, road or site in or on any place to which the public has access, except in a container or at a place which has been specially indicated, provided or set apart for such purpose. In case of such pollution, a fine or a prison term is imposed on the polluting party. The latter is also responsible for the clean-up of the solid waste pollution it caused.

Section 64 of the EPML requires the acquirement of a "Solid and Hazardous Waste Disposal License" in case of generation, storage, handling, transport or disposal of hazardous waste, or else ownership or operation of a waste disposal site. The EPA provides this license for a period of not more than one year. This license entails the party who is generating the waste to take up waste management measures such as treatment, determination or recycling and re-mediation.

Section 71 of the EPML requires the acquirement of a "Pollution Emission License" for any project or activity which is likely to pollute the environment in excess of any standards or guidelines issued under the EPML. This license is provided by the EPA for a period of not more than one year.

Section 75 of the EPML prohibits the below activities in relation with a river, lake or wetland that are declared as protected areas by the EPA. These activities include:

- Use, erect, construct, place, alter, extend, remove or demolish any structure in, on, under, or over the bed;
- Excavate, drill, tunnel or disturb the bed otherwise;
- Introduce or plant any part of a plant, plant specimen or organism whether alien or indigenous, dead or alive in a river, lake or wetland;
- Introduce any animal or micro-organism whether alien or indigenous, dead or alive in a river, lake or wetland;
- Deposit any substance in a river, lake, or wetland or in or under its bed, which is likely to have adverse environmental effects on the river, lake or wetland;
- Direct or block a river, lake or wetland from its natural and normal course; and
- Drain any river, lake or wetland.

Section 91 of the EPML, states that the EPA may impose on the party that has caused or is likely to cause harm to the environment an "Environmental Restoration Order" requiring it to remedy/prevent the harm within 21 days of the service of the order. Section 92 allows the party to request the Agency to reconsider that order by giving reasons in writing within the same period. Section 107 states that noncompliance with the restoration order convicts the responsible party to imprisonment and/or a fine.

2.2.4 National Environmental and Occupational Health Policy

The Ministry of Health and Social Welfare has a Division of Environmental and Occupation Health; however, the Division lacks standards and policies specific to industries and/or occupational hazards. The National Environmental and Occupational Health Policy (NEOHP) was developed in 2007 to provide a framework for identifying policy needs and actions to improve occupational health and safety. It supplements the National Health Policy (Table 2-4), which focuses on public health and health systems. The NEOHP identified the following key Environmental and occupational health needs:

1. Environmental sanitation
2. Food Safety Services
3. Water Quality and Safety
4. Vector Control & Chemical Safety
5. Waste Management
6. Disaster Management
7. Health Promotion
8. Occupational Health Services
9. Port Health
10. Pollution Control
11. Sanitary Engineering

Table 2-4 Additional Safety, Health and Welfare Laws

Title	Year	Description
Public Health Law	1976	This Law provides a framework for the management of public health and health systems in Liberia. The 1976 Law is currently being updated in order to effectively govern the decentralized health sector and accommodate the changes that have taken place since its promulgation. For example, in 2010 a new chapter was added to the Law to manage HIV / AIDS.[3]
National Health Policy and National Health Plan[4]	2007	The document is a framework for health sector reforms in Liberia. The goal of the policy is to make health care delivery services throughout the country effective and efficient, thereby enhancing the quality of life of the population.

2.2.5 Additional Safety, Health and Welfare Laws

Other important safety, health and welfare legislation that may apply generally (not specifically to workers) to E&P activities in Liberia include the Public Health Law and the National Health Policy and National Health Plan. These are summarized in Table 2-4.

2.2.6 Liberia Land Commission Act of 2009

The objective of this act is to propose, advocate and coordinate reforms of land policy, laws and programs in Liberia. It does not have adjuratory or implementation role. The goal of the commission is "to develop comprehensive national land tenure and land use system that will provide equitable access to land and security of tenure so as to facilitate inclusive sustained growth and development, ensure peace and security and provide sustainable management of the environment"[5].

2.3 LIBERIAN ENVIRONMENTAL QUALITY STANDARDS

Several environmental quality standards are partly prepared by EPA. Some of these environmental quality standards are: 1) Air Quality Standards; 2) Water Quality Standards; 3) Noise Level Standards; and 4) Waste Management Standards.

Air quality standards are not complete for ambient air. Existing ambient air quality Standards are given in Table 2-5.

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[3] Liberia Ministry of Health and Social Welfare. 2010. An Act to Amend the Public Health Law, Title 33, Liberian Code of Laws Revised (1976). Accessed from the GOL website: http://legislature.gov.lr/sites/default/files/Public%20Health.pdf

[4] Liberia Ministry of Health and Social Welfare. 2007. National Health Policy and National Health Plan. Accessed from the ILO website: http://www.ilo.org/wcmsp5/groups/public/---ed_protect/---protrav/---ilo_aids/documents/legaldocument/wcms_126728.pdf

[5] Liberia Land Commission Act of 2009.

Water quality standards are only completed only for the marine waters. Drinking, domestic, industrial, agricultural and other types of water standards are still incomplete. However the Ministry of Health Water Testing Laboratory uses the drinking water standards presented in Table 2-6.

Noise level standards are complete for many environments. Relevant noise standards are presented in Table 2-7, Table 2-8, and Table 2-9. Other noise standards can be found in the Environment Protection and Management Law- Noise Pollution Control and Standards Regulations, 2009.

Table 2-5 Ambient Air Quality Tolerance Limits (Environment Protection and Management Law- Air Quality & Standards Regulations, 2009)

Pollutant	Time weighted Average	Industrial area	Residential, Rural & Other area	Controlled areas***
Sulphur oxides (SOX)	Annual Average*	80 µg/m³	60 µg/m³	15 µg/m³
	24 hours**	120 µg/m³	80 µg/m³	30 µg/m³
	Annual Average		*0.019 ppm/50* µg/m³	
	Month Average			
	24 Hours		*0.048 ppm /125* µg/m³	
	One Hour			
	Instant Peak		*500* µg/m³	
	Instant Peak (10 min)		*0.191 ppm*	
Oxides of Nitrogen (NOX)	Annual Average*	80 µg/m³	60 µg/m³	15 µg/m³
	24 hours**	120 µg/m³	80 µg/m³	30 µg/m³
	8 hours			
	Annual Average		*0.2 ppm*	
	Month Average		*0.3 ppm*	
	24 Hours		*0.4 ppm*	
	One Hour		*0.8 ppm*	
	Instant Peak		*1.4 ppm*	
Nitrogen Dioxide	*Annual Average*		*0.05 ppm*	
	Month Average		*0.08 ppm*	
	24 Hours		*0.1 ppm*	
	One Hour		*0.2 ppm*	
	Instant Peak		*0.5 ppm*	
Suspended particulate matter (SPM)	Annual Average*	360 µg/m³	140 µg/m³	70 µg/m³
	24 hours**	500 µg/m³	200 µg/m³	100 µg/m³
	Mg/Kg			
	Annual Average****		100 µg/m³	
	24 hours***		180 µg/m³	
Suspended Particulate matter (<10 µg/m³) (RPM)	Annual Average*	120 µg/m³	60 µg/m³	50 µg/m³
	24 hours**	150 µg/m³	100 µg/m³	75 µg/m³
Lead (Pb)	Annual Average*	1.0 µg/m³	0.75 µg/m³	0.50 µg/m³
	24 hours**	1.5 µg/m³	1.00 µg/m³	0.75 µg/m³
	Month Average		2.5	

Pollutant	Time weighted Average	Industrial area	Residential, Rural & Other area	Controlled areas***
Carbon monoxide (CO)/ carbon dioxide (CO_2)	*8 hours***	*5.0 mg/m³*	*2.0 mg/m³*	*1.0 mg/m³*
	1 hour	*10.0 mg/m³*	*4.0 mg/m³*	*2.0 mg/m³*
Hydrocarbons (HC)	*24 hours***			
VOC	*24 hours***			
Ozone	*1-Hour*		*0.12 ppm*	
	Instant Peak		*1.25 ppm*	
* Annual Arithmetic mean of minimum 104 measurements in a year taken twice a week 24 hourly at uniform interval. ** 24 hourly/8 hourly values should be met 98% of the time in a year. However, 2% of the time, it may exceed but not on two consecutive days. The 24-hour limit may not be exceeded more than three times in one year. *** Not to be exceeded more than once per year average concentration Whenever and wherever two consecutive values exceed the limit specified above for the respective category, it would be considered adequate reason to institute regular/continuous monitoring and further investigations.				

Table 2-6 Liberian Drinking Water Quality Standards (Ministry of Health and Social Welfare)

Parameter	Unit	WHO	Class I	Class II	Class III
pH	-logH	-	6.5 - 8.0	6.0 - 9.0	5.5 - 9.0
Chloride	mg Cl/l	350	≤ 250.0	≤ 350.0	≤ 450.0
Sulphate	mg SO_4/l	250	≤ 150.0	≤ 200.0	≤ 250.0
Hardness	$CaCO_3$ mg/l	100-500	≤ 190.0	≤ 300.0	≤ 600.0
Iron Total	Fe mg/l	0.1	≤ 0.1	≤ 1.5	≤ 2.0
Manganese	Mn mg/l	0.1	≤ 0.1	≤ 0.3	≤ 0.8
Zinc Total	Zn mg/l	5	≤ 1.0	≤ 2.0	≤ 5.0
Coliform Bacteria	n/ml	0	0	0	≤ 5
Bacteria Total	n/ml	0	0	≤ 10	≤ 50
Dissolved Substance	mg/l	500	≤ 500.0	≤ 1000.0	≤ 1200.0
Suspended Solids	mg/l	-	≤ 10.0	≤ 30.0	≤ 50.0
Ammonia	mg NH_4/l	0.5	≤ 1.0	≤ 3.0	≤ 6.0
Nitrate	mg NO_3/l	50	≤ 40.0	≤ 60.0	≤ 80.0
Nitrite	mg NO_2/l	-	≤ 0.1	≤ 0.5	≤ 1.0
Phosphate	mg PO_4/l	-	≤ 0.01	≤ 0.02	≤ 0.05
Phenols	mg/l	0.001	≤ 0.001	≤ 0.02	≤ 0.05
Detergents	mg/l	-	≤ 1.0	≤ 2.0	≤ 3.0
Fluoride	F mg/l	1.5	≤ 1.5	≤ 1.5	≤ 2.0
Cyanide	Cn mg/l	0.05	n.d.	≤ 0.02	≤ 0.05
Lead	Pb mg/l	0.1	≤ 0.1	≤ 0.1	≤ 0.1
Mercury	Hg mg/l	0.01	n.d.	≤ 0.005	≤ 0.01
Copper	Cu mg/l	0.05	≤ 0.01	≤ 0.01	≤ 0.2
Cadmium	Cd mg/l	0.01	n.d.	≤ 0.001	≤ 0.01
Chromium Trivalent	Cr mg/l	-	≤ 0.5	≤ 0.5	≤ 0.8
Chromium Hexavalent	Cr mg/l	0.05	≤ 0.05	≤ 0.1	≤ 0.1
Nickel	Ni mg/l	-	≤ 1.0	≤ 1.0	≤ 0.1
Silver	Ag mg/l	0.05	≤ 0.01	≤ 0.01	≤ 0.01
Vanadium	V mg/l	-	≤ 1.0	≤ 1.0	≤ 1.0
Boron	B mg/l	-	≤ 1.0	≤ 1.0	≤ 1.0
Arsenic	As mg/l	0.05	≤ 0.05	≤ 0.05	≤ 0.2
KEY					
mg	milligram				
L	Liter				
ml	milliliter				

Parameter	Unit	WHO	Class I	Class II	Class III
n	count				
n.d.	non detectable				
Water Classification	**Water can be used as**				
Class I	Drinking water for the population, Water Supply for industry requiring drinking water.				
Class II	For Fisheries, Cultivated fisheries, Organized public bath, Recreationnal water sports.				
Class III	Industry supply except for industry requiring drinking water, irrigation or agricultural land.				
Prepared for the Government of Liberia by UN Department of Technical Cooperation for UNDP New York 1987					

Table 2-7 Maximum Permissible Noise Levels for General Environment (Environment Protection and Management Law- Noise Pollution Control & Standards Regulations, 2009)

Facility	Noise Limits B (A) (Leq)	
	DAY	NIGHT
Any building used as hospital, convalescence home, home for the aged, sanatorium and institutes of higher learning, conference rooms, public library, environmental or recreational sites.	45	35
Residential buildings	50	35
Mixed residential (with some commercial and entertainment)	55	45
Residential + industry or small-scale production + commerce	60	50
Industrial	70	60
Time Frame: use duration ***Day : 6.00 a.m. 10.00 p.m.*** ***Night : 10.00 p.m. 6.00 a.m.*** ***The time frame takes into consideration human activity***		

Table 2-8 Maximum Permissible Noise Levels (Continuous or intermittent noise) from a Factory or Workshop (Environment Protection and Management Law- Noise Pollution Control & Standards Regulations, 2009)

Leq dB (A)	Duration (Daily)	Duration (Weekly)
85	8 hours	40 hours
88	4 hours	20 hours
91	2 hours	10 hours
94	1 hour	5 hours
97	30 minutes	2.5 hours
100	15 minutes	1.25 hours
103	7.5 minutes	37.5 minutes
106	3.75 minutes	18.75 minutes
109	1.875 minutes	9.375 minutes
Noise Levels shall not exceed a Leq of - ***(i) Factory/Workshops 85 dB (A)*** ***(ii) Offices 50 dB (A)*** ***(iii) Factory/Workshop Compound 75 dB (A)***		

Table 2-9 Maximum Permissible Noise Levels for Residential & Commercial Areas (Environment Protection and Management Law- Noise Pollution Control & Standards Regulations, 2009)

Facility	Limit Value in dB(C)
For any building used as a hospital, school, convalescent home, old age home or residential building.	109 dB (C)
For any building in an area used for residential and one or more of the following purposes: Commerce, small-scale production, entertainment, or any residential	114 dB (C)

apartment in an area that is used for purposes of industry, commerce or small-scale production, or any building used for the purpose of industry, commerce or small-scale production.	

2.4 INTERNATIONAL STANDARDS

As a condition of accessing international financing sources as well as a way of committing to the development of the Project in way that manages environmental and social issues responsibly, the Project is committed to comply with international requirements. The World Bank Safeguard Policies, the World Bank General Environmental, Health and Safety Guidelines and the World Bank Group Environmental, Health and Safety Guidelines for Solid Waste Management have been specifically considered as part of this assessment.

2.4.1 The EHS Guidelines

The World Bank Group's EHS Guidelines are technical reference documents with general and industry-specific examples of Good International Industry Practice (GIIP). The Guidelines contain performance levels and measures that are generally considered to be achievable in new facilities at reasonable costs by existing technology (Box 2-1).

The EHS Guidelines for Waste Management Facility are the specific-sector guidance relevant to the Project, providing an overview of the key environmental, health and safety topics that are particularly relevant (Box 2-2).

The World Bank Safeguard Policies most relevant to this waste management facility are presented in Table 2-10 along with justification of the triggered policies. The triggered policies include OP/BP 4.01 Environmental Assessment and OP/BP 4.12 Involuntary Resettlement OP 4.09 Pest Management.

Table 2-10 World Bank policies relevant to the Project's activities

Safeguard Policies	Triggered Yes/No	Explanation
Environmental Assessment OP/BP 4.01	Yes	OP/BP 4.01 has been triggered because the landfill construction will involve several civil work and waste management activities that have the potential to adversely impact the biophysical environment as well as the health and safety of the public in the surrounding areas and those involved directly involved with the project activities. Given the nature of this project, potential adverse impacts may arise during all stages of the project including construction, operation and post-closure phases. An ESIA which includes a detailed ESMP is being developed to ensure that all associated environmental and social impacts are clearly identified with defined mitigation measures and monitoring activities provided.
Natural Habitats OP/BP 4.04	No	The project activities will not have any impacts on natural habitats. The site has been used for farming for decades and is predominantly covered by secondary vegetation. No sensitive ecosystems will be affected by the project.
Forests OP/BP 4.36	No	The project activities will not involve investment in forest or protected areas or related forestry activities that have the potential to adversely impact forests, or restrict people access to or use of forest resources.
Pest Management OP 4.09	No	The project activities do not involve procurement, transportation or storage of pesticides or pesticide application equipment.
Physical Cultural Resources OP/BP 4.11	Yes	There are no recognized physical cultural resources in the project area. However, OP/BP 4.11 has been triggered for precautionary reason since the construction of the landfill includes activities that involve large excavation activities such as construction of leachate pond and drainage system, excavation of landfill cells/trenches and construction of access roads. The ESIA will include a chance find procedure that outlines the steps to be followed in case of chance finds.
Indigenous Peoples OP/BP 4.10	No	This not applicable to the project area and to Liberia at large.
Involuntary Resettlement OP/BP 4.12	Yes	The project includes the construction of a landfill and other ancillary structures. One hundred (100) acres of land in the Township of Cheesemanburg is acquired from 4 families by MCC. The proposed sites are farm lands and would not require physical relocation. The acquisition will however reduce the amount of land that is currently being held (or owned) by these families and may restrict their access to land resources during and after the construction. An Abbreviated Resettlement Action Plan (ARAP) is being prepared by the client and will contain safeguard measures aimed at addressing the anticipated adverse impacts of land acquisition and other resettlement issues.
Safety of Dams OP/BP 4.37	No	Project activities do not involve construction of new dam or renovation of existing dams.
Projects on International Waterways OP/BP 7.50	No	The project activities will have no impact on international waterways.
Projects in Disputed Areas OP/BP 7.60	No	Project activities are not within disputed areas.

The Environmental Assessment Policy seeks to ensure that the possible impacts of World Bank financed activities are analyzed and that a system is established to avoid, minimize and mitigate negative impacts while positive impacts are maximized. This ESIA is the instrument that describes the system for managing the Landfill's environmental impacts.

The Physical Cultural Resources Policy aim is to assist countries to avoid or mitigate adverse impacts of development projects on physical cultural resources. For purposes of this policy, "physical cultural resources" are defined as movable or immovable objects, sites, structures, groups of structures, natural features and landscapes that have archaeological, paleontological, historical, architectural, religious, aesthetic, or other cultural significance. Physical cultural resources may be located in urban or rural settings, and may be above ground, underground, or underwater. The cultural interest may be at the local, provincial or national level, or within the international community.

The objective of the Involuntary Resettlement policy is to (i) avoid or minimize involuntary resettlement where feasible, exploring all viable alternative project designs; (ii) assist displaced persons in improving their former living standards, income earning capacity, and production levels, or at least in restoring them; (iii) encourage community participation in planning and implementing resettlement; and (iv) provide assistance to affected people regardless of the legality of land tenure.

Box 2-1 Relevant General EHS Guidelines

1. ***Environmental***
   a. Air Emissions and Ambient Air Quality
   b. Energy Conservation
   c. Wastewater and Ambient Water Quality
   d. Water Conservation
   e. Hazardous Materials Management
   f. Waste Management
   g. Noise
   h. Contaminated land
2. ***Occupational Health and Safety***
   a. General Facility and Design and Operation
   b. Communication and Training
   c. Physical Hazards
   d. Chemical Hazards
   e. Biological Hazards
   f. Radiological Hazards
   g. Personal Protective Equipment
   h. Special Hazard Environments
   i. Monitoring
3. ***Community Health and Safety***
   a. Water Quality and Availability
   b. Structural Safety of Project Infrastructure

c. Life and Fire Safety (L&FS)
d. Traffic Safety
e. Transport of Hazardous Materials
f. Disease Prevention
g. Emergency Preparedness and Response

Box 2-2 Sector-specific Guidelines for Waste Management Facilities

Environmental Topics

1. Municipal Solid Waste
    a. Waste Collection and Transport
        i. Litter and clandestine dumping; and
        ii. Air Emissions.
    b. Waste Receipt, Unloading, Processing, and Storage
        i. Contaminated Runoff;
        ii. Litter;
        iii. Air Emissions; and
        iv. Noise and Vibration.
    c. Biological Treatment
        i. Leachate and Runoff;
        ii. Air Emissions; and
        iii. Fire.
    d. MSW Incineration Facilities
        i. Air Emissions;
        ii. Ash and Other Residuals;
        iii. Water Effluents; and
        iv. Noise.
    e. Landfilling
        i. Landfill Siting;
        ii. Leachate Generation;
        iii. Groundwater and Leachate Monitoring;
        iv. Landfill Gas Emissions; and
        v. Closure and Post-Closure.
2. Industrial Hazardous Waste
    a. Waste Collection and Transport
    b. Waste Receipt, Unloading, Processing, and Storage
        i. Spills and Releases;
        ii. Fires and Explosions;
        iii. Air Emissions; and
        iv. Water Effluents.
    c. Biological and Physico-Chemical Treatment
        i. Air Emissions;
        ii. Water Effluents; and
        iii. Waste Residuals.
    d. Hazardous Water Incineration
        i. Air Emissions;
        ii. Water Effluents;
        iii. Ash and Residues.
    e. Landfilling
        i. Leachate Generation;
        ii. Groundwater and Leachate Monitoring;
        iii. Landfill Gas; and

iv. Closure and Post-Closure.

f. Industrial Non-Hazardous Waste

i. Waste Collection and Transport
ii. Waste Receipt, Unloading, Processing, and Storage
iii. Biological and Physico-Chemical Treatment
iv. Incineration
v. Landfilling.

Health and safety topics

1. Accidents and injuries;
2. Chemical exposure; and
3. Exposures to pathogens and vectors.

2.5 ENVIRONMENTAL IMPACT ASSESSMENT PROCESS IN LIBERIA

An EIA Process Flow Chart has been included as Figure 2-1. The main steps in the process are:

- Prepare Application for Environmental Impact License
- Prepare Notice of Intent (NOI)
- Submit Project Brief (allow 14 working days for EPA review and feedback)
- Conduct Scoping Process:
    1. Publish NOI in Media
    2. Prepare Terms of Reference (TOR)
    3. Conduct Meetings with EPA Environmental Committee and District Environmental Committees, as needed.
    4. Conduct Public Meetings with Potentially Affected Communities
    5. Submit Scoping Report to EPA
- Prepare Environmental Review
- Obtain EPA Approval of TOR and Environmental Review
- Prepare Environmental Impact Study and Report (included in EIA)
- Prepare Environmental Impact Statement (EIS) (included in EIA)
- Develop Comprehensive Environmental Mitigation Plan and Implementation Strategy (included in EIA)
- Agency Review of EIA (within 3 months)
- Public Consultation on EIA (within first 30 days of 3 months)
- Public Hearings (EPA to decide whether to hold these)
- Liberia Line Ministries Comment on EIA

- Review by EPA Environmental Assessment Committee
- Approval or Rejection by EPA (within 3 months of receiving EIA)

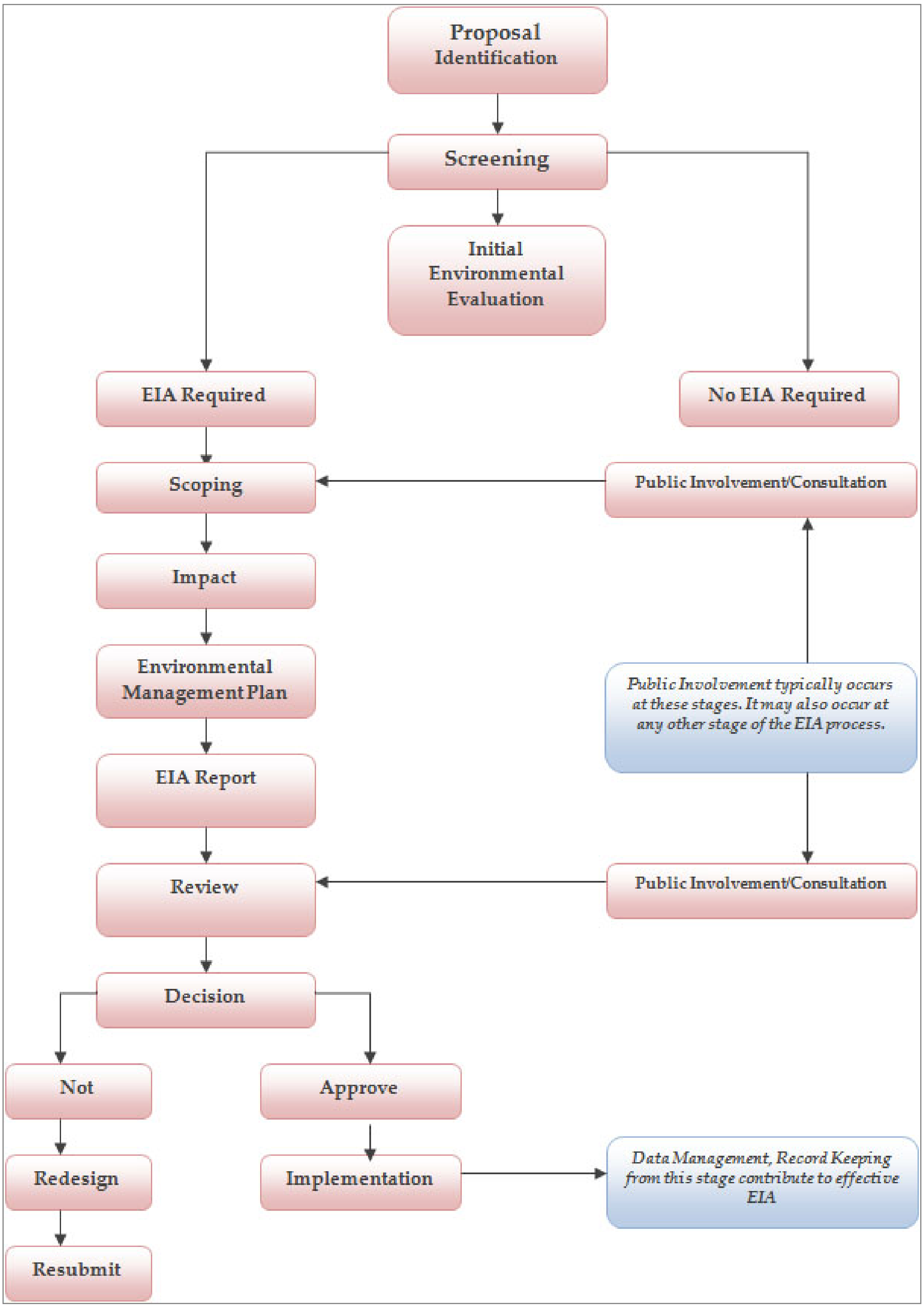


Figure 2-1 EIA process in Liberia

2.5.1 Public Consultation Requirements of the EIA Process

Involvement of the public in the EIA commences with the launch of the EIA process and continues throughout its course. Detailed below are the different requirements of the public involvement throughout the EIA process:

1. After the submission of an application for an environmental impact assessment permit, the project proponent should publish a "notice of intent" that states the information that may be necessary to allow the stakeholders or any interested party to identify their interest in the proposed project or activity. This information should include: the nature of the project, its related activities, its timeframe and its site of operation and the area that may be impacted.
2. Before preparing the EIA document, the project proponent should conduct public consultations with the potential affected stakeholders. This procedure is called the "scoping process" which aims to: 1) inform the stakeholders about the project's details, its potential impacts on the physical, biological and socio-economic environments, and the mitigation measures that can be taken in order to minimize these impacts, and 2) get the stakeholders' input on the various related issues. By achieving this, the scoping process is also a guiding tool for the project proponent and its consultants. It helps them in identifying the project's impacts, mitigation measures and alternatives, which will form the essential part of the EIA document. The scoping process consists of publishing the project's details in the affected district's media, holding public meetings to consult directly with the affected communities and stakeholders, and incorporating the views of these stakeholders in the scoping report which is submitted to the EPA.
3. On the completion of the EIA study report, the public is invited again to participate in the EIA review through public consultation meetings. The public's views on the EIA are taken into consideration by the EPA when deciding about approving or rejecting the project.
4. In some cases, the EPA also decides to hold a public hearing about the project in order to fortify the public participation. These cases include but are not limited to: requests by the public for a public hearing, controversy about the project or expiry of the period stipulated for receipt of comments.

3 PROJECT DESCRIPTION

3.1 PROJECT LOCATION

The site is located at the boundary between Montserrado and Bomi Counties around 20 Km away from Monrovia, at an elevation ranging between 20 and 50 meters above mean sea level and within the coordinates listed in Table 3-1. The Landfill is located within Cheesemanburg Township approximately 400 meters off the Liberia- Sierra-Leon highway.

The project area and surrounding area is primarily rural with a wood mill located around 350 m to the southwest boundary of the proposed landfill. The project area does not fall in any existing community, but it is surrounded by several communities listed in Table 3-2.

Surface water bodies in the vicinity of the proposed landfill site include the Po River and the Dima Creek that pours into the Po River. The Po River extends along the northeastern boundary of the proposed landfill facility, and the Dima Creek along the southeastern boundary. The closest distance between Po River and the site is approximately 300 m while the closest distance between Dima creek and the site is approximately 200 m.

Table 3-1 Cheesemanburg Pillar Coordinates

Pillar No.	UTM North	UTM East
CMB 1	721587.649	298810.654
CMB 2	721577.632	298557.977
CMB 3	721349.987	298339.406
CMB 4	721243.565	298279.119
CMB 5	721063.293	298408.246
CMB 6	720999.370	298486.876
CMB 7	720817.914	298853.609
CMB 8	720967.880	299035.630
CMB 9	721075.741	299151.949

Table 3-2 Towns surrounding the project site and their approximate distance to site

Town Name	Approximate Distance to Site Boundary (m)
Vincent Town	1200
Clean Town	800
Dolela	450
Dimei	1300
Quendee	1600
Gbonjema	1300
Korsosr	900
Varnjah	300
Brown Town	1000

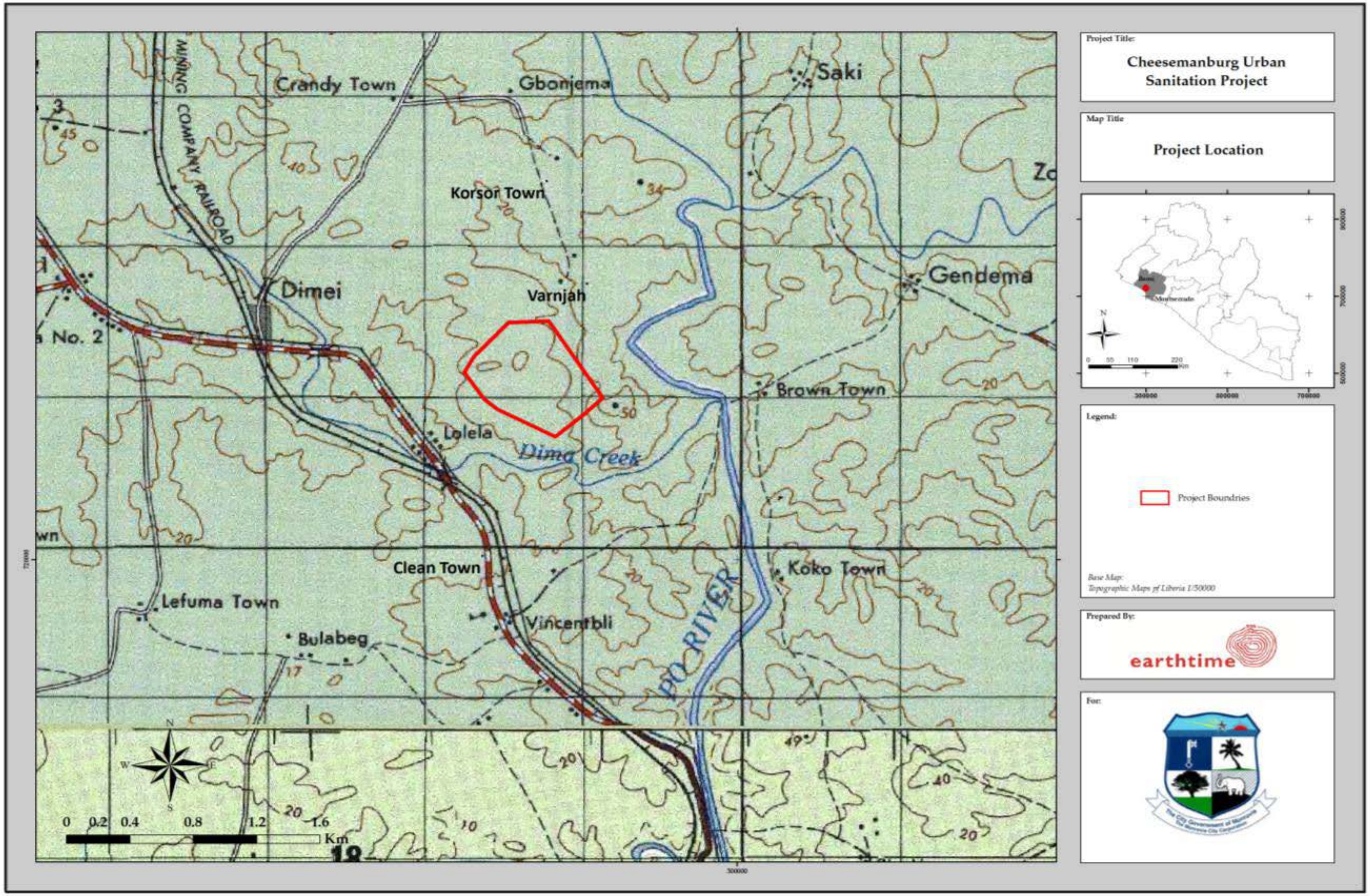


Figure 3-1 Cheesemanburg Landfill Location

3.2 PROJECT COMPONENTS

3.2.1 Component 1: Construction of the Cheesmanburg Regional Landfill and Partial Closure of the When Town Landfill

This component will finance: (1a) technical studies and preparation for the tender documents for the new Cheesmanburg landfill (1b) construction of the first cell of the landfill (1c) closure and construction of a perimeter wall at Whein Town landfill (1d) minor upgrades to the existing transfer stations to accommodate larger waste transfer trucks; and (1e) acquisition of waste collection equipment.

3.2.2 Component 2: Waste Collection and Disposal

This component will help MCC continue to deliver a consistent level of SWM service delivery by closing the gap between the cost of the SWM service and the revenue generated by MCC. This component will provide financial support to MCC on semi-annual basis through the special solid waste management account to provide solid waste management services in Monrovia.

3.2.3 Component 3: Institutional Capacity Development and Technical Assistance:

This component will finance (3a) Capacity building to the solid waste management staff at MCC and the PIU; (3b) preparation and implementation of a cost minimization and revenue enhancement study (3c) preparation of a long-term waste management strategy for the greater Monrovia (3d) assessment of waste recovery and valorization options including a market study for future recycling (3e) public awareness and citizens engagement activities (3f) Technical assistance to improve urban management in the city (3g) the PIU's administrative fees and the cost to hire a safeguard consultant and a Community Liaison Officer to assist the PIU during project implementation.

3.3 QUANTITY AND CHARACTERISTICS ON INCOMING WASTES

The facilities within the proposed plan are expected to treat and dispose SW generated from Monrovia. The population of Monrovia city is estimated at approximately 860,000, while that of Greater Monrovia is estimated at 1.2 million inhabitants with an annual growth rate of approximately 2.5%. Total domestic waste generated in Monrovia city is estimated at 542 tons/day (based on 0.63 kg/capita/day. Total domestic waste generated in greater Monrovia is 756 tons/day. Under EMUS, on average 330/tons/day was collected in 2012 and 2013, which is approximately 60% of the waste in Monrovia city and 45% of the waste in Greater Monrovia.

The Cheesemanburg Landfill Facility, which constitutes the subject of this report, is expected to receive the solid waste generated by Monrovia for sorting, composting, and landfilling. In addition, the waste stream remaining after sorting and composting at the site will also be landfilled.

Table 3-3 & Figure 3-2 present the general composition of solid waste generated in Monrovia. The distinctive feature in the composition of the waste lies in the presence of high proportion of organic putrescible. In this respect, the organic rich content of the SW presents an opportunity for biological treatment prior to usage/disposal, thus reducing the total waste quality requiring landfilling, increasing the lifespan of the landfill, and providing a useful by-product that can be used as a soil conditioner in land application or reforestation, a soil cover within the landfill, or for rehabilitation of existing quarries.

Table 3-3 Waste Composition in Monrovia (Source: Solid Waste Management Plan.)

Type of Waste	Percentage (%)
Leather, Rubber	0
Glass, Ceramics	1
Metals	2
Wood, Bones, Straw	5
Textiles	6
Paper & Cardboard	10
Plastic	13
Miscellaneous Items	20
Vegetable / Putrescible	43

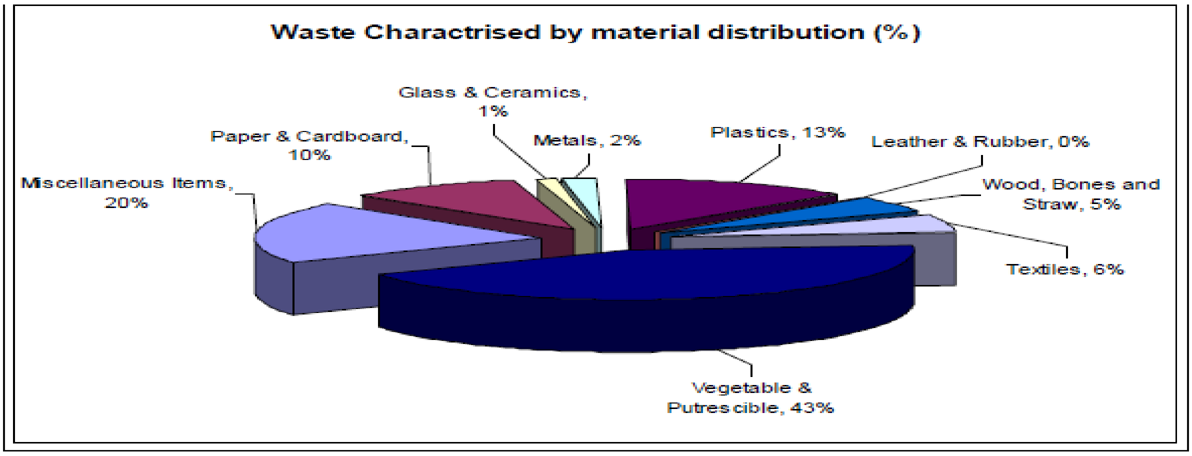


Figure 3-2 Waste characterized by material distribution percentage (Source: Solid Waste Management Plan)

3.4 CHEESEMANBURG FACILITY DESIGN CAPACITY

The Cheesemanburg landfill facility is proposed to provide increased access to solid waste management (SWM) services in Cities of Monrovia, Paynesville, Browerville and Tubmanburg and Cheesemanburg Township as a regional SWM facility to improve access to and ensure sustainability of solid waste management services in participating cities. Beneficiary secondary cities including Kakata, Buchanan, Gbanga and Ganta will receive technical assistance to provide solid waste services to citizens particularly in disadvantaged communities within these participating cities.

The landfill is a planned to operate for 50 years and to be utilized as a regional SWM facility for selected sister cities to Monrovia. Targeted secondary cities would put in place systems (personnel, organizational, financial, and others) to start off properly structured solid waste management. Recycling will be instituted as a way to waste minimization and expansion of the life of the landfill.

3.5 CHEESEMANBURG LANDFILL COMPONENTS

The full Landfill design and components has not been completed at the time of preparation of this document and only typical component processes are outlined and discussed in this section. The final landfill design should be based on detailed geological, hydrological and geotechnical studies of the site. The ESMP will updated accordingly to include the outcome of these studies with regards any potential impacts and the mitigation measures thereof.

An integrated plan for solid waste treatment and disposal is proposed at the level of Monrovia. As such, the Cheesemanburg landfill will be constructed to house a Material Recovery Facility (MRF) for the sorting of waste and further recovery of recyclables, a compositing plant for transforming organic matter into a usable by-product, along with a sanitary landfill that will receive the remaining waste stream. The proposed integrated waste management scheme is illustrated in Figure 3-3.

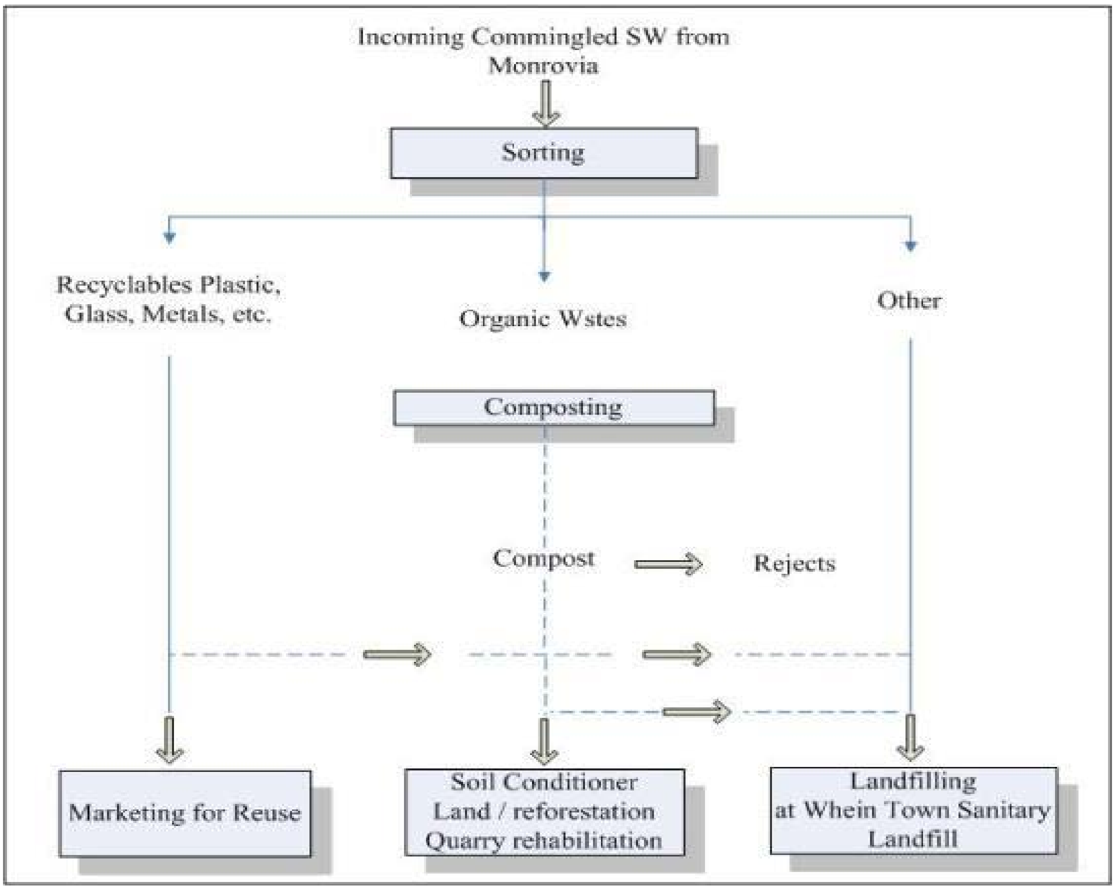


Figure 3-3 Waste Management scheme for the Landfill Facility

The site is also expected to include a fence, entrance gate, waste reception area, control office and weighbridge, administrative buildings, parking for collection trucks, cleaning area for trucks, workshop, and housing for guard.

3.5.1 Sorting

The separation, processing and recovery of materials from the solid waste stream constitute an important part of an integrated solid waste management plan. In a commingled state, SW is biologically unstable, can become odorous, and is unusable. Although the final design in not yet ready, it is expected that the Cheesemanburg landfill facility will house a sorting plant.

Such a plant should be a complete Material Recovery Facility (MRF).

MRFs are used to separate commingled SW into usable materials, whereby plastics, glass and metals can be recycled and organic materials can undergo composting. Figure 3-4 depicts a typical simple flow diagram of the concept of an MRF. The process starts with receiving the wastes in a dedicated receiving area where bulky items are removed. The incoming bags are first opened and the contents manually segregated along sorting conveyors and separated into metals, plastics, and glass. Since the organic and inorganic portions of the waste have different size distributions, the use of a trammel or similar separators for their differential separation becomes a suitable option. The purpose of magnetic separation is for the removal of small pieces of metals, thus reducing any potential environmental and health impacts that may be posed by the presence of heavy metals in the future compost and in the landfilled wastes (Table 3-4). Note that the contractor shall divert at least 30 percent of the incoming SW into composting and recycling prior to disposal at the allocated landfill.

The MRF facility should be designed as a closed building made of cement, natural stones, or hermetically closed metallic hangars. The number of inner pillars should be minimized as well as obstacles hindering the proper movement of vehicles, loading and unloading activities. Specific areas should be designated for storage of the sorted wastes.

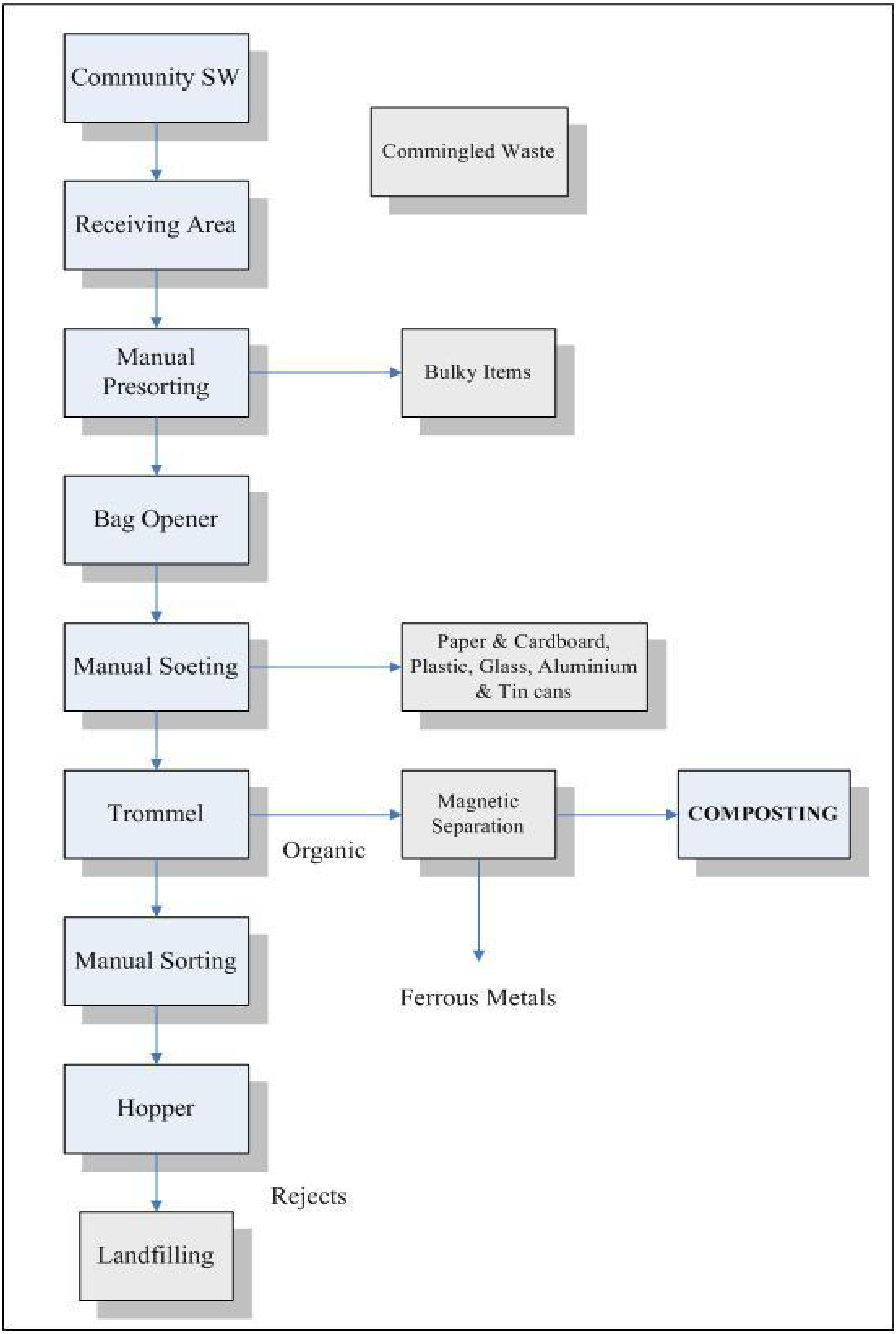


Figure 3-4 Typical MRF process flow diagram

Table 3-4 Description of the basic stages of sorting

Stage	Description
Bulk items removal	• Received waste that may obstruct any further separation during the process, is removed
Bag opening	• The mechanical processing entailed in this initial step is through a bag opening machine
Manual picking	• Further big items, such as cardboard, nylon sheets and also glass are picked up manually in order to help eliminate the blockage of the services during screening
Screening	• The waste goes through a rotary (trammel) • The operation trammel screen is large-diameter drum positioned nearly horizontally in which the refuse is introduced into the elevated end • The surface of the drum consists of sieve with holes in well determined sizes. As the drum rotates; the particles are carried up the side of the drum until they reach a certain height, where they then fall to button to repeat the cycle. Throughout the turning process the screening and the separation of the waste will be executed according to the size of the waste. • Small particles that process through the sieve opening are considered the compostable material which is basically rich in the organic matter • The remaining are the rejects which also contain the recyclable products
Magnetic separation	• The compostable material pass under the magnetic separator where the ferromagnetic items such as batteries, tins, steel cans and others are being separated and pressed for recycling purposes
Manual picking	• After the magnetic separator, the non-ferrous material like aluminium cans and other non-organic material are picked up manually to enhance the quality of the end product.
Manual picking	• The rejects that did not pass through the sieve of the screening trammels are exposed to a group of pickers where the plastic, glass, cardboards, and metals are picked up and collected for the interested industries to recycle.

3.5.2 Composting

3.5.2.1 Composting Techniques

The composting process is currently viewed primarily as a waste management method to stabilize organic wastes, such as manure, yard trimmings, and municipal organic wastes. The stabilized end-product (compost) is widely used as a soil cover in landfills or as amendment to improve soil structures, provide plant nutrients, and facilitate the re-vegetation of disturbed or eroded soil. It can also be used for quarry rehabilitation.

Typically, composting operations consist of four basic steps namely:

1. Pre-processing of the MSW;
2. Decomposition of the organic fraction of the MSW;
3. Curing; and
4. Preparation and marketing of the final compost product.

Composting starts with the collection and receipt of organic materials. These materials are then processed for use in the composting system. The compostable materials can be chipped, pulverized, or shredded into similar-sized pieces to facilitate rapid decomposition. A pile is constructed to maintain porosity and retain heat. Oxygen, temperature, and moisture in the compost are sustained at ideal conditions for the decomposition organisms to be active. Initially, high microbial activity and heat production cause temperatures within the compostable material to rise rapidly. This temperature is controlled by periodic turning, the use of controlled airflow, and/or the introduction of moisture. After the rapidly degradable components are consumed, temperatures gradually fall during the "curing" stage. At the end of this stage, the material is no longer self-heating, and the finished compost is ready for use and should have an earthy odor. Substantial changes occur in microbial populations and species abundance during the various temperature stages. The resulting compost has a high microbial diversity, with microbial population higher than fertile, productive soils and many times higher than in highly disturbed or contaminated soils.

There are two main aerobic composting systems available: namely, windrow composting, and in-vessel systems.

Windrow composting is the production of compost by piling organic matter or biodegradable waste in long rows (windrows). There are two methods of windrow composting: 1) the agitated method (Figure 3-5), where the piled organic material to be composted is agitated (turned) periodically by a mechanical turner to improve porosity, to introduce oxygen, to control the temperature and to mix the material to obtain a more uniform product, and 2) the static method (Figure 3-6), where the piled organic material to be composted is placed over a perforated piping system through which air is forced. In the latter method, the composting material remains static and the forced aeration reduces the need for mechanical turning which is required frequently in the agitated windrow composting method to maintain porosity. In both methods (the agitated and the static windrow composting) the organic materials are biodegraded and placed in narrow piles. These can be used to process yard trimmings, food scraps, paper products, and bio-solids. Heat production eliminates pathogens, creating a compost product for use as a mulch, soil conditioner, or topsoil additive. The generic layout of a typical composting facility adopting windrow composting is presented in Figure 3-7.

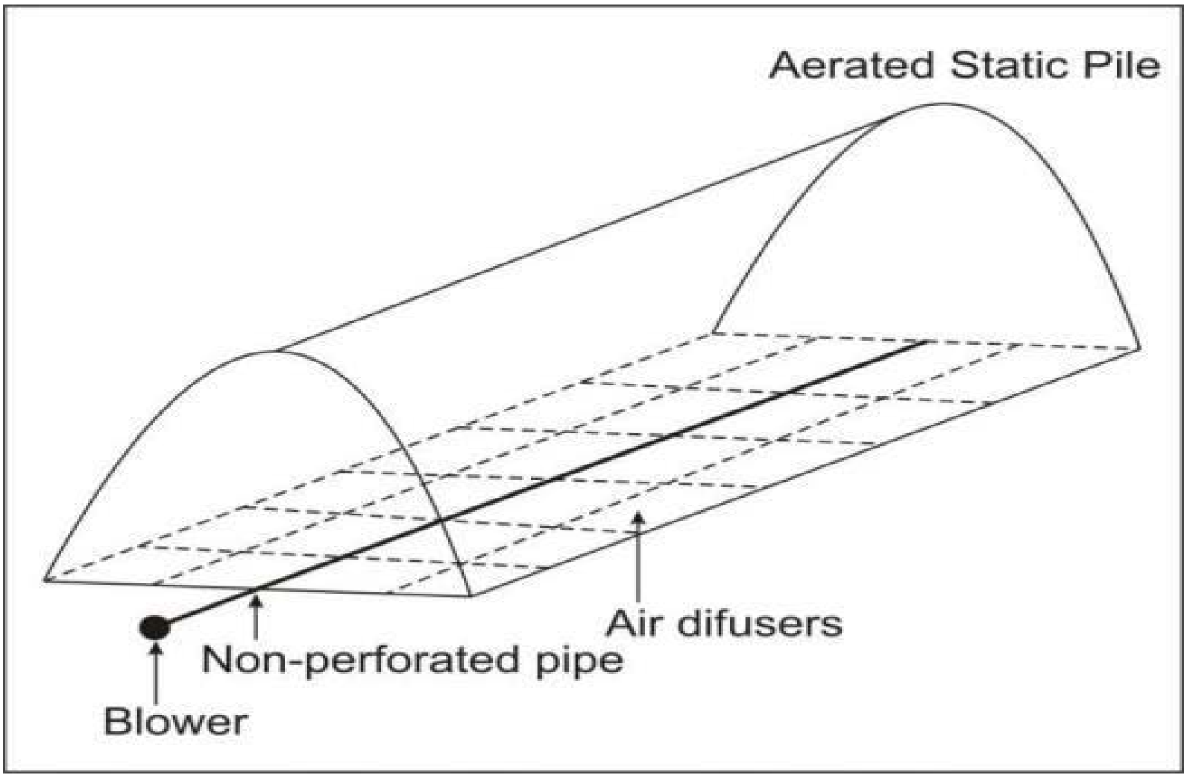


Figure 3-5 Agitated windrow composting technology

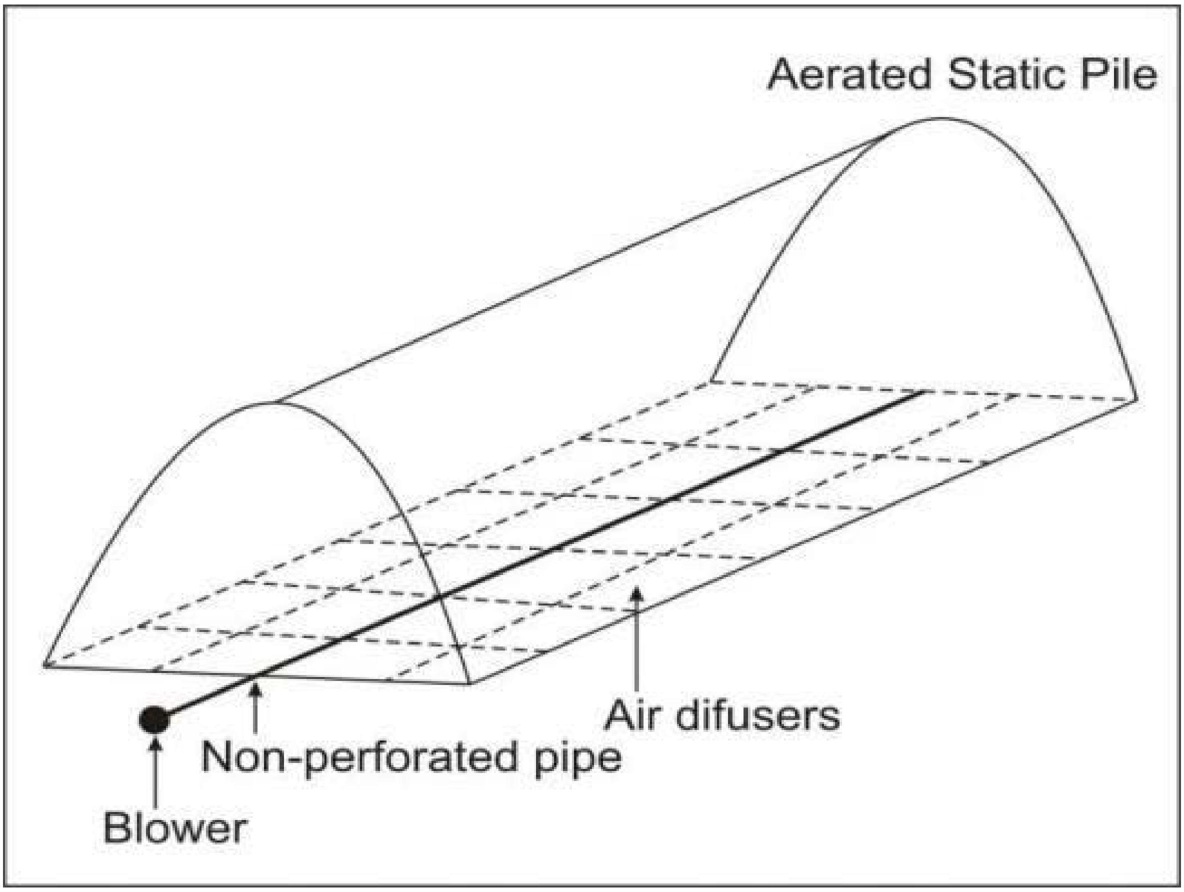


Figure 3-6 Schematic diagram of aerated static pile composting system

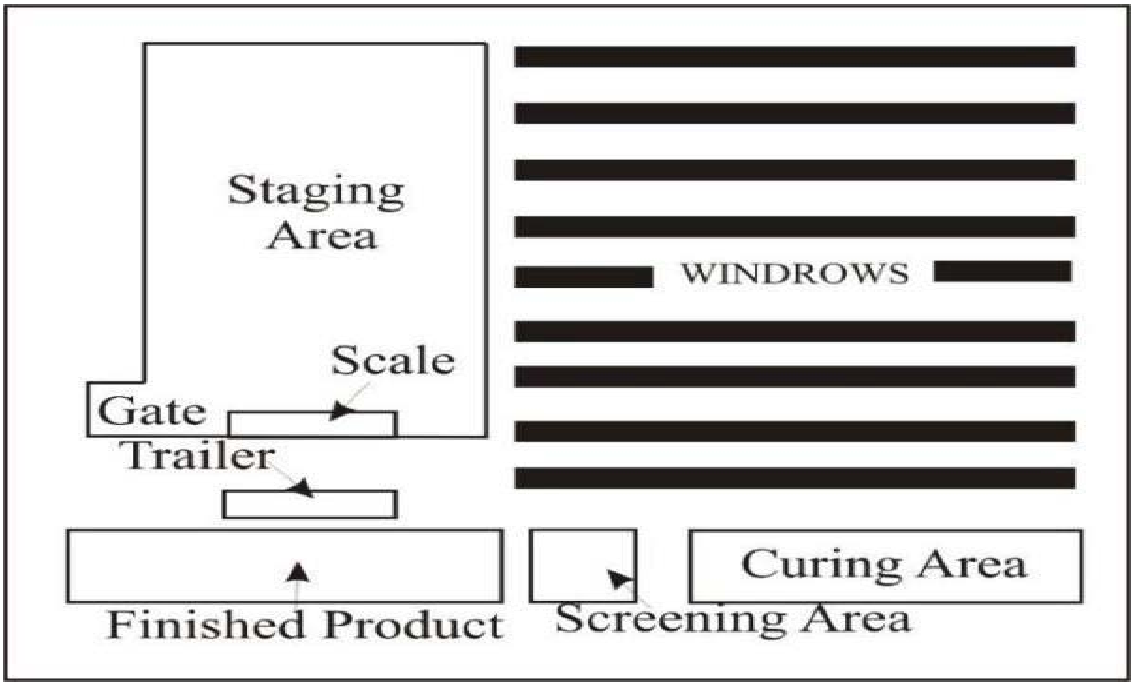


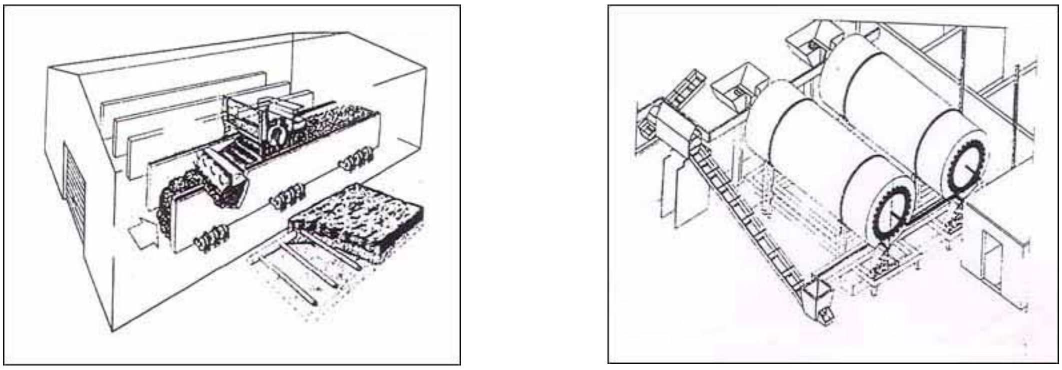
Figure 3-7 Layout of typical composting plant

In-vessel systems can compost yard trimmings, food scraps, sewage sludge, mixed wastes, and paper products. Such materials are degraded inside an enclosed container or vessel under controlled conditions (air, flow, temperature, oxygen). In-vessel systems can be divided into two major categories: 1) plug flow systems and 2) dynamic (agitated) systems. In plug flow systems, the relationship between particles in the composting mass stays the same throughout the process and the system operates in a first-in, first-out principle. In dynamic systems, the composting material is mixed mechanically during the processing (Tchobanoglous *et al.*, 1993).

In-vessel systems are designed to minimize odors and process time by controlling environmental conditions such as air flow, temperature and oxygen concentration. Thus, in-vessel composting systems have become more popular over the years due to their advanced odor control, faster throughput, lower labor costs and smaller area requirements.

In-vessel dynamic systems have greater positive results than in-vessel plug flow systems in terms of their odour control and process time. The "tunnel technology (or compost agitator)" and the "dynamic drums technology" are examples of in-vessel dynamic systems (Figure 3-8). The tunnel technology consists of a working unit which travels on steel rails, and which mixes and moves the composition material in the concrete channels in order to produce the compost.

The dynamic drum technology consists of stainless steel rotary drums, each with a capacity ranging from 2.5 to 15.0 tons, which are continuously rotated to enable the decomposition of organic material to produce compost. The figures below are schematic illustrations of the in-vessel dynamic tunnel technology and the in-vessel dynamic drums technology.



(a) (b)

Figure 3-8 Layout of in-vessel composting technology; (a) In-vessel tunnel technology; (b) In-vessel drums technology

3.5.2.2 Proposed Composting Technology

The composting technology has not yet been proposed by the consultant as the process is still under design.

3.5.2.3 Liquid Waste Management in the Sorting and Composting Plant

The leachate liquid generated from the Cheesemanburg sorting and composting facility during storage, processing and composting activities will hereinafter be referred to as "liquid waste". The liquid waste generated from sorting and composting facility has different chemical and biological characteristics than leachate from landfill facilities. The wash water of the facility and transportation trucks could also be added to the liquid waste.

Therefore, a liquid waste management system should be developed and implemented in order to properly control, collect, monitor and treat the liquid waste on site along with the leachate generated from the sanitary landfill.

3.5.2.4 Waste Storage Areas for Cheesemanburg Sorting and Composting Plant

The Cheesemanburg sorting and composting plant is expected to incorporate areas for the remaining waste streams, which will include recyclables, compostable and produced compost, and a temporary storage area for the refuse (rejects). The latter is expected to be transferred to the Cheesemanburg sanitary landfill, which is expected to be located adjacent to the sorting and composting plant.

The receiving area as well as the storage area for recyclables and compostables and produced compost will be designed with a capacity of at least two days throughput. The design of these areas and other storage areas intended for recyclables and illegally disposed wastes should take into account:

1. Roofing to prevent rainwater infiltration, limit the uncontrolled release of gases, and suppress the proliferation of vectors;
2. Impermeable paving to minimize the infiltration of the resulting liquid waste into the subsurface;
3. Proper drainage and ventilation systems; and
4. Proper mixing of the concrete slab on grade with adhesive and resistant materials to liquid waste effect.

3.5.2.5 Cheesemanburg Sorting and Composting Plant Design Components

The MRF plant should be designed as a closed building made of cement, natural stones, or hermetically closed metallic hangars. The number of inner pillars and other obstacles should be minimized as they hinder the proper movement of vehicles as well as the loading and unloading activities. Specific area should be designated for liquid waste collection and treatment and storage of the sorted wastes.

A preliminary conceptual design map of the sorting and composting plant is yet provided. However, such plants should contain the following components:

- **Guard room and weighbridge:** incoming trucks are weighed at the entrance of the facility and waste loads are kept as records.
- **Unloading area:** incoming trucks park in this area to unload waste unto the receiving area or tipping floor.
- **Receiving area:** large components are removed from the incoming waste. The remaining waste is loaded on to the sorting line.
- **Sorting line:** bags are opened by a mechanical bag opener. Wastes are then transferred to the trammel screen for mechanical sorting. The oversized material is transferred to

a large conveyor belt for manual separation (hand picking) into reusable materials and recyclables, refuse and organic material. The remaining organics on the conveyor pass through a magnetic separator (overhead magnet) then through a shredder to reduce the size of the compostable material before composting. All ferrous material collected by the overhead magnet are diverted to a separate conveyor.

- **Composting unit:** ***composting unit is not chosen yet.*** The recommended one is the In-vessel Tunnel Technology. This technology consists of nine composting tunnels and one emergency tunnel where the sorted organic material is spread and automatically agitated/mixed with the help of a movable toothed drum on conveyor. The composting tunnels are continuously aerated by perforated PVC pipes. Water may also be added to the tunnels from overhanging PVC pipes.
- **Curing area:** after composting is over, the compost is moved to the curing area for an additional 20-30 days. The curing process usually occurs on concrete pads which are covered and at time aerated.
- **Compost fine screening and storage (stock) area:** the cured compost material is then fed to a trammel screen in the refining area with the help of a front-end loader. The trammel will then remove all fine particles, such as impurities and recyclables (plastic, glass, metals), from the compost which will then be sent to the storage area.
- **Administrative area:** an area will be specialized for the facility administration with an associated parking space facing it (serves the entire facility: sorting, composting and sanitary landfill).
- **Worker's facility:** the room situated under the administrative area will contain lockers, showers and toilets for the facility's workers (serve the entire facility-sorting: composting and sanitary landfill).
- **Liquid waste collection tank:** liquid waste collection tank should be included on site.
- **Biofilter:** a biofilter consisting of at least two cells (this depends on the facility capacity) will be included at the plant. These cells consist of biological media i.e. microorganisms to treat minimal amounts of odorous air expected to be generated from the sorting area as well as the composting area.
- **Temporary storage areas:** these will be included on site and will be used to store 1) recyclables, 2) material resulting from the sorting process which is neither recycled nor

composted (rejects) and 3) any illegally disposed waste identified at the sorting and composting plants.

- **Workshop:** the workshop will be used for repairing trucks and other site machinery. The workshop will also consist of an equipment storage room where repair tools and spare parts will be stored. Several benches can also be placed in the workshop.

3.5.2.6 Cheesemanburg Sanitary Landfill Components

Sanitary landfill refers to an engineered facility for the disposal of the remaining rejected inert portion of treated solid waste after sorting and composting activities have been carried out. Sanitary landfills are designed and operated to minimize public health and environmental impacts.

The contractor should prepare a preliminary overall detailed design for the proposed sanitary landfill. The design should be based on detailed geological, hydrogeological and geophysical conditions of the site.

The principal elements that must be considered in the planning, design and operation of sanitary landfills consist of: 1) landfill layout and design which takes into account a liner system, top cover and daily cover, 2) leachate collection and treatment, 3) landfill gas management and 4) landfill closure and port-closure. Figure 3-9 below depicts a simplified typical diagram of the concept of a controlled sanitary landfill consisting of a liner system, a leachate collection system, a gas control system as well as a top soil cover.

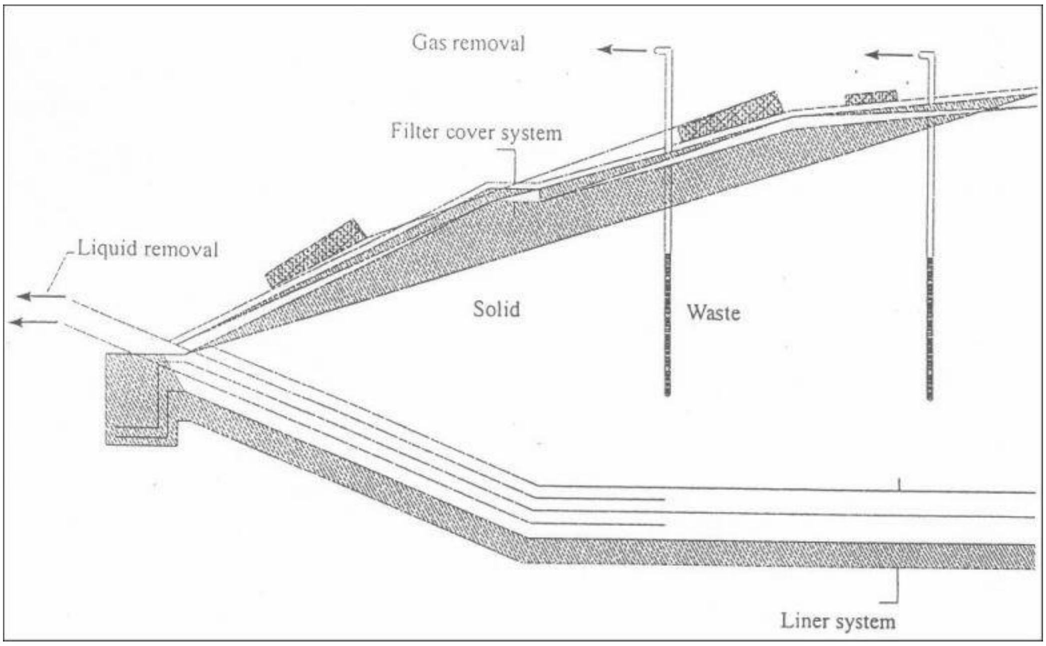


Figure 3-9 Typical controlled sanitary landfill

3.5.3 Landfilling Method

There are three principal methods used for the landfilling of solid waste and these consist of 1) excavated cell/trench, 2) area and 3) canyon/depression. In the case of Cheesemanburg facility, the excavated cell/trench method does not appear to be suitable, because the water table appears to be shallow; this also applies to the canyon/depression method since the topography of the site hosting the landfill is flat.

3.5.4 Landfill Basal Liner System at the Cheesemanburg Facility

Landfill liners are materials (both natural and manufactured) that are used to line the bottom area and below-grade sides of a landfill. The objective of landfill liners is to minimize the infiltration of leachate into the subsurface soils below the landfill, thus eliminating the potential for groundwater contamination. Figure 3-10 is an illustration of a typical landfill basal liner system. ***The basal liner system discussed in this section provides an example of a typical basal liner system. The appropriate basal liner system to be used at the landfill will be designed based on detailed geological, hydrological and geotechnical studies of the site.***

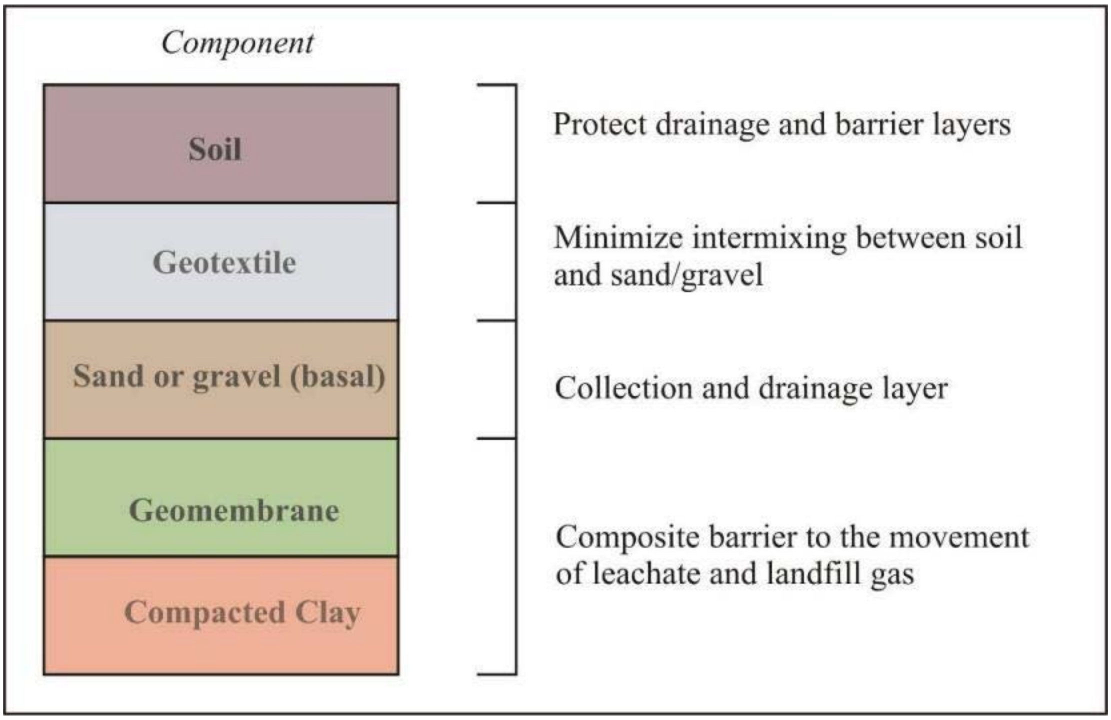


Figure 3-10 Typical components that constitute a landfill barrier liner (Source: Tchobanoglous et al., 1993)

It should be noted that there are several options available for landfill liners. The most suitable landfill basal liner that is proposed for the Cheesemanburg landfill site is based primarily on the geology of the site. The basal liner should be layered from the bottom layer to the top layer per the EU Landfill Directive as follows:

- Compacted clay layer, composed of 2 layers of 25 cm (each) of clay with permeability less than 5x10-9 m/sec or equivalent geo-composite liner.
- Geomembrane HDPE, of thickness between 0.15-0.25 cm, securely welded and impermeable over the complete length of joints. The weld seams shall be checked for their impermeability and mechanical stress along their complete length.
- Drainage layer:
  - Option 1 (recommended): Sand layer of 25 cm thickness which does not react with the leachate and which allows proper drainage to the leachate collection system. This layer should contain perforated pipes in order to collect and convey the collected leachate to a central location.
  - Option 2: Geonet layer of high density polyethylene and geotextile covered with a protective layer of soil. The geonet and geotextile composite function together as a drainage layer to convey the leachate to the leachate collection system.

- Geotextile layer above the sand layer which minimizes intermixing of the sand and soil layer.
- Soil layer of 50 cm thickness which protects the drainage and barrier layers.

3.5.5 Waste Placement and Daily Cover/Intermediate Layer

Once the landfill site has been prepared, the next step in the process involves the actual placement of waste material. The waste deposited in each operating period, which is usually a one day-shift, forms a working day cell. Waste is placed in these working day cells beginning along the compaction face and continuing outwards and upward from the face. Wastes deposited by the collection and transfer vehicles are spread out in 0.5-0.6 m layers and compacted. The total emplaced wastes should have an average density of more than 800 km/m^3. A working day cell includes the deposited inert waste and the daily cover material surrounding it.

The accumulation of working day cells over several years will result in an individual landfill cell. Typically, such cells are designed for a lifetime of two (2) to four (4) years. Typical heights for such cells vary from 2.4 to 3.7 m and widths vary from 3.0 to 9.0 m both depending upon the design and the capacity of the landfill. A complete layer of such cells over the active area of the landfill is referred to as a lift (Figure 3-11). It should be noted that each completed cell shall have a sloped surface between 2-5% however not exceeding a gradient of 1 in 3. The sloping of each cell is necessary to enhance surface water runoff. This provisional landfill capping system shall consist of a granular protection layer (minimum width of 30 cm) and an overlaid soil cover (minimum width 1 m). Intermediate cover layers or daily covers (made of compost or soil) should be used to cover the wastes placed after each operation period (i.e. day) in order to:

- Eliminate the harboring of disease vectors.
- Enhance the aesthetic appearance of the landfill site.
- Reduce odour emissions, and
- Limit the amount of surface infiltration.

It should be noted that significant quantities of water enter the landfill and ultimately become leachate during the operation phase. Therefore, the type and thickness of the intermediate cover material applied plays an important role in landfill management as it can limit the amount of surface water that enters the landfill. The most effective daily cover materials are soil or Grade C or Grade D compost with a thickness of at least 10 cm. In addition, the intermediate cover layer of each cell within the landfill must be sloped between 2-5% (as mentioned previously), in order to enhance surface water runoff.

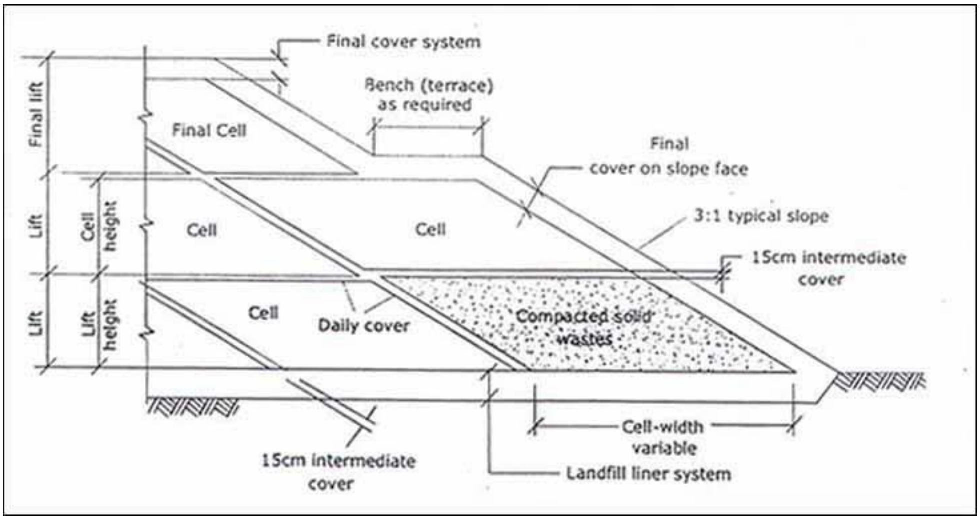


Figure 3-11 Schematic illustration of sectional view through s sanitary landfill

3.5.6 Intermediate Drainage Layers

Installation of an intermediate drainage layer is recommended after one or two lifts have been completed. This intermediate drainage layer is necessary to speed up the leachate collection process. The number of intermediate drainage layers and their placement within the landfill depends upon the final height of the landfill and will therefore be determined in the detailed design phase of the project.

3.5.7 Landfill Top Cover

When the landfill reaches its full capacity it will be closed. This is typically carried out by capping off the landfill with a final layer or cover of top soil. The primary purposes of the final landfill cover are to:

- Minimize water infiltration from rainfall after closure thereby limiting leachate generation.
- Protect surface water and groundwater in the surrounding area.
- Limit the uncontrolled release of landfill gases.

- Control odour emissions from the site.
- Suppress the proliferation of vectors.
- Limit the potential for fires.
- Provide a suitable surface for the re-vegetation of the site.
- Serve as the central element in the reclamation of the site.

Many types of landfill cover designs have been proposed and are used. Generally, a basic landfill cover consists of a series of layers (Figure 3-12) each of which has a special function. The sub-base soil layer is used to contour the surface of the landfill and to serve as a sub-base for the barrier layer. The barrier layer is used to restrict the movement of rainwater into the landfill and the release of landfill gas through the cover. A drainage layer transport rainwater that percolates through the cover material away from the barrier layer and reduces the water pressure on the barrier layers while the surface layer is used to contour the surface of the landfill and to support the vegetation that will be used in the long-term closure design of the landfill.

Typical landfill final cover configurations are illustrated in Figure 3-13.

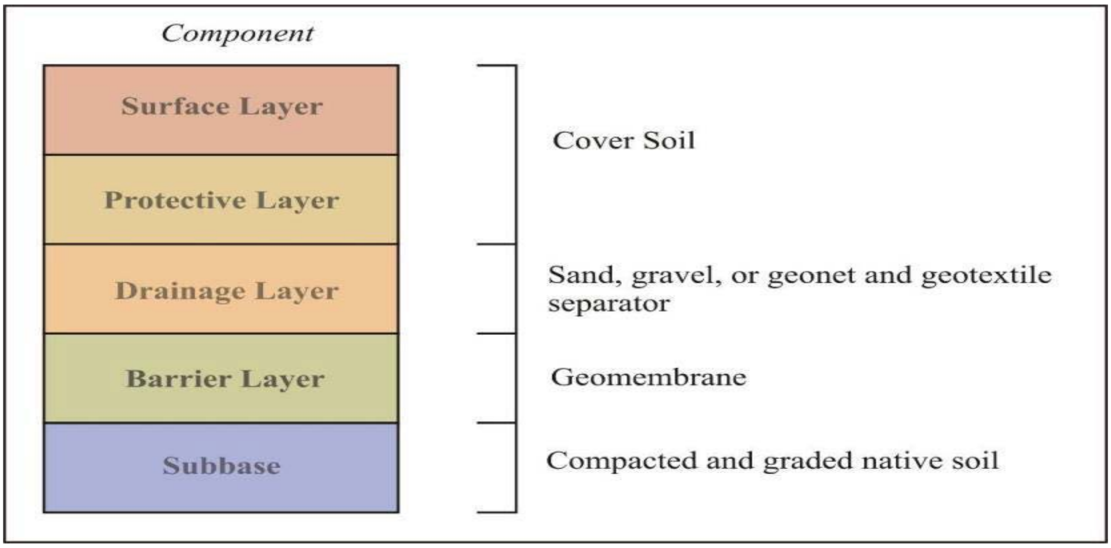


Figure 3-12 Typical components that constitute a landfill cover (Source: Tchobanoglous et al., 1993)

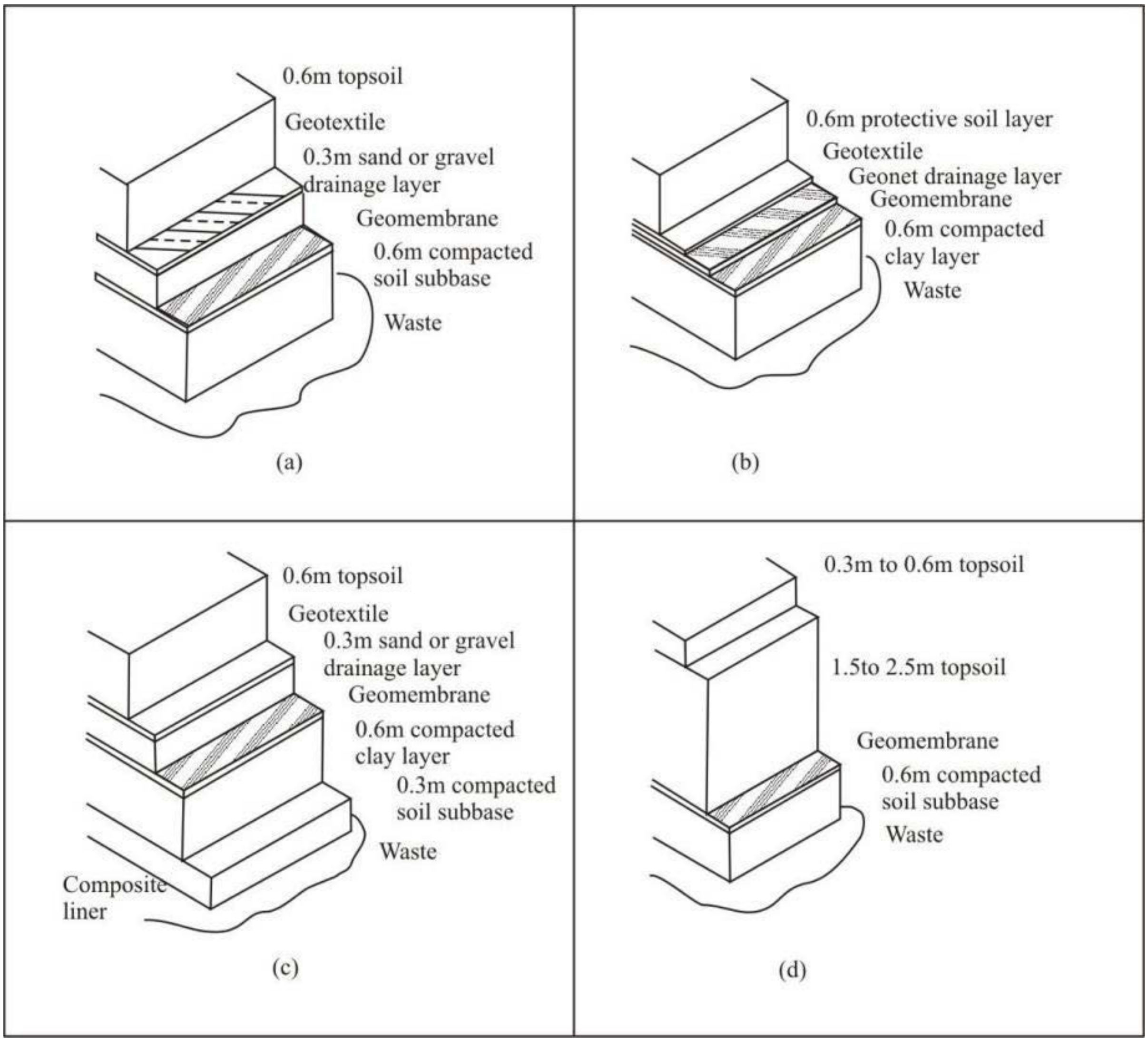


Figure 3-13 Typical landfill final cover configurations (Source: Tchobanoglous et al., 1993)

The landfill cover shall include the following components and layers that are presented in order, starting with the first layer placed at the bottom, above the landfilled wastes:

1. *Sub-base:* Compacted soil or native soil layer sub-base covering the last layer of landfilled waste (0.3 – 0.6 m thick).
2. *Barrier layer:*
   - Geomembrane layer placed on the sandy layer.
   - Compacted clay barrier layer (60 – 100 cm thick) placed above the geomembrane layer.
3. *Drainage layer:* Sand and gravel drainage layer (30 cm thick).
4. *Protective/surface layer:*
   - Membrane layer (optional)

- Agricultural soil layer (1.5 m thickness) to be added as a landfill cap layer; this soil is expected to be clay loam and will be used as a cultivation layer.

It should be noted that the above order and thickness of the different components making up the final cover layer should be proposed based on the existing geology of the site, rate of precipitation as well as common practices in the field of landfill design.

A recuperation canal system is recommended to control and manage rainfall runoff from the surface of the closed landfill. The final landfill cover should have suitable inclines to allow proper rainwater diversions into lower level aqueducts feeding into collection tanks. The collected rainfall runoff from the surface of the landfill can be used for daily consumption at the facility.

3.5.8 Leachate and Liquid Waste Management

Leachate is water that comes into contact with waste and is potentially contaminated by nutrients, metals, salts and other constituents. Leachate will be generated from the landfill. Leachate has the potential to cause serious pollution to groundwater and surface water if not managed properly.

Hence, the objective of leachate management is to:

- Minimize the generation of leachate.
- Manage leachate to safeguard the protected environmental values of surface water and groundwater.
- Detect and promptly remediate pollution of surface water or groundwater.

The design of the leachate collection system involves: 1) the selection of the type of liner system, 2) the development of a drainage system for the removal of the generated leachate, and 3) leachate treatment.

3.5.9 Design of Leachate Drainage System

A proper leachate drainage system should be installed above the geomembrane layer within the landfill. This is comprised of two principal components: 1) sloped terraces and 2) piped bottom. This combined approach should be applied at the Cheesemanburg facility to enhance the collection of leachate generated in the landfill. The bottom terraces at this facility site should be shaped to a slope gradient of 1-2% thereby allowing the leachate generated to laterally drain through the sand or gravel drainage layer into the perforated pipes. Figure 3-14 represents a typical layout of a leachate drainage system.

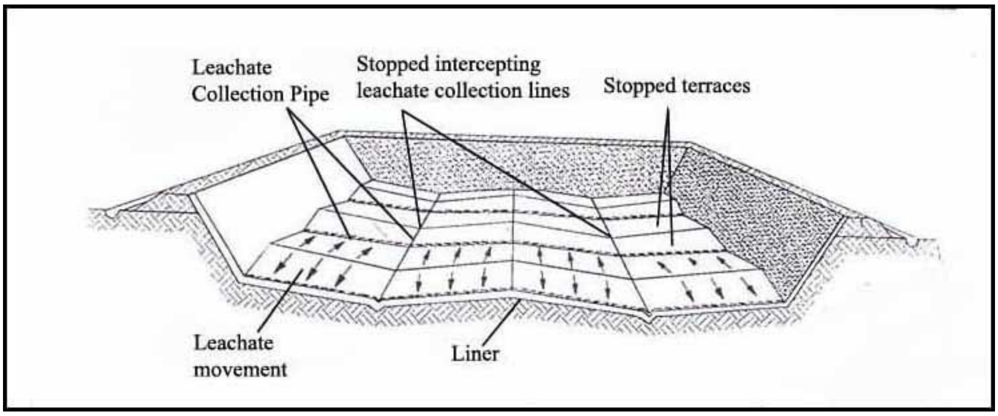


Figure 3-14 Schematic diagram for leachate collection system

The proposed leachate drainage system design could be as follows:

- The drainage layer shall have a thickness of 30 cm composed of gravel of basaltic nature or gravel with a permeability of less than $1x10^{-2}$ m/sec and a maximum content of $CaCO_3$ of 30%.
- The leachate collection pipes are placed horizontally in the drainage layer (the use of a piped leachate collection system will ensure the rapid removal of leachate from the bottom of the landfill).
- The distance between the leachate collection pipes shall be between 10-15 m apart.
- The collection pipes shall be perforated 2/3 and made of High Density Polyethylene (HDPE) or Polypropylene (PP). The pipes should have an inner diameter of minimum 20 cm and should be placed following a 1 percent inclination. The perforation should amount to a minimum 100 cm^2 per m. Each cell within the landfill should have an independent leachate drainage system. The pipes should be covered by a gravel-rigole made of granular layer and with a filling over the pipes of no less than 30 cm.
- The perforated pipes will intercept and convey the collected leachate to a holding tank with an impermeable layer.

3.5.10 Leachate Treatment and Management

During the dry season, it is proposed to re-circulate the collected leachate on the active landfill cells. Recirculation has several advantages including: (i) accelerating the biological processes within the landfill and thereby assisting in the degradation of the waste (ii) reducing the overall quantity of leachate that requires treatment and (iii) reducing the harsh characteristics of the leachate.

In addition to recirculation, the remaining generated leachate must be treated on site prior to discharge. Technologies for leachate treatment can be classified as follows (i) biological methods, (ii) physiochemical, (iii) heat and (iv) membrane methods. Therefore, the recommended leachate treatment system is recirculation coupled with a combined biological and chemical treatment method.

In addition to leachate, wash water from the facility and transportation trucks will also be generated at the landfill. As mentioned above, this generated wash water is referred to as "liquid waste". Therefore, the liquid waste and leachate generated from the sanitary landfill will be collected and treated on site along with the liquid waste generated from the sorting and composting plant.

3.5.11 Landfill Gas Management

The degradation of putrescible waste in a landfill generates gases such as methane, carbon dioxide and other trace gases that pose potential hazards to site safety, human health and the environment. Generation of landfill gas can continue for years after placement of the waste. Methane is explosive if present in the range of 5% and 15% by volume in air. Both methane and carbon dioxide are not only asphyxiates if present in excessive concentrations, they are also greenhouse gases. Although methane and carbon dioxide are odorless, other components of landfill gas can be very odorous. Therefore the objective of management strategies for the movement of gases generated from landfill is to:

- Reduce atmospheric emissions and therefore potential associated hazards.
- Minimize the release of odorous emissions and dust.
- Minimize subsurface gas migration.
- Allow for the recovery of energy from methane
- Comply with the Clean Development Mechanism (CDM).

The Clean Development Mechanism (CDM) is an arrangement under the Kyoto Protocol allowing developing countries, such as Liberia, to obtain funding and technologies developed countries that have a greenhouse gas reduction commitment.

3.5.12 Landfill Gas Control System

Landfill gas control systems can be classified as either passive or active. In passive gas control systems, the pressure of the gas that is generated within the landfill serves as the driving force for the movement of the gas. In active gas control systems, energy in the form of an induced vacuum is used to control the flow of gas generated within the landfill. Passive gas control systems are less costly and less energy consuming than active gas control systems.

Passive control of landfill gases is proposed as the most appropriate means of controlling gas emissions at the landfill.

The passive control method is based on the fact that the lateral migration of landfill gas can be reduced by relieving gas pressure within the landfill interior. This therefore entails the installation of perforated pipes or gravel-filled columns into the landfill to provide a flow path for the gas to reach the surface. These vents are installed through the final landfill cover extending down to the liner system that will limit the movement of landfill gases. This therefore creates an impermeable barrier within the landfill, controlling the movement of the landfill gases to adjacent soil formations. The gas collection system should be constructed for each cell prior to construction of the capping.

3.5.13 Landfill Gas Treatment

Typically, landfill gases that have been recovered are either flared or used for the recovery of energy in the form of electricity or both. Enclosed flaring is the method proposed for the control of landfill gases, whereby methane and any other trace gases (including VOCs) are combusted in the presence of oxygen to carbon dioxide, sulphur dioxide, oxides of nitrogen and other related gases. This is usually accomplished in a specially designed enclosed flaring facility. Due to associated air pollution concerns, modern flaring facilities are designed to meet relevant operating specifications (such as minimum combustion temperature and residence time) to ensure the effective destruction of VOCs and other similar compounds that may be present in the landfill gas.

The landfill gas control and treatment system to be used in the landfill will be available when the landfill design is completed. Once designed, specific mitigation measures will be developed for the method in use.

3.6 LIFESPAN, CLOSURE, POST CLOSURE DESIGN PLAN AND POST CLOSURE MAINTENANCE PLAN

Taking into account the current rate of waste generation and the rise in quantities generated from Monrovia, the proposed landfill is designed for a lifespan of 25 years. This lifespan will actually depend on many factors related to future waste production rates and compost production and uses.

The capacity of the MRF plant, composting plant and sanitary landfill shall be determined with the goal of achieving optimum SW minimization and cost effectiveness. In addition, peak periods and seasonal changes shall be taken into consideration.

Design plans shall be prepared for the closure and post-closure stages of the Cheesemanburg sanitary landfill facility: A management plan (post-closure maintenance) shall also be developed for the facility.

3.7 CLOSURE PLAN

When the landfill reaches its full capacity, it will be closed and can therefore no longer receive any solid waste. However, the facility must continue to function by adhering to all relevant environmental control and management requirements.

The closure plan, usually developed in the design phase, is expected to change during the operational phase. This closure plan should therefore be updated regularly and a final revised update should be approved prior to final closure.

The closure plan at the Cheesemanburg landfill shall include:

a) *Final cover design:* this ensures long term post-closure integrity of the landfill and supports growth of vegetation.

b) *Surface water and drainage control systems:* these systems control surface water runoff and prevent ground water from penetrating the liner system.

c) Control of sanitary landfill gases.

d) *Control and treatment of leachate:* after site closure and maturity of the wastes deposited on site, the quantity of leachate as well as the level of BOD and COD concentrations are normally expected to decrease with time. Leachate collection and treatment facilities are designed and built when the landfill first starts operation. The same facilities are used during the post-closure phase.

e) *Environmental monitoring systems:* the environmental monitoring plan serves to ensure that the integrity of the sanitary landfill is maintained with respect to uncontrolled release of any contaminants to the environment.

3.8 Post Closure Plan

Although closed landfills usually provide a large surface that can be used for several purposes in a post-closure restoration scheme, the end use of a former landfill is dictated by the needs of the local community, the regional land planning, and the availability of funds for the reclamation project. Parks with limited facilities and wildlife habitats, for example, would require less expenditure than multi-recreational areas.

Following landfill closure, an investigation shall be carried out regularly at the landfill in order to examine site stability and safety. The outcome of this investigation will determine the possible future uses of the site, which may include rehabilitation into parks, recreational areas, nature reserves, botanic gardens, and commercial development.

Once site conditions have been determined, the following steps shall be carried out in a post-closure rehabilitation scheme:

1. Use of cover soil of good quality for the top 20-40 cm layer. If needed soil amendment should be mixed before spreading the top soil layer.
2. Avoid cover soil compaction (spread dry cover soil and avoid the use of soil scrappers for application and spread).
3. Consider application of mulch (a top dressing layer of organic and inorganic material) to control top cover soil erosion, increase moisture retention, moderate

soil temperature and inhibit weed growth.

4. Plant selection will largely depend on the chosen end use of a site; one recommendation is towards the restoration into the surrounding natural landscape.

The selection of plant species must be addressed with special care as they should survive the environmental conditions and comply with the landscape of the site. Selection of plant species for the post-closure plan at the landfill should take into account plant tolerance to the following parameters:

1. Generation of landfill gases (CO_2, CH_4, H_2S and C_2H_4) that can either be directly phytotoxic (toxic to the plant itself) in high concentrations (CO_2) or minute amounts (H_2S and C_2H_4) or that can affect plant growth by the displacement of oxygen and the creation of anaerobic conditions at root level.
2. Low top soil oxygen content, thin cover soils and high soil compaction resulting from heavy machinery which were used on site which considerably reduce soil porosity and permeability.
3. Limited Cation Exchange Capacity (CEC) or organic matter content ranging between 2-5% in the soil or the compost used in post-closure rehabilitation schemes.

Before initiating a planting program at the Cheesemanburg landfill, the quality of top soil to be used must be determined by soil sampling and testing to assess macro and micro nutrients content, pH, conductivity, bulk density, and organic matter content.

3.8.1 Post Closure Maintenance

Post-closure maintenance will be carried out at the Cheesemanburg landfill facility. This will be conducted for at least 30 years following closure of this sanitary landfill and consists of routine inspections, infrastructure maintenance and environmental monitoring.

The environmental monitoring plan at the landfill facility will cover the following:

a. Landfill gases management system.
b. Leachate management system.
c. Infrastructure maintenance.

d. Landscape maintenance.
e. Landfill settlement.

3.9 SECONDARY WASTE TRANSFER STATIONS (SWTS)

The City of Monrovia is divided into 3 waste collection regions: (a) Northern Region, (b) Central Region, and (c) Southern Region. Each region includes a number of collection points listed in the MCC Proposed Solid Waste Collection & Disposal System (2017) (Appendix A).

Two transfer stations are currently being operated by the MCC. The Fiamah and Stockton Creek transfer stations will be inherited by this project. Separate ESMPs had been developed for these transfer stations under the EMUS Project. The existing ESMPs for these transfer stations will be re-designated and re-disclosed in-country and on the World Bank's website as the ESMPs for the operation of these stations under this project.

4 ANALYSIS OF ALTERNATIVES

The analysis of alternatives in the context of the proposed sanitary landfill for Liberia includes selection of suitable sites for the implementation of the solid waste treatment and disposal facilities as well as a technical comparison between the various available solid waste management options and determination of the most suitable option.

4.1 SITE SELECTION

The proposed site was selected prior to the preparation of the Environmental Impact Assessment. In 2014 MCC hired a consultant who provided technical support for the landfill site selection. Based on the report submitted to MCC (Sanitary Landfill Site Selection Process, August 2014) the identification of the site was based on the following criteria:

- Visual Site Inspection;
- Relevant document search and literature review;
- Interviews of knowledgeable local individuals;
- Topography;
- Geology;
- Hydrology;
- Land cover;
- Ecological assessment; and
- Socio-Economic Impact Assessment.

Several sites were identified to be considered for possible selection for landfill development. The candidate sites amounted to five (5). The search method was based on the process of elimination. Areas excluded, included those that are not considered suitable for the development of landfill site, because of environmental and social unacceptability. Some areas are built up areas, while others are marked for future development, located in flood plains, poor road access, or associates with significant water resources. The following sites were investigated during the site selection process (Table 4-1) and were compared as per Table 4-2:

- **Cheesemanburg:** located off the Monrovia-Tubmanburg Highway at approximately 20 km north of Monrovia.
- **Crosierville:** located at approximately 30 km northeast of Monrovia City, and approximately 10 km east of Mount Coffee and adjacent to the former Bong Mining Company railway.
- **Louisiana:** located at approximately 15 km northeast of Monrovia City, and close to the Pipeline Road Leading to Mount Coffee.
- **Mount Barclay:** The site is located at Monrovia-Kakata highway 10 km northeast of Monrovia.
- **Bardnersville**: The site located 10 km north of Monrovia

Table 4-1 Sites investigated during site selection process

Site Name	Location	Land size	Ownership
Cheesemanburg	Cheesemanburg	105 Acres	Public and Private
Crosierville	Crosierville	122.265 Acres	Public
Louisiana	Upper Louisiana	79.806 Acres	Private
Mount Barclay	Mount Barclay	86.605 Acres	Private
Bardnesville	Bardnesville - Between Kiaba & Samoka town	86.089 Acres	Public and Private

Table 4-2 Comparison of the five initially identified landfill sites

Site Name	Landfill Suitability	Ranking	Comments
Cheesemanburg	Highly suitable for landfill. 90% of land site is dry.	Site number 1	Site is void of residential communities and within reasonable distance from City of Monrovia.
Crosierville	Good land space; two permanent streams (Fatala and Kpanae) runs to the northwest of the site.	Site number 2	First issue, very far from City of Monrovia; second need to build access road over or on a busy train track.
Louisiana	15% of proposed site in wetland; rest of it is good for landfill.	Site number 3	Zoe Creek runs in middle of site. Creek is used by bordering towns
Bardnersville	Not suitable for landfill. 85% of proposed area is within wetland	Site number 4	Congested urbanized residential area with high population
Mount Barclay	Not suitable for landfill. 90% of proposed area is within wetland.	Site number 5	Residents opposed to landfill project. Site is in close proximity to residential dwelling and burial site.

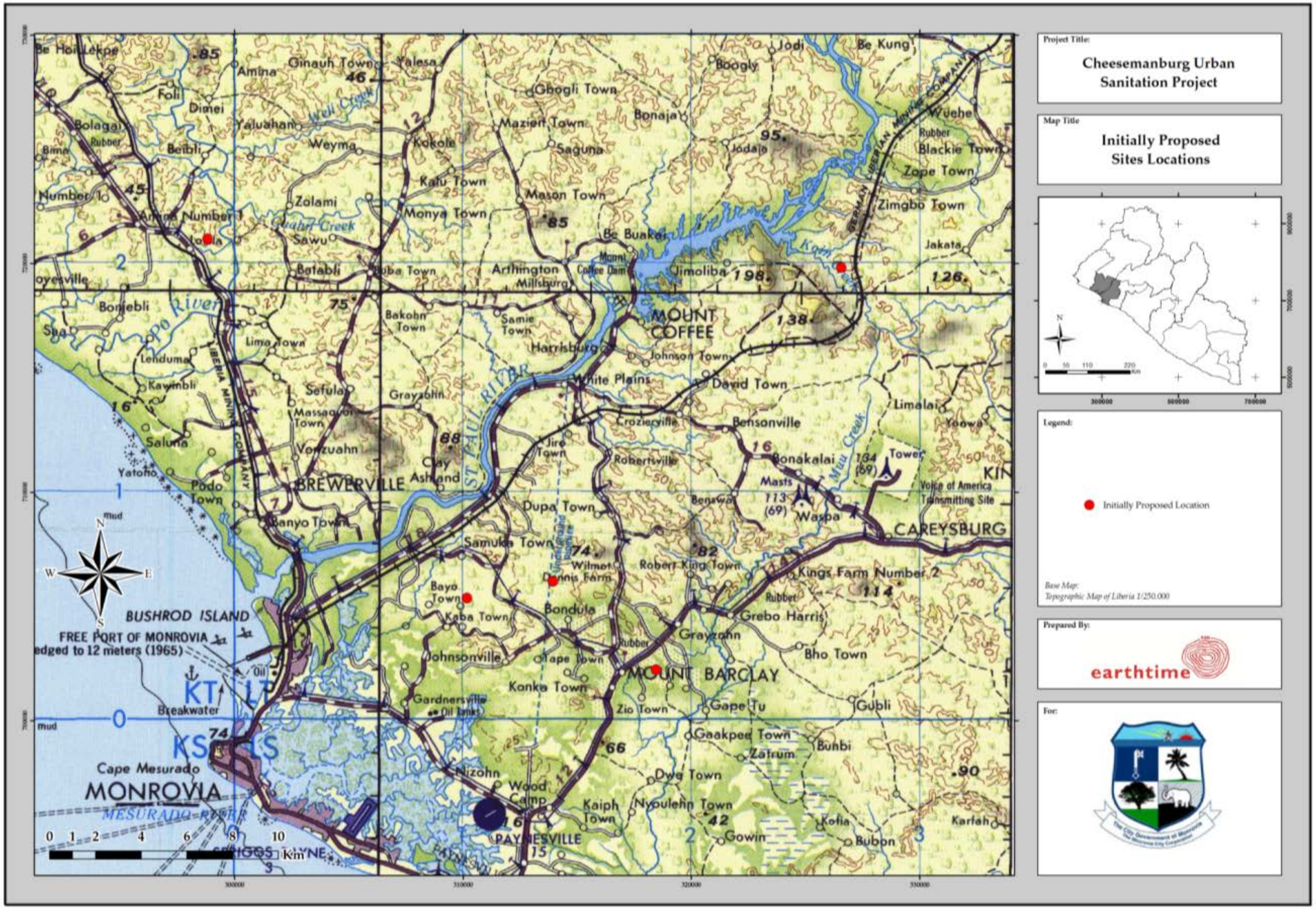


Figure 4-1 Location map showing location of the 5 initially identified sites

4.2 SOLID WASTE MANAGEMENT OPTIONS

Various alternatives for Solid Waste treatment/disposal are available. These alternatives include the proposed scheme (sorting, composting, and landfilling) vs. other alternative management options. Note that the "do nothing" scenario was also assessed.

4.2.1 Landfilling

In case landfilling alone is opted, it is expected that the area requirements will be greater as compared to the proposed management plan and will significantly increase the generation rates of leachate and landfill gas, thus requiring a more elaborate system for their management. Therefore landfilling in conjunction with sorting and composting is better. Sorting and composting activities are crucial elements in any integrated solid waste management plan since they are capable of diverting a significant portion of the waste stream into useful by-products thus reducing the amount of waste to be landfilled. On the other hand, composting and recycling may not be adopted solely but only in parallel with landfilling.

4.2.2 Incineration

At present, the adoption of incineration may not be a very favourable option in the context of Liberia since the costs of implementing it are prohibitively high.

Furthermore, the adoption of incineration technology is highly dependent on achieving effective source separation of organic matter (putrescibles) from other waste types for efficient operations. The disadvantages of incineration are mainly its high costs, high technical skill requirements, as well as the emission of a variety of air pollutants (POPs). In addition, incineration is not a complete waste treatment method as ash is left over requiring special handling procedures. It should also be noted that there are strict legislations with regards to incineration (for air pollutants such as POPs) both nationally and internationally therefore making it very difficult to implement in addition to the fact Solid waste in Liberia is anticipated to have high moisture content especially during the wet season.

4.2.3 Sorting and Recycling

Sorting is a process of arranging incoming commingled solid waste into a specific sequence and/or different sets. During the sorting process, rejects (inert materials) and recyclable materials are removed from the incoming commingled solid waste leaving behind the organic fraction which will be composted. In general, recycling can be carried out either at source (in recycling bins referred to as Source Separation or at a MRF). Source separation is currently not practiced in Liberia and should be targeted in the long-term. Sorting and recycling activities divert a significant portion of the waste stream into useful by-products thus reducing the amount of waste to be landfilled. Hence, these activities should be included in the general framework of an integrated solid waste management plan.

4.2.4 Aerobic Digesting / Composting

This is the controlled aerobic decomposition of the biodegradable organic portion of municipal solid waste, performed primarily by aerobic (oxygen consuming) organisms. Rather than allowing nature to take its slow course, a composting technology (such as in-vessel dynamic big drums, small drums or windrows systems) provides an optional environment in which decomposers can thrive. The end product of aerobic decomposition is compost material which can be used in agricultural, horticultural, landscaping, re-cultivation of abandoned quarries or soil for green space along traffic roads or golf courses, based on the quality of the compost produced. In order to obtain good quality compost, aerobic digestion must be carried out in combination with sorting and recycling activities and the general framework of an integrated solid waste management plan. These activities should be further followed by landfilling.

4.2.5 Anaerobic Digestion

This is the decomposition of the biodegradable organic portion of solid waste in an enclosed air tight vessel or container otherwise known as a digester, in the absence of oxygen. The by-product of this method of decomposition includes: 1) biogas consisting of about 60% methane, and 40% carbon dioxide, 2) liquor digestate which can be used as a soil enhancer and 3) solid digestate which can be used as compost. The biogas can be burnt to generate heat and/or electricity. In order to obtain good quality by-products and in order to prevent technical problems from developing within the digesters, anaerobic digestion must be carried out in combination with sorting and recycling activities. Anaerobic digestion is an alternative to aerobic digestion and can also be adopted in the general framework of an integrated solid waste management plan in combination with sorting and recycling activities followed by landfilling.

However, anaerobic digestion is still a relatively new technology. It is very costly and requires highly skilled technical staff for its operation. It is also worth noting that this technology is susceptible to technical problems, relating to the digestion process, as a result of impurities that may remain in the organic waste even after sorting activities have been carried out at the MRF. Hence, due to the disadvantages mentioned above, this method of treatment for the Cheesemanburg sanitary landfill is not recommended.

4.2.6 Do-Nothing Scenario

Monrovia City has a limitation in terms of size of the temporary landfill site situated at Whein town, identified and developed in 2012 as an emergency stop-gap measure since the earlier disposal site at Fiamah was filled to capacity. The Whein town landfill site will be fully filled and no more available for usage by end of 2016. The "do nothing" scenario implies that there will be a risk of increased haphazard dumping and open burning of municipal solid waste, if the Whein Town Landfill is exhausted as expected. Open dumping and burning of wastes have adverse effects on the environment and constitute a public nuisance, diminishing landscape aesthetics, and causing unpleasant odours. It also causes public health impacts by allowing the breeding of rats, and other disease vectors, and the generation of toxic gases and irritating smokes. Other effects include the contamination of soil, surface and groundwater by leachate. Although the "do nothing" scenario will avoid temporary environmental impacts associated with construction activities, on the long-term it will result in a marked deterioration of the environmental, health and socio-economic conditions at the national scale.

A comparative matrix for assessing four solid waste management options for the facilities namely, 1) sorting coupled with composting and landfilling (existing plan), 2) landfilling alone, 3) incineration and landfilling and 4) "do nothing" is presented in Table 4-3. A weighted-rating checklist was used to select among the four scenarios. Two groups of weights were used. First, each alternative was rated on a scale from 1 to 4, with 1 denoting the least plausible and 4 the most plausible, relative to 9 selection criteria. Then, each selection criterion was assigned an importance weight reflecting its significance. Weights ranged between 1 and 3, with 3 assigned to the highly important decision factors while 1 was assigned to the less important decision factors. The scenario with the highest number of points, which is the proposed plan, was considered as the most favourable scenario.

4.2.7 Comparison of Available Solid Waste Management Options

Table 4-3 presents a comparison among the available solid waste management options described above based on a number of relevant criteria. Table 4-4 presents a comparative matrix for general solid waste management plan evaluation based on criteria and rating system.

Table 4-3 Comparison of available solid waste management options

Parameters	Treatment Disposal Method							
	Landfilling	Thermal			Biological		Re-use, Recycling, Recovery	
		Grate Incineration	RDF	Pyrolysis	Aerobic Composting	Anaerobic Digestion	Source Separation	MRF separation
Proven Technology	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes
Technology Track Record	Very common	Very common	Few	Few	Very Common	common	common	common
Technical Reliability	High	High	High	Low-Medium	Low-Medium	Medium	Low	Medium
No. of personnel required for operation	Low	High	Medium	High	Medium	Medium	Low	High
Energy Recovery	Low	High	High	High	N0	Very High		
Life Span	High	Medium	Medium	Medium	High	Medium		Medium
Flexibility of process to waste quantity	Very High	Low	Low	Low	Medium	Medium	High	Medium
Maintenance Requirements	Low	High	High	High	Medium	High		Medium
Restrictions on waste composition	Very Low	Medium	High	Medium	High	High	High	High
Acceptance of wet household waste	Yes	Technically Yes but generally No	No	No	Yes	Yes	Yes	Yes
Capital cost	Medium	High	High	Very High	Low	High	Low	Medium
O & M	Low	High	High	High	Medium	High	Low	Medium
Economic Recovery Rate	Low	High	High	High	Medium	Medium	Medium	Low
Pollution abatement costs	Medium	Very High	Medium	Very High	Medium	Medium - High	Low	Medium
Monitoring costs	Medium	High	Medium	High	Medium	High		Low
Land acquisition costs	Very High	Medium	Medium	Medium	High	Medium		Low
Surrounding land depreciation	High	High	Medium	High	High	High		Medium
Disposal Fee	Low	High	Low	Very High	Medium	High		Low
Cost of treatment/disposal	Low	Medium to High	Low	Medium -high	Low to High	Medium to high		Medium
Air emissions	Low	Medium - High	Low	Medium	Low	Medium		
Control of odor	Bad - good	Good	Good	Medium-good	Bad - good	Bad - good	good	Bad - good
Liquid effluent	High	High	Low	Medium- High	Medium	High		Low

Parameters	Treatment Disposal Method							
	Landfilling	Thermal			Biological		Re-use, Recycling, Recovery	
		Grate Incineration	RDF	Pyrolysis	Aerobic Composting	Anaerobic Digestion	Source Separation	MRF separation
Waste volume reduction	Low	High	High	Low	Low	Low		
Local Public acceptability	Very Low	Very Low	Medium	Very Low	Low	Low	Medium	High
Public nuisance	Medium	High	Medium	High	Medium	Low	Low	Medium
RDF = Refuse Derived Fuel **MRF = Materials Recovery Facility**								

Table 4-4 Comparative matrix for solid waste management plan evaluation

Criteria	Weight	Score							
		Composting coupled with sorting and landfilling (proposed plan)		Landfilling alone		Incineration and landfilling		"do nothing"	
		R	W	R	W	R	W	R	W
Area requirements	1	3	3	2	2	4	4	1	1
Operational costs	2	3	6	2	4	1	2	4	8
Leachate generation	2	3	6		4	4	8	1	2
Air pollution	2	3	6	2	4	1	2	1	2
Odour	2	2	4	3	6	3	6	1	2
Surface and groundwater contamination	3	3	9	2	6	4	12	1	3
Capital costs	3	2	6	3	9	1	3	4	12
Health and sanitation	3	3	9	3	9	3	9	1	3
Public perception	3	4	12	3	9	1	3	1	3
Total			***61***		***53***		***48***		***36***

- *Weight = Represents the importance of each selection criterion whereby 1 represents the least importance criterion and 3 the most important criterion.*
- *R = Raw score ranging between 1 and 4 whereby 1 represents the worst alternative and 4 the best alternative for each of the selection criteria.*
- *W = Weighted score representing the product of the weight and the raw score.*

5 DESCRIPTION OF ENVIRONMENT

Environmental baseline data is important to understand the physical, biological and socio-economic characteristics of the project's environment. Such information sets the ground for analysis of the potential impacts of the project's activities on the existing environment.

5.1 PHYSICAL ENVIRONMENT

An initial assessment of the project area based on a review of aerial photography, topographic maps, public databases, published literature as well as site visits was conducted. This initial assessment will be followed by additional site visits and field surveys that will help provide required data to prepare a complete Environmental and Social Impact Assessment Report.

5.1.1 Topography

Liberia can be divided into three distinct topographical areas. First, a flat coastal plain which extends up to 80 km inland, with creeks, lagoons, and mangrove swamps; second, an area of broken, forested hills with altitudes from 180–370 m, which covers most of the country; and third, an area of mountains in the northern highlands, with elevations reaching 1,384 m.

The landfill site is located within the coastal plain (Figure 5-1). The elevation on site ranges between 20 and 40 m asl, forming a hill with the highest elevation almost in the center of the site (Figure 5-2).

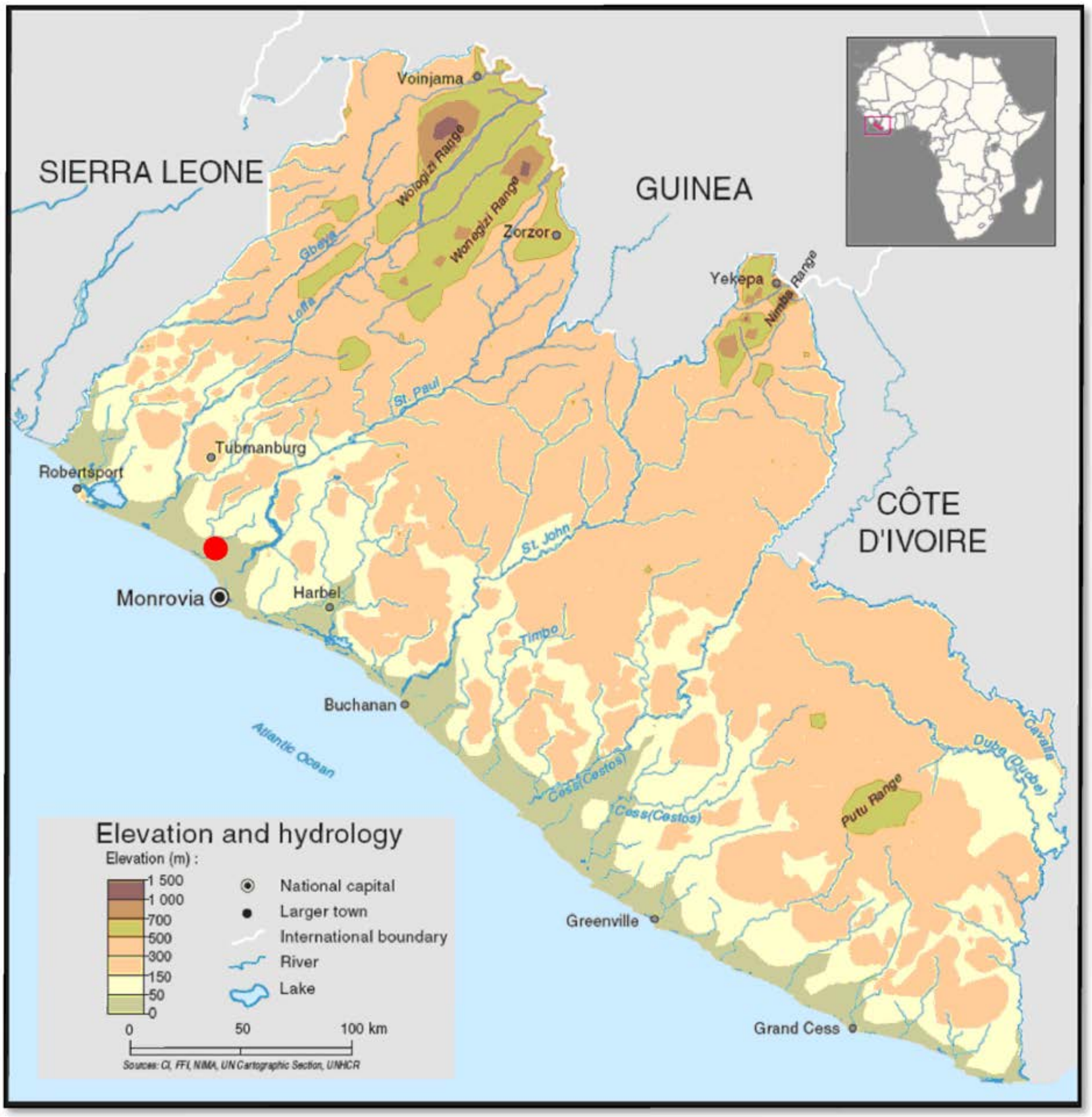


Figure 5-1 Project location with respect to the general elevation map of Liberia (UNEP, 2004. Desk Study on the Environment in Liberia)

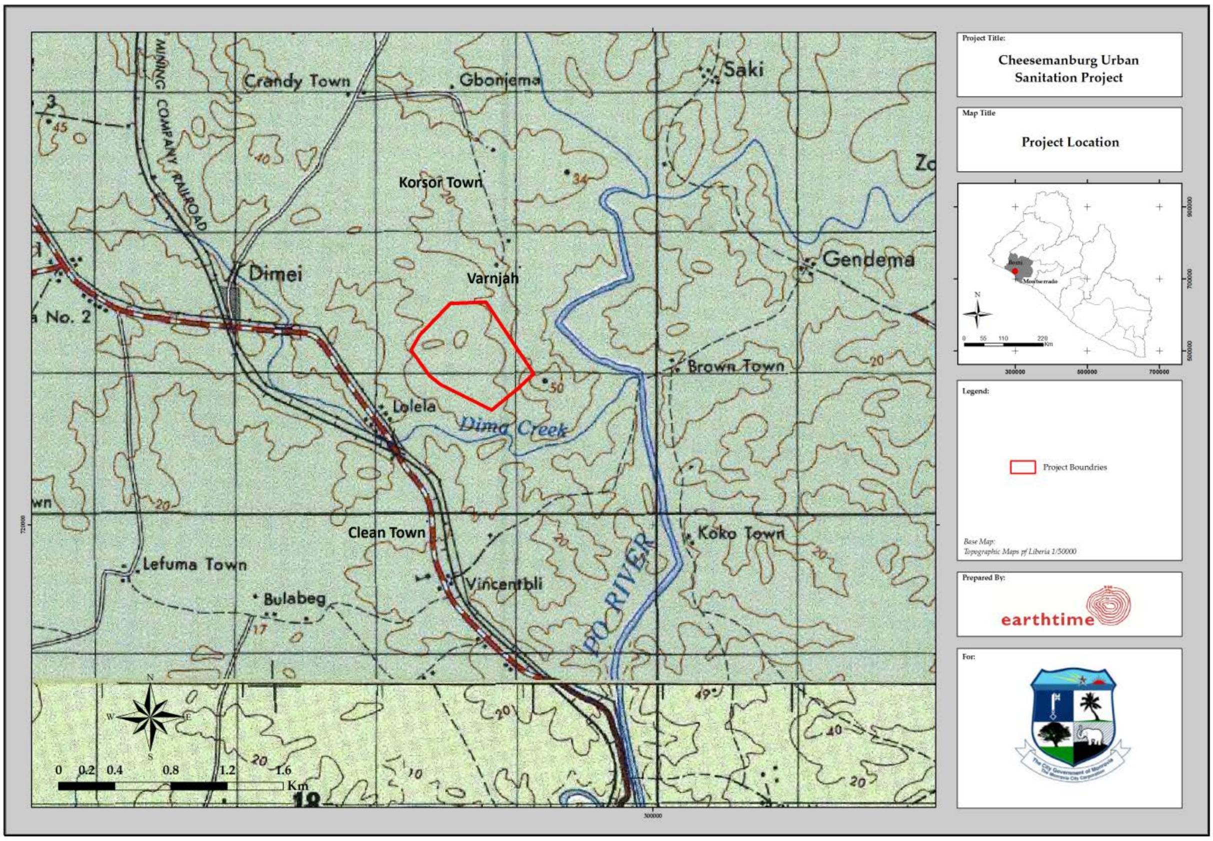


Figure 5-2 Topography in and around the site

5.1.2 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 the 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.[6]

Figure 5-3 gives a general idea about the evolution of the different meteorological parameters in the country throughout the year.

[6] UNDP,2006. First State of the Environment Report for Liberia. Monrovia, Liberia.

Figure 5-3 Average meteorological parameters throughout the year in Monrovia (www.climatetemp.info, retrieved on May 18, 2016)

Meteorological data including primarily precipitation, ambient temperature, as well as wind direction and speed, are necessary for developing and understanding an important part of the environmental conditions in the region and consequently for adequately assessing environmental impacts in a comprehensive approach.

Although no recent or historical data is available for the project site, the following sections present available historical data for the period between 1950 and 1980 in three weather stations that were installed in the counties surrounding the project area. Those stations are:

- **Monrovia** in the St-Paul River Basin (Latitude: 6º44'N; Longitude: 10º57'W; almost 15 km from project site)
- **Bomi Hills** in the Lofa River Basin (Latitude: 6º54'N; Longitude: 10º50'W; almost 40 km from project site)
- **Robertsport** in the Mano/Lofa River Basin (Latitude: 6º45'N; Longitude: 11º22'W;

almost 45 km from project site).

A meteorological station should be installed at the site to monitor atmospheric indicators (rain, wind, Temperature, Humidity, etc) that are useful in evaluating impacts on groundwater flow direction, quality and quantity, as well as refining the design of the odor control system at the composting facility, and various landfill components particularly the liner system, the leachate collection and management system, the gas collection and management system, and the cover system.

5.1.2.1 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 4,000 mm (157 inches) but reduces significantly to 1,300 mm (51 inches) at the forest-savannah boundary in the north.[7] Monrovia, the capital, receives almost 4,572 mm (181 inches) of rain per year. The corridor of the eastward flowing Cavalla River is one of the driest areas of the country, but even there the land receives over 1,775 mm (70 inches) of rain annually. The months of heaviest rainfall vary from one part of the country to another, but are normally June, July and September. Observations concerning the diurnal distribution of rainfall prove that most of the rain received along the coast falls during the night and early morning between 18:00 and 07:00 hours.

Although no recent or historical data is available for the project site, Figure 5-4 presents available historical data on the variation of the rainfall throughout the year in the three weather stations mentioned earlier for the following periods:

- **Monrovia** in the St-Paul River Basin: average monthly rainfall from 1951-1973.
- **Bomi Hills** in the Lofa River Basin: average monthly rainfall from 1952-1977; and
- **Robertsport** in the Mano/Lofa River Basin: average monthly rainfall from 1952-1973;

[7] Bongers, F., Poorter, L, Van Rompaey, R.S.A.R, and Parren, M.P.E, 1999. Distribution of Twelve Moist Forest Canopy Tree Species in Liberia, and Cote d'Ivoire

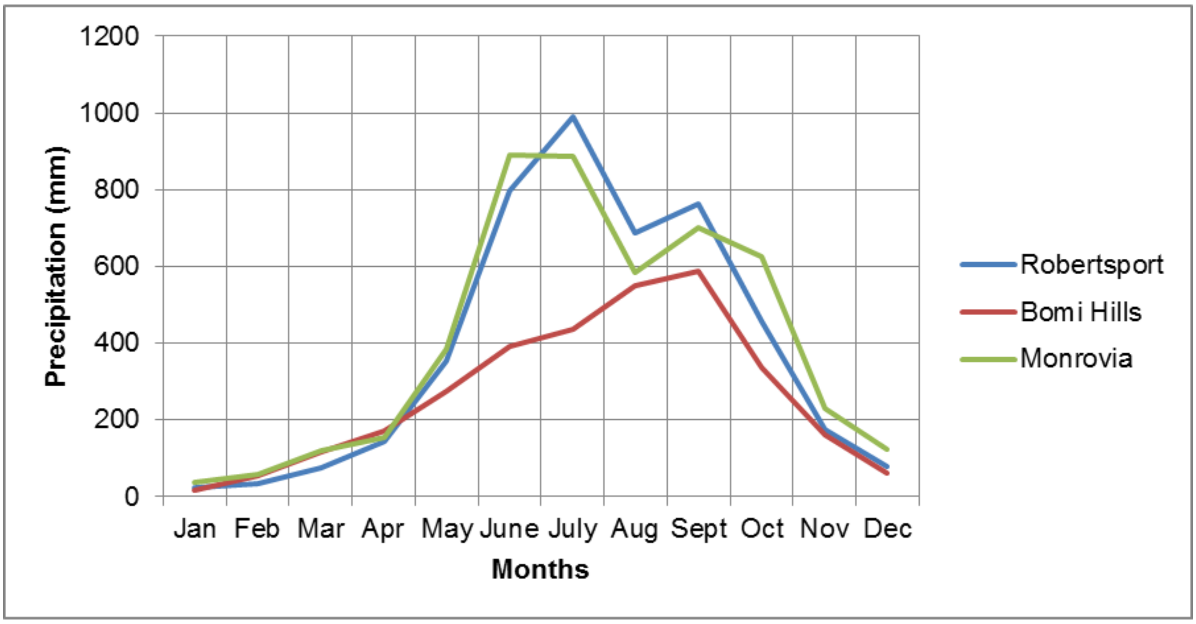


Figure 5-4 Average rainfall (mm / Month) in the project area (adapted from Liberian Hydogeological Service, 1982, 1981)

5.1.2.2 Temperature and Sunshine

Generally, temperature remains warm throughout the country 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.[8] Temperature would be much higher without cloud cover, winds, humidity and rainfall, which are influenced by the vegetation cover of the country. The days with longest hours of sunshine fall between December and March. Daily sunshine hours are at a minimum during July, August and September.

Figure 5-5 shows average temperature variation throughout the year recorded by the Robertsport, Bomi Hills and Monrovia stations described in the previous section.

[8] UNDP, 2006.

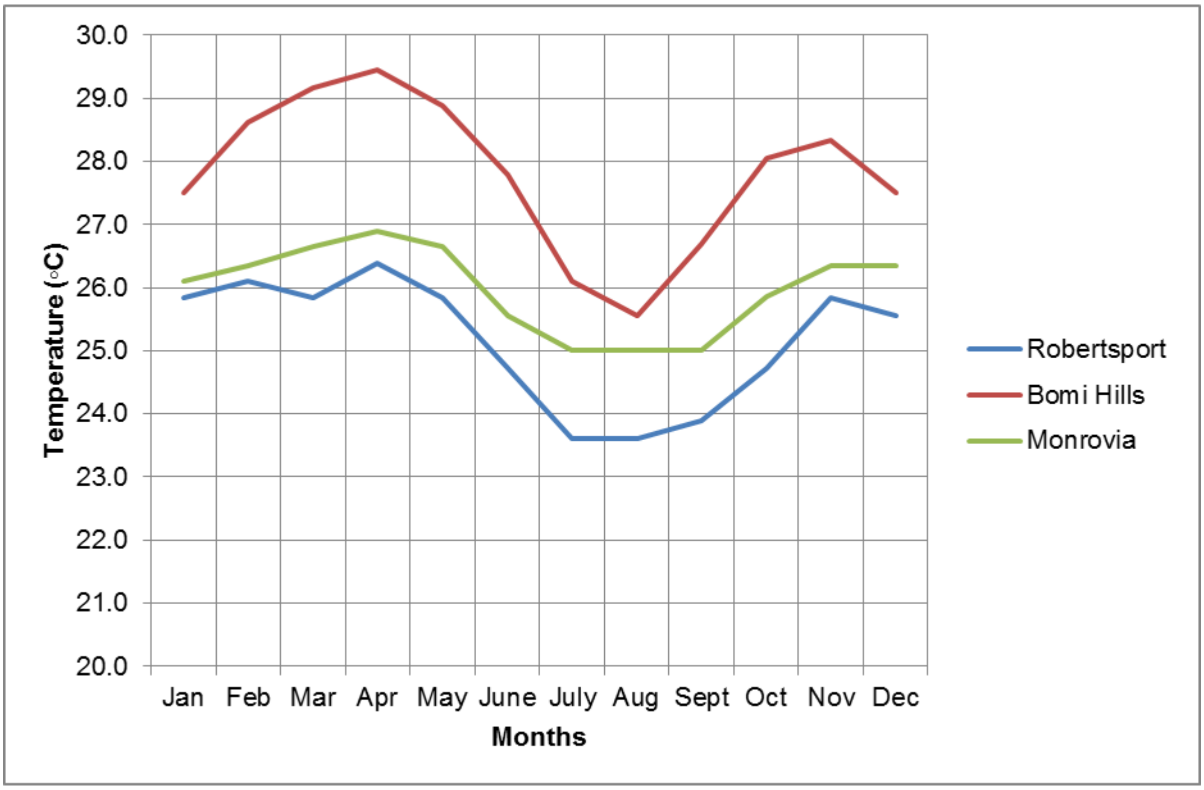


Figure 5-5 Average monthly temperature (in Celsius degree) in the project area (adapted from Liberian Hydogeological Service, 1982, 1981)

5.1.2.3 Wind

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

- The Inter-Tropical Convergence Zone (ITCZ) from the northern hemisphere, and
- 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.[9] Available information about the wind direction and speed is for Robertsfield in Montserado County (JICA, 2000-2006).

5.1.2.3.1 Wind Direction

Monthly mean wind direction shows southeast as the dominant direction and south as the second dominant direction (Figure 5-6).[10]

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[9] UNDP, 2006
[10] JICA,2009, The Master Plan Study on Urban Facilities Restoration and Improvement in Monrovia in The Republic of Liberia. Monrovia, Liberia.

5.1.2.3.2 Wind Speed

Monthly mean wind speed shows maximum 10.3km/hrs in August, minimum 7.1km/hrs in January and average 9.3km/hrs.[11] Total wind speed is greatest in the rainy season and lowest in the dry season, being lower in the interior, where high vegetation cover serves as a windbreak. Along the coast, the average annual wind speed is 30 km/h.[12]

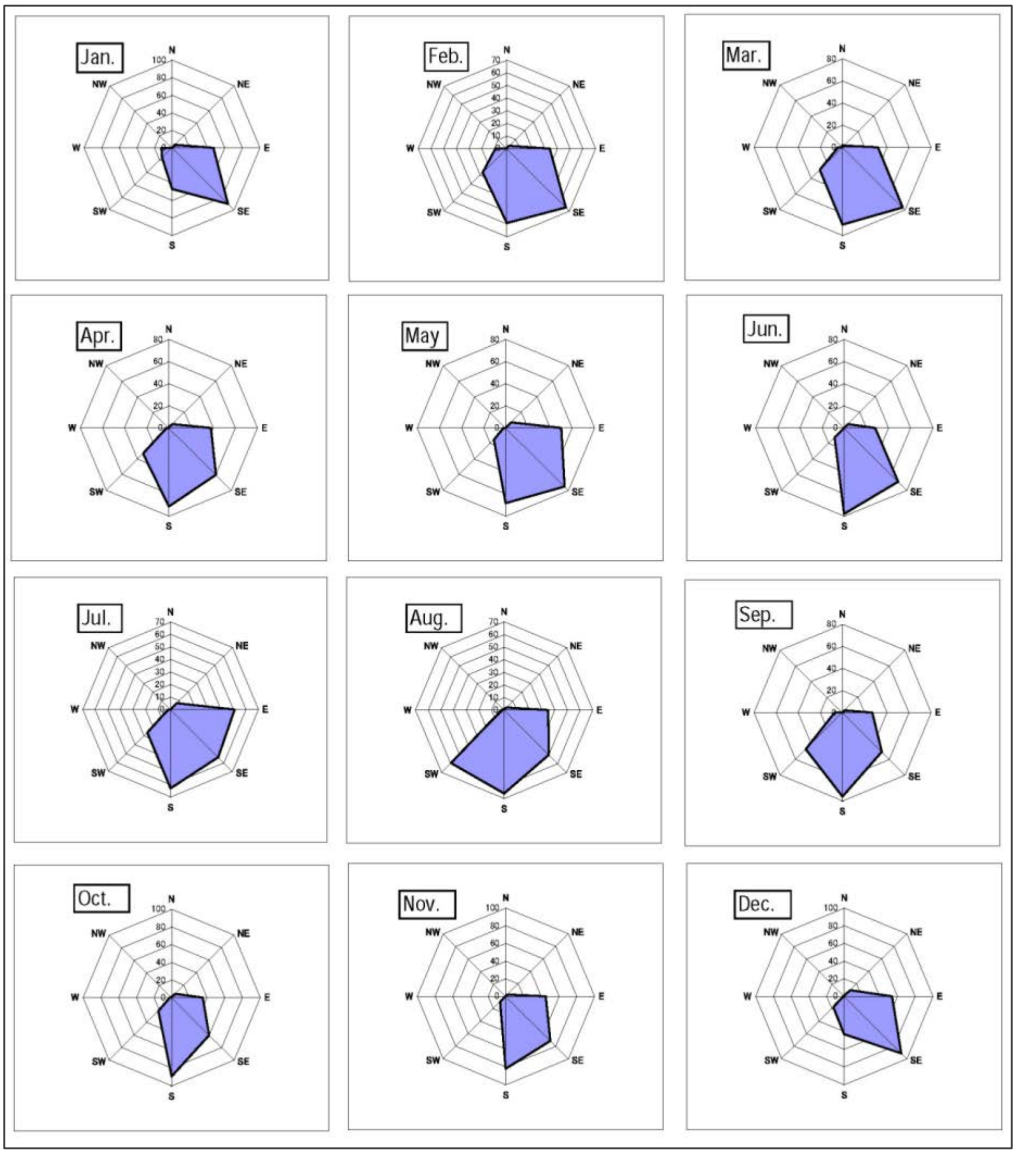

Figure 5-6 Monthly frequency of wind direction at Robertsfield in 2000-2006 (JICA, 2009. The Master Plan Study on Urban Facilities Restoration and Improvement in Monrovia. The Republic of Liberia, Monrovia, Liberia)

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[11] JICA, 2009

[12] Brandolini, G. V. and M. Tigani (2006). Liberia Environmental Profile. December 2006, Monrovia.

5.1.2.4 Relative Humidity

Relative humidity is generally high throughout the year (Figure 5-7). A relative humidity of 90% to 100% is common during the rainy season. During the dry season it decreases to as low as 65%.[13] Along the coast it does not drop below 80% and on the average is above 90%. There is a wider variation in the interior and may fall below 20% during the Harmattan period characterized by dust laden wind from the Sahara Desert.

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 January 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%. Only the zone north of the Inter-Tropical Front, where the continental air masses prevail from mid-December to the end of January, exhibits arid conditions. At times, due to the extreme dryness of the Harmattan, the humidity may drop to below 50%.[14]

Figure 5-7 shows average humidity variation throughout the year recorded by the Robertsfield station in the Farmington/Du River Basin (Latitude: 6º14’N; Longitude: 10º22’W).

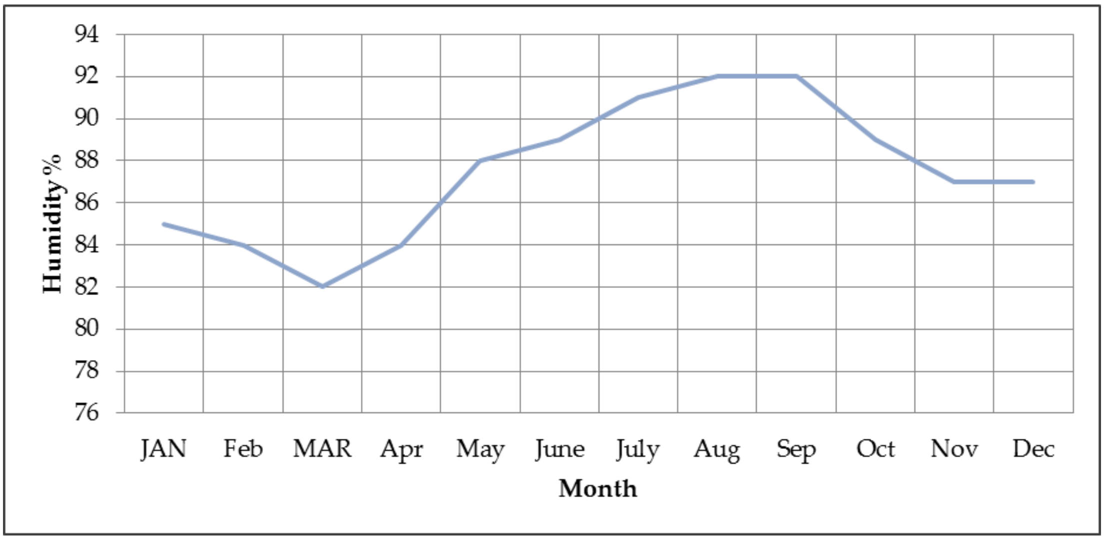


Figure 5-7 Average monthly relative humidity (in %) in Robertsfield station (1977-1982). (adapted from Liberian Hydrological Service, 1982, 1981)

[13] UNDP, 2006.
[14] Schulze,W. (1975). A new geography of Liberia. Monrovia, Liberia.

5.1.3 Geological Settings

Geological investigations in Liberia have shown that nearly all of the terrain is underlain by Precambrian crystalline metamorphic rocks which form part of the West Africa shield known as the Guinea Shield. The rocks forming this crystalline shield are a series of granite, gneiss, and schist beds which have resulted from metamorphism by tectonic forces acting on a regional scale. The structural features of the rocks in this region are uniform over relatively large areas. Gneissic structure and schistosity dip at high angles in most places and are often vertical.

Geologically, the site is located in the Pan African Age Province which mainly consists of gneiss and granitic gneiss. As per the geologic map, the only formation in the project area is the Melanocratic Gneiss Formation (gnm) which includes varying proportions of dark-colored hypersthene-diopside-hornblend-plagioclase-biotite gneiss with varying amounts of pyroxenes, hornblende amphibolites (with and without pyroxenes), granitic gneiss (with and without pyroxenes), and sillimanite-hypersthene-garnet-two mica gneiss; only very acid rocks, which are subordinate, are light colored (Figure 5-8). The map also indicates that the site is located between two major fault zones.

Outcrops are not present in the project area; those allow a more detailed analysis of the geologic setting on site and the types and dip direction of the underlying rocks that control the groundwater flows; thus, it is important to drill boreholes and conduct core analysis to be able to perform a more detailed and accurate geologic assessment of the project area.

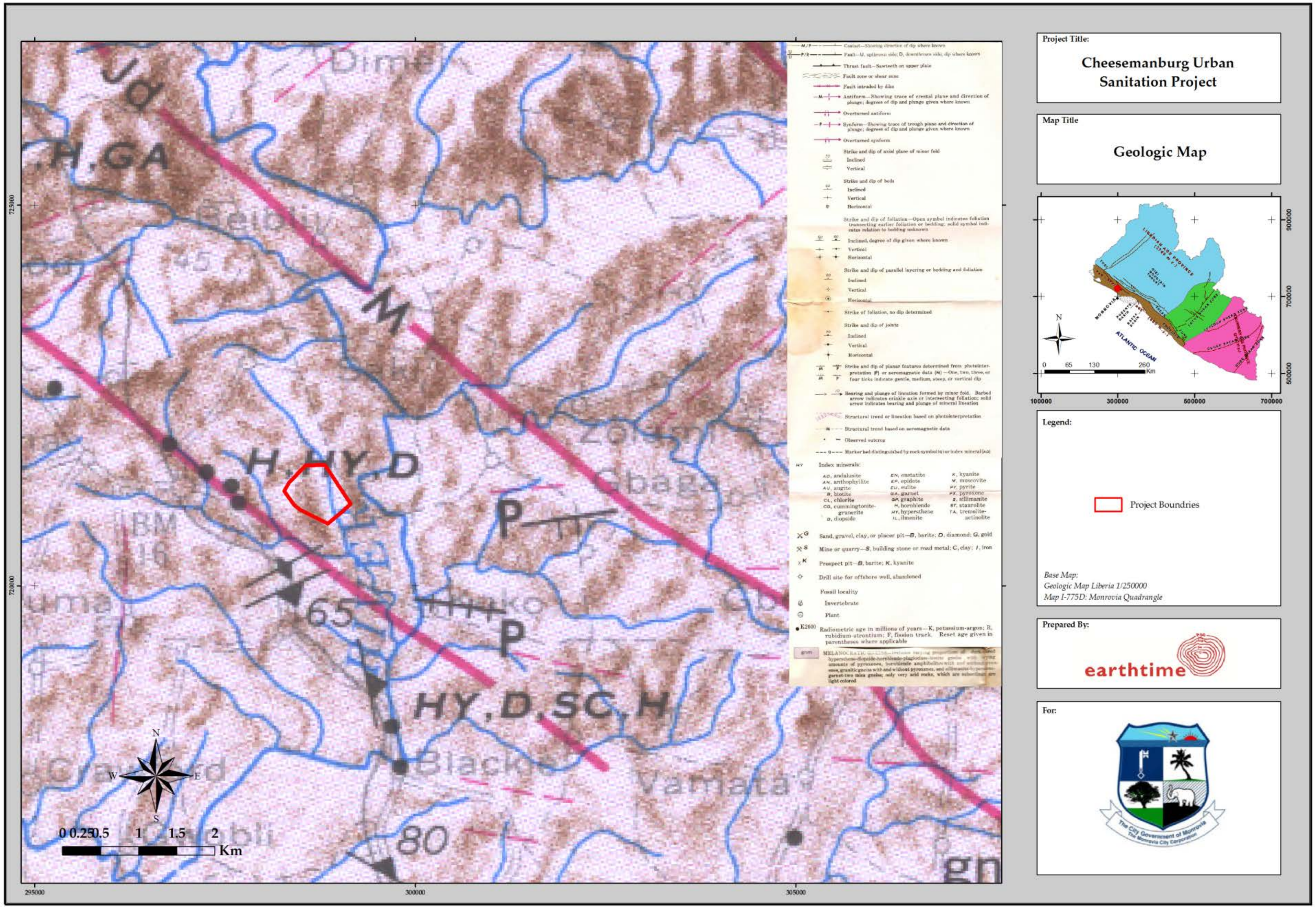


Figure 5-8 Geologic map of the proposed transmission line route

5.1.4 Water Resources

The site is surrounded by communities (Table 5-1) that rely on wells and hand pumps for drinking, cooking, cleaning and sanitary use. The communities also rely on surface water bodies for water supply especially in dry season when the wells are almost dry. Rivers and creeks are also crucial to the livelihood of the communities as they are source of food through fishing and a mean of transportation and exchange of goods between communities living on either side of the banks.

Table 5-1 Towns surrounding the project site and their approximate distance to site

Town Name	Approximate Distance to Site Boundary (m)
Vincent Town	1200
Clean Town	800
Dolela	450
Dimei	1300
Quendee	1600
Gbonjema	1300
Korsosr	900
Varnjah	300
Brown Town	1000

5.1.4.1 Surface Water

Surface water bodies in the vicinity of the landfill site include the Po River and the Dima Creek that pours into the Po River. The closest distance between Po River and the site is approximately 300m while the closest distance between Dima creek and the site is approximately 200m. In addition, the site is surrounded by a swampy area on its Northwestern and Southeastern side and includes perennial and seasonal creeks that contribute to the Dima creek and Po River (Figure 5-9).

Understanding the surface water level and flow is an important factor in the impact assessment of the project and help design proper mitigations with respect to effluent and leachates.

To better assess the surface water and it's relation to the site, water level and water flow monitoring should be performed for at least a year to cover dry and wet seasons.

5.1.4.2 Ground Water

A well survey was conducted as part of this scoping report and ESIA study. Twenty four

(24) wells were identified in the communities surrounding the site within a radius of 2Km from the site and limited by the right bank of Po River (Figure 5-9). Wells and hand pumps details and coordinates are presented in Table 5-2.

Additional groundwater assessment is important to understand the groundwater flow and help design proper mitigations with respect to effluent and leachates. Multi-level monitoring wells should be drilled on site to assess the water level and flow within the different lithology on site. One well should be installed on the highest elevation onsite and at least three other wells on different sides of the site to identify water flow directions. A detailed hydrogeological evaluation should be conducted prior to the initiation of the construction activities. Data on depth and yield of aquifers, recharge basins, groundwater flow direction are necessary for a better understanding of the hydrogeological regime in the area.

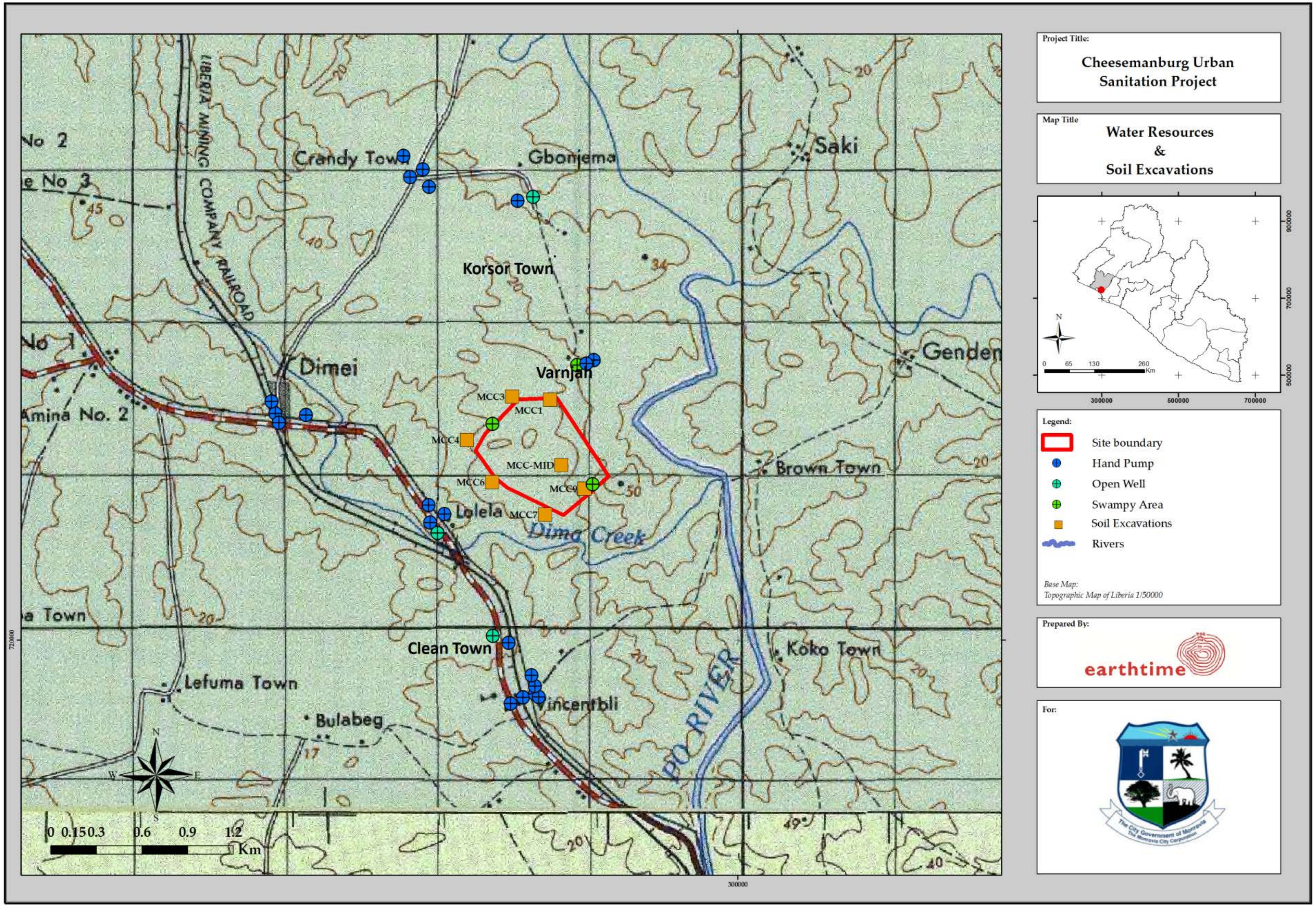


Figure 5-9 Water resources and soil excavations around the project area

Table 5-2 Details of wells and hand pumps surveyed in the project area

No	Type	Town	Coordinates (WGS 1984)		altitude (m asl)	Depth (mBG)		Water Level (mBG)		Comments	Sampled	Date surveyed
			Latitude	Longitude		Measured on Site	Informed	Measured on Site	Informed			
1	Hand pump	Clean Town	6.510294	-10.822243	20.31			2.47		Dry by March	No	11/9/2016 11:14
2	Open well	Clean Town	6.51071	-10.823185	21.03		5.48			Don't get dry	No	11/9/2016 11:02
3	Hand pump	Vincent Town	6.506706	-10.822113	23.92		10.97		3.048	Don't get dry	Yes	11/9/2016 11:37
4	Hand pump	Vincent Town	6.507056	-10.821371	21.27					Pump not operational	No	11/9/2016 11:43
5	Hand pump	Vincent Town	6.507283	-10.820662	22.24					Pump not operational	No	11/9/2016 11:47
6	Hand pump	Vincent Town	6.50709	-10.820442	22.48	6.64		3.16			No	11/9/2016 11:50
7	Hand pump	Vincent Town	6.507743	-10.820669	27.28						No	11/9/2016 11:59
8	Hand pump	Vincent Town	6.508366	-10.820868	26.08						No	11/9/2016 12:02
9	Hand pump	Dimei	6.523861	-10.836131	25.12	7.77		4.33		Don't get dry	No	11/9/2016 12:37
10	Hand pump	Dimei	6.523316	-10.835927	19.59					Dry by March	No	11/9/2016 12:39
11	Hand pump	Dimei	6.523782	-10.834309	25.12	10.35		4.68			No	11/9/2016 12:47
12	Hand pump	Dimei	6.524581	-10.836353	25.12						No	11/9/2016 12:55
13	Open well	Gbonjema	6.536786	-10.820878	21.03	6.04		3.69			No	11/9/2016 13:25
14	Hand pump	Gbonjema	6.53656	-10.821801	14.55					Dry by March	No	11/9/2016 13:30
15	Hand pump	Varnjah	6.527113	-10.817253	15.99		12.192			Dry by January	No	11/9/2016 14:26

No	Type	Town	Coordinates (WGS 1984)		altitude (m asl)	Depth (mBG)		Water Level (mBG)		Comments	Sampled	Date surveyed
			Latitude	Longitude		Measured on Site	Informed	Measured on Site	Informed			
16	Hand pump	Varnjah	6.526909	-10.817676	19.83		6.096				Yes	11/9/2016 14:33
16	Hand pump	Quendee	6.538403	-10.827439	26.32					Pump not operational	No	11/9/2016 18:06
18	Hand pump	Quendee	6.539185	-10.828589	21.03						No	11/9/2016 18:13
19	Hand pump	Quendee	6.537922	-10.828182	25.6						No	11/9/2016 18:16
20	Hand pump	Quendee	6.537359	-10.827063	28.97					Dry by March	No	11/9/2016 18:19
21	Hand pump	Bolela	6.51794	-10.826064	26.08					Dry by February	No	11/10/2016 10:51
22	Hand pump	Bolela	6.518454	-10.827009	22.48	10.6		7.84		Pump not operational	No	11/10/2016 10:58
23	Hand pump	Bolela	6.517425	-10.826929	28.24						No	11/10/2016 11:21
24	Open well	Bolela	6.516804	-10.82648	22.72	6.07		4.07		Don't get dry	Yes	11/10/2016 11:15

5.1.5 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 (coastal and alluvial sands) (Figure 5-10).

The site lies entirely over regosol soil (mainly coastal sands). Regosols are very weakly developed mineral soils in unconsolidated materials. They contain a high amount of the necessary plant nutrients and are best for agricultural production.

On site, small soil excavations were performed at the locations displayed in Figure 5-9 and Table 5-3. A hole with a diameter of approximately 50 cm and a depth of approximately 80 cm was dug in each of these locations to assess the soil profile on site. Description of the soil profile in each of the excavated holes is described in Table 5-3.

Additional soil investigation is important to assess the actual depth of the soil profile on site and to better characterize the soil types ad particle sizes which can help in a better assessment of effluent and leachate impacts and mitigation measures by understanding the infiltration and saturation rates of the soil on site.

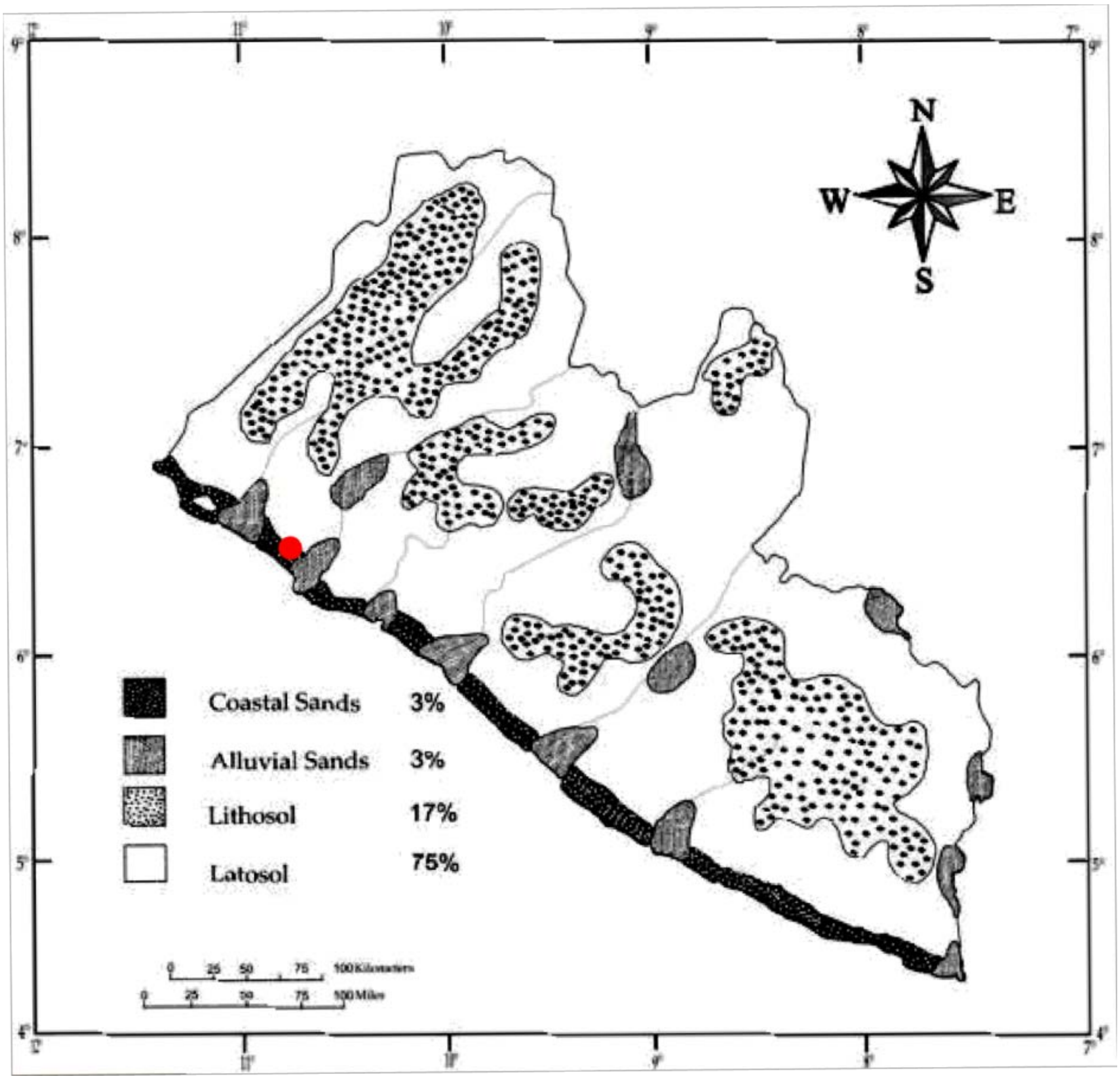


Figure 5-10 site location with respect to the general soil profile of Liberia

Table 5-3 Coordinates (WGS 1984) of excavation pits on site and description of soil profile

Site ID	Coordinates (WGS 1984)		altitude (m asl)	Depth (cm)		Description
	Latitude	Longitude		From	to	
MCC1	6.524755	-10.819839	17.91	0	80	Dark brown clayey sand with some gravels
MCC3	6.524922	-10.822082	27.28	0	80	Dark brown friable silty sand with some gravels
MCC4	6.52235	-10.82476	28.72	0	10	Dark brown friable silty sand with some gravels
				10	80	Reddish to light brown consolidated clayey sand with some gravels
MCC-MID	6.520872	-10.819147	20.55	0	12	Dark brown friable silty sand with some gravels
				12	80	Reddish to light brown consolidated clayey sand with some gravels
MCC6	6.519852	-10.823255	18.87	0	22	Dark brown friable silty sand with some gravels
				22	80	Reddish to light brown consolidated clayey sand with some gravels
MCC7	6.517934	-10.820101	22	0	80	Dark brown friable silty sand with some gravels
MCC9	6.519473	-10.817758	19.59			Dark brown friable silty sand with some gravels
				33		Water Level encountered
						Reddish to light brown consolidated sandy clay with some gravels

5.1.6 Soil and Water Quality

As part of the baseline study for the ESIA, soil, groundwater and surface water samples are collected and tested to characterize the local soil, groundwater and surface water conditions within the project area. Table 5-4 and Figure 5-11 present the location and type of samples collected and Table 5-5 presents the list of parameters to be tested for.

The sampling program aims at creating a comprehensive baseline system to assess if the site has any level of contamination and to be used as a reference point for the monitoring phase where additional samples should be tested and compared.

Table 5-4 Samples' type and location

Sample ID	Sample Type	Coordinates (WGS 1984)		altitude (m asl)	Sampling Date	Description
		Latitude	Longitude			
BolelaW	Ground water	6.516804	-10.82648	22.72	10/11/2016	Bolela Well
MCC1	Soil	6.524755	-10.819839	17.91	10/11/2016	Near cornerstone MCC1
MCC4	Soil	6.52235	-10.82476	28.72	10/11/2016	Near cornerstone MCC4
MCCCenter	Soil	6.520872	-10.819147	20.55	10/11/2016	Near center of the site
SwampS	Soil	6.519473	-10.817758	19.59	10/11/2016	Swamp on the southeastern side of the site
PO01	Surface water	6.538888	-10.816069	11.42	9/11/2016	Po river upstrean of the site
PO-DWST	Surface water	6.514706	-10.808415	13.1	10/11/2016	Po river downstream of the site
PO03	Surface water	6.502158	-10.811161	0.37	10/11/2016	Po river downstream of the site after intersection with creek system
Dimah	Surface water	6.515538	-10.819588	-0.11	10/11/2016	Dimah creek
SwampW	Surface water	6.523285	-10.823246	15.75	10/11/2016	Swamp on the Northwestern side of the site
VAR-HP	Ground water	6.526909	-10.817676	19.83	9/11/2016	Hand pump at varnja town
VTHP1	Ground water	6.506706	-10.822113	23.92	10/11/2016	hand pump at vincent town

Table 5-5 List of parameters to be tested

General Parameters	Filtered (Dissolved) Metals		
Conductivity	Aluminium	Bismuth	Strontium
Nitrite as NO_2	Mercury	Iron	Tellurium
pH	Silicon	Boron	Thallium
Sulphate	Antimony	Cadmium	Tin
Chloride	Calcium	Chromium	Uranium
Ammoniacal Nitrogen as NH4	Zirconium	Cobalt	Titanium
Phosphate (ortho) as PO4	Arsenic	Copper	Vanadium
Nitrate as NO3	Sodium	Lead	Zinc
Sulfur	Tungsten	Lithium	
Total Suspended Solids	Barium	Manganese	
Dissolved Oxygen	Magnesium	Molybdenum	
Temperature	Beryllium	Nickel	
Total organic carbon	Potassium	Phosphorus	
Phenol	Silver	Selenium	

5.1.6.1 Results

Samples were sent to Alcontrol laboratory in the UK to be tested for parameters listed in Table 5-5. The results were compared to the WHO guidelines for drinking water, USEPA guideline for water and soil and the Dutch Standard (Soil Remediation Circular 2009 Netherlands) for water and soil. Full laboratory results are presented in Appendix B and a summary of the results are presented in Table 5-6 for soil and Table 5-7 for water.

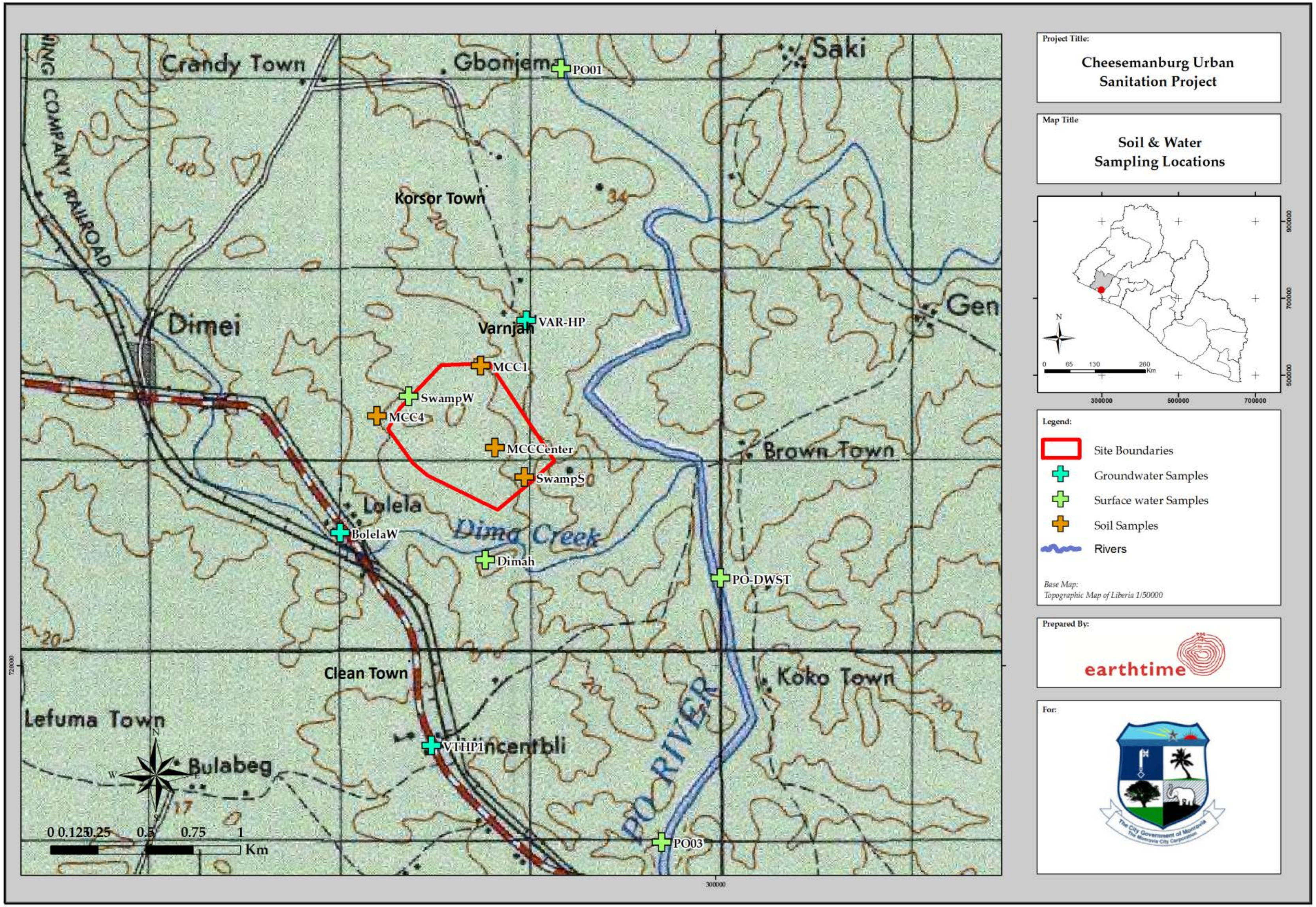


Figure 5-11 Baseline soil and water sampling locations

Table 5-6 Results of soil samples compared to USEPA Region 3 Regional screening levels and Dutch Standards

Parameters	Unit	International Standards		MCC1	MCC4	MCCCenter	SwampS
		USEPA Region 3 Regional Screening Levels	Dutch Standard (Soil Remediation Circular 2009 Netherlands)				
Sample Description							
Colour	-			Light Brown	Dark Brown	Red	Orange
Description	-			Sandy Loam	Sandy Clay	Sandy Loam	Sandy Loam
Grain Size	-			0.063 - 2.00 mm	0.063 - 2.00 mm	0.063 - 2.00 mm	0.063 - 2.00 mm
Inclusion 1)	-			Stones	Stones	Stones	Stones
Inclusion 2)	-			Vegetation	None	Vegetation	Vegetation
Moisture Content Ratio (% of as received sample)	%			17	21	15	22
Carbon							
Organic Carbon, Total	%			0.454	0.497	0.401	0.327
Inorganics							
Chloride (soluble)	mg/kg			<5	<5	<5	<5
Conductivity @ 20 deg.C	mS/cm			1.6	1.68	1.75	1.55
Exchangeable Ammonia as NH4	mg/kg			<15	<15	<15	<15
Nitrate as NO3, 2:1 water soluble	mg/kg	1600000		5.94	2.85	3.34	<1
Nitrite as NO2, 2:1 water soluble	mg/kg	100000		1.91	1.58	0.95	1.31
pH	pH			5.28	5.88	5.38	5.66
Phosphate (ortho) as PO_4	mg/kg	50000000		<1	<1	<1	<1
Sulphate, Total	mg/kg			164	105	<48	101
Total Sulphur (ASB)	%			0.00546	0.00349	<0.0016	0.00337
Water Soluble Sulphate as SO_4 2:1 Extract	g/l			<0.004	<0.004	0.0353	<0.004
Metals - (Solids)							
Aluminium	mg/kg	990000		50300	72000	64200	57800
Antimony	mg/kg	410	15	7.37	<6	<6	<6
Arsenic	mg/kg	2.4	55	<6	<6	<6	<6
Barium	mg/kg	190000	625	<6	<6	<6	13.8
Beryllium	mg/kg	6900	30	0.261	0.174	0.255	<0.1
Bismuth	mg/kg			41.4	29.5	56.6	17.1
Boron	mg/kg	200000		<7	<7	<7	<7
Cadmium	mg/kg	9300	12	<0.2	<0.2	<0.2	<0.2

Parameters	**Unit**	**International Standards**		**MCC1**	**MCC4**	**MCCCenter**	**SwampS**
		USEPA Region 3 Regional Screening Levels	**Dutch Standard (Soil Remediation Circular 2009 Netherlands)**				
Chromium	mg/kg	0	380	545	219	323	146
Cobalt	mg/kg	1900	240	4.22	4.18	1.15	1.76
Copper	mg/kg	41000	190	16.2	<14	<14	<14
Iron	mg/kg	72000		128000	98300	169000	64300
Lead	mg/kg	800	530	10.1	13.6	10.6	17.6
Lithium	mg/kg	2000		<10	<10	<10	<10
Manganese	mg/kg	23000		75.9	94.6	67.9	24.1
Mercury	mg/kg	43	10	<0.14	<1.4	<0.14	<0.14
Molybdenum	mg/kg	5100	200	<1	<1	<1	<1
Nickel	mg/kg	64000	210	16	12.9	10.9	15.7
Phosphorus	mg/kg	20		414	478	451	323
Selenium	mg/kg	5100	100	<10	<10	<10	<10
Strontium	mg/kg	610000		2.49	2.92	2.95	2.18
Tellurium	mg/kg		600	26.2	25.9	28	15.5
Thallium	mg/kg	10	15	<7	<7	<7	<7
Tin	mg/kg	610000	900	<2.4	<2.4	<2.4	<2.4
Titanium	mg/kg			1880	1830	1270	699
Vanadium	mg/kg	5100	250	348	238	325	288
Zinc	mg/kg	310000	720	<19	<19	29.5	<19
Metals - (Liquid)							
Calcium	mg/kg			36.2	71.6	300	57.9
Magnesium	mg/kg			104	155	24.3	142
Potassium	mg/kg			112	152	150	305
Silver	mg/kg	5100	15	<10	<10	<10	<10
Sodium	mg/kg			47.2	46.2	50.3	46.1
Phenols							
Phenol	mg/kg	180,000	40	<0.01	<0.01	<0.01	<0.01

Color Code:
Exceeded USEPA Standards
Exceded Dutch Standards
Exceeded more than one Standard

Table 5-7 Results of water samples compared to WHO guidelines, USEPA-National Primary Drinking Water Regulations and Dutch Standards

Parameter	Unit	International Standards			BOLELAW1	DIMAH	PO01	PO03	PO-DWST	SWAMP W	VAR_HP	VT HP1
		WHO Standards	USEPA-National Primary Drinking Water Regulation	Dutch Standard (Soil Remediation Circular 2009 Netherlands								
Inorganics												
Sulphur, Total*	mg/l	N/A	N/A	N/A	<10	<10	<10	<10	<10	<10	<10	<10
Ammoniacal Nitrogen as NH4	mg/l	N/A	N/A	N/A	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
Chloride	mg/l	N/A	250	100	10.5	<2	<2	<2	<2	<2	3.2	3.7
Conductivity @ 20 deg.C	mS/cm	N/A	N/A	N/A	0.106	0.012	0.0151	0.0126	0.0134	0.0151	0.0555	0.0563
Nitrate as NO_3	mg/l	50	10	N/A	29.3	<0.3	<0.3	15.6	<0.3	<0.3	16.3	8.03
Nitrite as NO_2	mg/l	3	1	N/A	0.054	0.067	<0.05	<0.05	<0.05	0.053	0.103	<0.05
Oxygen, dissolved	mg/l				10.2	10.1	10.3	11.5	10.9	10.8	11.6	11
pH	pH Units	N/A	N/A	N/A	6.45	6.87	6.89	6.85	7.04	5.88	6.09	6.51
Phosphate (ortho) as PO_4	mg/l	N/A	N/A	N/A	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Sulphate	mg/l	N/A	250	N/A	<2	<2	<2	<2	<2	<2	<2	<2
Suspended solids, Total	mg/l				<2	4	6.5	10	5	<2	<2	<2
Carbon												
Organic Carbon, Total	mg/l				<3	3.08	4.08	4.17	3.21	<3	<3	<3
Filtered (Dissolved) Metals												
Aluminium (diss.filt)	µg/l	N/A	50 - 200	N/A	9.63	22.2	93	83.1	51.1	28.2	77.2	43.3
Antimony (diss.filt)	µg/l	20	6	20	<0.16	<0.16	<0.16	<0.16	<0.16	<0.16	<0.16	<0.16
Arsenic (diss.filt)	µg/l	10	10	60	0.644	0.591	0.554	0.653	0.658	<0.51	<0.51	0.525
Barium (diss.filt)	µg/l	700	2000	625	9.06	7.34	13.5	13.3	14.6	7.41	10.3	9.12
Beryllium (diss.filt)	µg/l	N/A	4	15	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Bismuth (dis.filt)	µg/l	N/A	N/A	N/A	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Boron (diss.filt)	µg/l	50	N/A	N/A	9.58	<5	<5	<5	<5	6.27	7.69	<5
Cadmium (diss.filt)	µg/l	3	5	6	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	0.0966
Calcium (diss.filt)	mg/l	N/A	N/A	N/A	7.23	1.08	0.62	0.939	0.65	0.51	3.96	6.18
Chromium (diss.filt)	µg/l	50	100	30	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2

Parameter	Unit	International Standards			BOLELAW1	DIMAH	PO01	PO03	PO-DWST	SWAMP W	VAR_HP	VT HP1
		WHO Standards	USEPA-National Primary Drinking Water Regulation	Dutch Standard (Soil Remediation Circular 2009 Netherlands								
Cobalt (diss.filt)	µg/l	N/A	N/A	100	<0.15	0.186	<0.15	<0.15	<0.15	0.286	0.345	0.182
Copper (diss.filt)	µg/l	2000	1300	75	<0.85	<0.85	<0.85	<0.85	<0.85	<0.85	13.2	12.3
Iron (diss.filt)	mg/l	N/A	0.3	N/A	<0.019	0.323	0.186	0.199	0.177	<0.019	<0.019	0.0233
Lead (diss.filt)	µg/l	10	15	75	0.141	<0.1	<0.1	0.113	<0.1	<0.1	0.284	0.306
Lithium (diss.filt)	µg/l	N/A	N/A	N/A	<1	<1	<1	<1	<1	<1	<1	<1
Magnesium (diss.filt)	mg/l	N/A	N/A	N/A	1.75	0.475	0.348	0.347	0.401	0.421	0.324	0.443
Manganese (diss.filt)	µg/l	400	50	N/A	18.4	9.43	3.96	4.28	4.61	10.2	13.4	16.7
Mercury (diss.filt)	µg/l	6	2	0.3	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Molybdenum (diss.filt)	µg/l	70	N/A	300	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62
Nickel (diss.filt)	µg/l	70	N/A	75	<0.44	<0.44	<0.44	<0.44	<0.44	0.519	0.559	0.864
Phosphorus (diss.filt)	µg/l	N/A	N/A	N/A	<15	<15	<15	<15	<15	<15	<15	<15
Potassium (diss.filt)	mg/l	N/A	N/A	N/A	3.06	<1	<1	<1	<1	<1	1.24	<1
Selenium (diss.filt)	µg/l	10	50	160	1.21	<0.81	<0.81	0.819	<0.81	<0.81	<0.81	<0.81
Silicon (diss.filt)	mg/l	N/A	N/A	N/A	1.43	2.44	2.67	2.69	3.21	2.38	1.36	2.16
Silver (diss.filt)	µg/l	N/A	100	40	<1	<1	<1	<1	<1	<1	<1	<1
Sodium (diss.filt)	mg/l	N/A	N/A	N/A	7.79	1.37	1.17	1.18	1.31	1.05	5.04	3.34
Strontium (diss.filt)	µg/l	N/A	N/A	N/A	30.3	6.28	6.81	6.83	7.17	6.05	35.9	34.3
Tellurium (diss.filt)	µg/l	N/A	N/A	70	<7	<7	<7	<7	<7	<7	<7	<7
Thallium (diss.filt)	µg/l	N/A	2	7	<2	<2	<2	<2	<2	<2	<2	<2
Tin(diss.filt)	µg/l	N/A	N/A	50	<0.36	<0.36	<0.36	<0.36	<0.36	<0.36	<0.36	<0.36
Titanium (diss.filt)	µg/l	N/A	N/A	N/A	<1.5	<1.5	2.75	2.75	3.23	<1.5	<1.5	<1.5
Tungsten (dis.filt)	µg/l	N/A	N/A	N/A	<1	<1	<1	<1	<1	<1	<1	<1
Uranium (diss.filt)	µg/l	15	30		<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Vanadium (diss.filt)	µg/l	N/A	N/A	70	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3
Zinc (diss.filt)	µg/l	N/A	5000	800	15.9	6.05	<1.3	9.75	<1.3	2.67	29.8	134
Zirconium (dis.filt)	µg/l	N/A	N/A	N/A	<1	<1	<1	<1	<1	<1	<1	<1
Phenols												
Phenol	mg/l	N/A	N/A	2	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002

Parameter	Unit	International Standards			BOLELAW1	DIMAH	PO01	PO03	PO-DWST	SWAMP W	VAR_HP	VT HP1
		WHO Standards	USEPA-National Primary Drinking Water Regulation	Dutch Standard (Soil Remediation Circular 2009 Netherlands								
Color Code: Exceeded WHO Standards Exceeded USEPA Standards Exceded Dutch Standards Exceeded more then one Standard												

5.1.7 Noise

Limited activities take place in the landfill site, like subsistence farming and charcoal production which are operations serviced by foot. Thus, mainly transient noise (intermittent with short duration) exists in the project area. However the site is in close proximity to the Liberia – Sierra Leone Highway (approximately 500m) where vehicular traffic can constitute a dominant source of noise. In addition, a Wood Logging company is located at a close distance from site (approximately 350m). The company uses heavy machineries to cut and move the wood, which is also considered as a source of continuous noise during working hours.

Other sources of noise in the area can be due to market cycle and other craft work within the surrounding communities.

5.1.8 Air Quality

There are no historic data for air quality available for the project area, and therefore, no baseline data have been developed.

The project falls within an area with a dominant rural character. Therefore, levels of gaseous pollution are low and sources of air pollutants are limited. The current principal source of air pollution is emissions from vehicular traffic (particulate and combustion emissions) along the Liberia –Sierra Leone Highway, along with dust pollution. Emissions from charcoal production, slash-and-burn activities and domestic cooking may also represent an important, localized source.

Continuous air quality monitoring is important to establish baseline data on site and to allow direct detection of air quality impacts generated by the project activities which will enhance the mitigation processes.

5.2 BIOLOGICAL ENVIRONMENT

A biodiversity assessment of the proposed landfill site and its surrounding was performed by a group of experts between 8 and 15 November 2016. The results of this survey are provided in the following sections. In addition to the field survey interviews with the local communities and review of available studies on the biodiversity of Liberia was performed to reach a better understanding of the biodiversity of the studied area.

5.2.1 Background

Liberia is located on the western edge of the Upper Guinea forest, which historically characterizes the main vegetation forest biome of the Guinea-Congo forest biome in West Africa. From empirical records, the country holds some of the largest proportions of the forest vegetation in the sub-region, which has however experienced significant fragmentation over the last couple of centuries (Cooper and Record, 1931). According to Gatter (1984), much of the original closed canopy primary forest was slashed centuries ago, as population densities and demand for food increase. The forest recovered because of disease and inter-tribal wars, but the present vegetation continues to undergo significant transformation due to urbanization, traditional agriculture and the establishment of plantations of oil palm and rubber. Today, Liberia's vegetation cover mainly comprises secondary closed canopy forest, farm bush (agricultural fallow) and few areas of derived grassland savanna. The vegetation in and around the vicinity of the proposed landfill site can be described as a mosaic of various vegetation structure and landscape features that seem to characterize most other areas in this part of the country. Some isolated patches of closed forests occur adjacent to human settlements and the strips of gallery forest along the river courses.

The type and nature of the vegetation and landscape component is a key factor that determines the distribution of fauna in an ecological system. Considering that the vegetation of Liberia is predominantly forest, its vertebrate fauna is expected to comprise mainly forest or forest-dependent species. In terms of mammals, the country holds about 150 species, including 9 endangered species, 12 vulnerable species and nine near threatened species, according to IUCN Red List (2016). With greater proportion of the country covered in tropical forest, the mammalian diversity is broadly forest species and their distribution follows the occurrence of closed forest ecosystems in the country. Consequently, relatively pristine forests support higher numbers of mammal species and accounts for greater proportions of threatened and rare species. The situation in and around the proposed landfill site is such that the most of the closed forest has been cleared for agriculture.

The avifauna diversity of Liberia is significant in terms of the representation of species associated with the Upper Guinea forest and so is a stronghold for many endemic, rare and threatened birds in the Upper Guinea Forest and the Guinea-Congo forest biome. The country supports 695 species of birds, including one, the Liberian *Greenbul Phyllastrephus leucolepis*, which is endemic only to the country (Gatter, 1997; Robertson, 2001; Demey, 2007). The Upper Guinea forest is an Endemic Bird Area and is highly ranked as a priority for conservation based on the combination of its biodiversity importance and threat status (Strattersfield, et al, 1998). There are 21 species of global conservation concern, based on the assessment of IUCN (2016) and Birdlife International (2016); 18 of these species are entirely forest dependent, including two endangered, seven vulnerable, six near threatened and three data deficient species. The resident species include 184 species restricted to the Guinea-Congo biome and 15 (100%) of the species endemic to the Upper Guinea forest block. No Sudan-Guinea Biome Dependent species has yet been recorded in the country.

The extent of herpetological studies and knowledge in West Africa is limited, though it has a long history. The diversity and distribution of many groups of amphibians and reptiles are poorly characterized because records are limited. With the exception of a few research, mainly carried out by expatriates, herpetological studies in West Africa have been mostly spurred by environmental and social impact assessments (ESIAs) commissioned by industrial companies. However, local scientist in West Africa have begun to make substantial contributions to the knowledge of the West African amphibian and reptile fauna, although much more research is need to update available data on the herpeto-fauna of the sub-region. According to records from pioneering fieldwork carried out by Taylor et al (1958), Hoke et al (2007) and a number of disparate sources, current understanding of the number of reptile and amphibian species in Liberia stand at 58 amphibian and 77 reptilian species. A rapid survey of amphibians and reptiles of three National Parks including Lorma, Gola and Grebo, recorded 40 amphibian and 17 reptile species (Hiller and Rodel, 2007; Hoke et al, 2007). There is yet a need for a comprehensive and updated list of reptiles and amphibians of Liberia as in the case of many other countries in the sub-region.

Knowledge on fish and freshwater diversity is actually limited in Liberia (Fermon and Gsegner, 2006), although various ad hoc surveys are ongoing to update national data. Paugy et al. (2004) conducted survey on the Fresh and Brackish Water Fishes of West Africa; the report includes a list of the occurrence of the species of several major river drainages of Liberia. In 2006, Fermon and Gsegner conducted a review of the fresh water fishes of the St Paul and St John Rivers in Liberia. Until now, no detailed and extensive investigation has been made on the fish diversity of Liberia. A checklist of fish species in Liberia from all sources, including specimens in major rivers, suggests a number of 205 fish species, of which 57 species are recorded from the Mano River (see Fermon and Gsegner, 2006). As in most African rivers, Cichlidae, Cyprinidae, Mormyridae, Characidae are the most important families (BHEP, 2004). This rapid assessment survey, gives only a broad picture of the potential fish diversity of the proposed landfill sites and environs, obtained through gill and scoop netting, supported by observations and assessment of catch by fishermen encountered during the survey.

5.2.2 Study Area

Eight study points were sampled for all aspects of the ecological surveys conducted. The sites are distributed across three sections into which the survey area was divided (Figure 5-12):

- Upstream (the Gbonjema–Varjna axis);
- Landfill site; and
- Downstream areas extending as far as Philip Town along the Po River

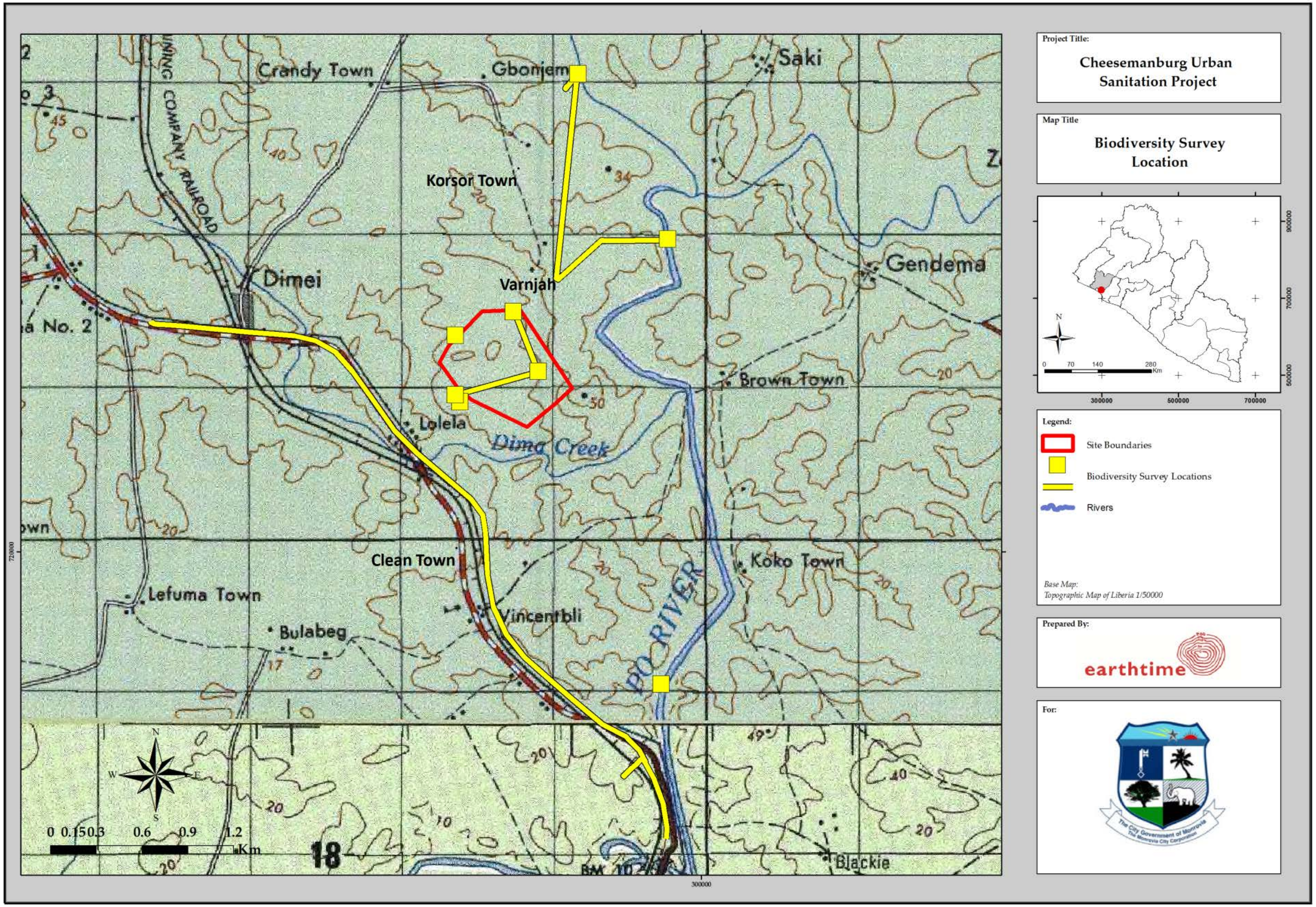


Figure 5-12 Biodiversity survey locations

5.2.3 Vegetation Cover

5.2.3.1 Methodology

Various locations were visited to observe, identify and describe the vegetation types that occur in the proposed project area. Assessment of the size and nature of vegetation cover plant species presence and distribution, were done to provide appropriate indications of the vegetation status. A general identification was performed for all categories of vascular plants (particularly trees, shrubs, lianas herbs and grasses), focusing on the possible occurrence of species of conservation interest in the area. Further data was collected on the growth form of plants and their uses by the various communities.

5.2.3.2 Findings

The vegetation of proposed landfill sites and surrounding areas shows a characteristic representation of the vegetation common to most areas in the rural communities close to Monrovia. The vegetation is a mosaic of plant communities, dominated by farmbush at various stages of succession, farmlands, patches of closed forest and gallery forest along the river. The farmbush (fallow vegetation left to regenerate after farming and harvest), is estimated to be between two and five years of regrowth, depending on the location. In general, the dominant farmbush is inundated by stands of wild oil palm trees.

The farming system mainly favors the cultivation of cassava with few farms of pineapple observed in places. This may be unconnected with the level of nutrient cycling allowed by the fallow periodicity practiced by the local communities, which is apparently suitable for cassava cultivation. Oil palm cultivation was also observed in some localities including areas southeast of the proposed landfill site.

The isolated patches of forests are found within the vicinities of human settlements, which is a traditional practice in most rural settings in West Africa. Such reserved forests are used for various purposes ranging from traditional conservation practices and cultural purposes. The gallery forests are quite thin in terms of their extent from the banks of the river to the nearest clearing or farmbush. It was observed that agricultural activities extend to within 20 to 30 meters of the river bank, thus depleting most of the forest cover along the rivers and streams.

A total of 208 vascular plant species of 52 families was recorded in the areas visited. Appendix C indicates the number of species recorded in the different areas with respect to the location of the landfill site. Of these plant species, 10 are listed as vulnerable in the IUCN Red List 2016 (Table 5-8), of which six are valuable timber species. In terms of growth form half the number of species recorded are trees (50%), followed by shrubs (22%) (Figure 5-13); the high proportion of tree species is probably an indication of the historic closed forest cover of the area, which in tropical forests is mainly characterized by high diversity of trees. There were a comparatively low diversity of herbs and grasses, but in many instances, they constitute the most abundant species in the agro-ecological plant communities, especially in young farmbush. *Chromolaena odorata* (herb species) and *Panicum sp* (grass species) were the most abundant plants species in the area.

Table 5-8 List of plant species listed as threatened in the IUCN 2016 Red List (VU - Vulnerable)

Botanical Name	Family	IUCN	Up stream	Landfill Site	Down stream
Terminalia ivorensis	Combretaceae	VU	x		
Amanoa bracteosa	Euphorbiaceae	VU	x		
Garcinia afzelii	Guttiferae	VU	x	x	x
Trichilia ornithothera	Meliaceae	VU	x	x	x
Turraenthus africanum	Meliaceae	VU	x	x	x
Milicia regia	Moraceae	VU	x	x	x
Hallea stipulosa	Rubiaceae	VU		x	
Nauclea diderrichii	Rubiaceae	VU	x		x
Zanthoxylum atchoum	Rutaceae	VU	x		
Sterculia oblonga	Sterculiaceae	VU	x		

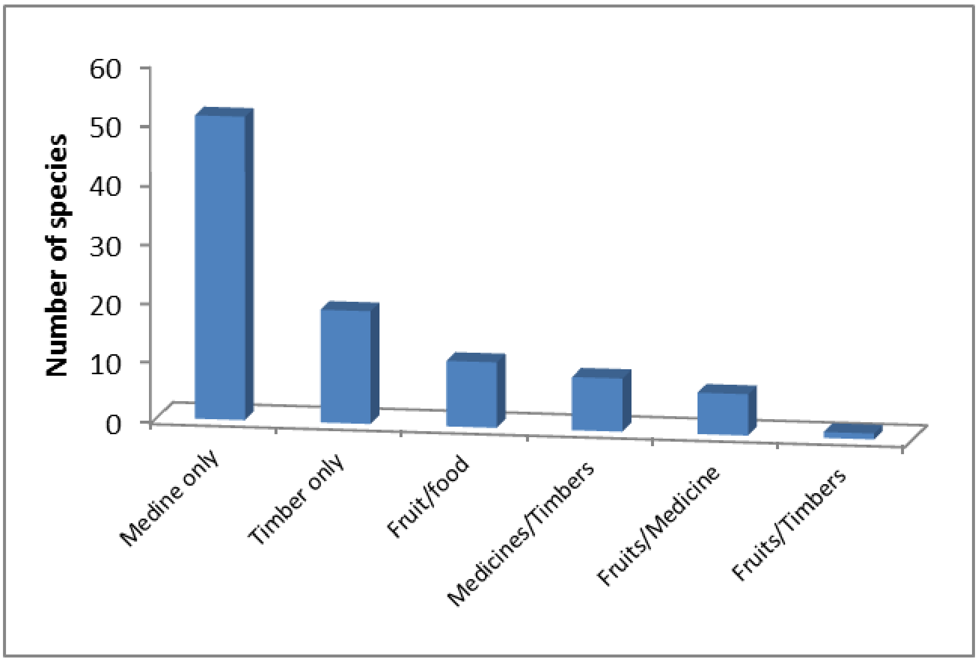


Figure 5-13 Comparison of plant species diversity with respect to local usage

Figure 5-14 Pictures showing vegetation cover on site

5.2.4 Mammals

5.2.4.1 Methodology

The mammalian diversity present in the area was assessed through direct field observations and semi-structured interviews with local hunters. Direct field observations were carried out along established transects or foot paths and in forest locations and involved first hand sightings, footprints and faecal deposits of the animal. Semi-structured interviews (which provided much of the data on mammals) were conducted for at least three respondents in each of the communities visited. Information provided by respondents was normally verified through triangulation. Observations for evidence of hunting and trapping also formed a vital component of the data collection.

5.2.4.2 Findings

The mammalian diversity in the entire study is low and the distribution is sparse as evident in the fact that encounter rates during the survey was extremely low. Only 18 species of mammals were noted to occur, from few direct evidences (such footprints and faecal matter) and interview with local hunters; these include three threatened species (Table 5-9) that are considered as very rare visitors to the area by local hunters. Anecdotal information therefore indicates a generally low density of mammals, and very rare occurrence of large mammals, which is related to the high rate of deforestation, mainly due to agriculture and to a significant extent high hunting and trapping pressure. Old spent hunting shot gun shell was found in the vicinity of a small riverine forest that is contiguous with the proposed landfill site and is an indication of a recent history of hunting in the area. Species of conservation concern include *Pied Colobus Monkey Colobus polykomos* (VU), *Sooty Mangabey Cercocebus atys* (VU), *Water Chevrotain Hyemoschus aquaticus* (DD) and *Tree Pangolins Phataginus trcuspis* (NT).

The primates and large mammals recorded for Liberia are mostly forest-dependent species, or at least associated with forest environments and so with the limited forest cover in the around the proposed landfill site there is justification for the low occurrence of mammals in the area. According to local respondents, the few large mammals mentioned are only very rarely encountered. The current mammalian fauna of the area consists mainly of small mammals and rodents, the relatively common species being squirrels, giant rats and grass cutters. Many active snares were encountered during the course of the survey and these are purposely installed to catch grasscutters. Among the sizeable mammals known in the area are *Maxwell Duiker Cephalophus maxwelli*, *Long-snorted Mongoose Herpestes naso*, *Civet Cat Civettictis civetta*. However, the local respondents indicated that most of these species are getting rare.

Table 5-9 Mammals species that are indicated to occur in the area by local hunters and trappers (Legend: VU - Vulnerable; LC - Least Concern; DD- Data Deficient; NT - Near Threatened)

Species	Scientific names	IUCN	Up Stream	Landfill Site	Down Stream
Pied Colobus Monkey	*Colobus polykomus*	VU	X		x
Sooty Mangabey	*Cercocebus atys*	VU	X		
Spot-nosed monkey	*Cercopithecus petaurista*	LC	X		x
Bush Pig	*Potamochoerus larvatus*	LC	X	x	x
Water chevrotain	*Hyemoschus aquaticus*	DD	X		
Bushbuck	*Tragelaphus scriptus*	LC	X	x	x
Maxwell's Duiker	*Cephalophus maxwelli*	LC	X	x	x
Tree Pangolin	*Phataginus trcuspis*	NT	X	x	x
Giant Pouch Rat	*Cricetomys emini*	LC	X	x	x
Marsh Cane-rat	*Thryonomys swinderianus*	LC	X	x	x
Mastomys Rat	*Mastomys sp*	LC	X	x	x
Fire-footed rope squirrel	*Funisciurus pyrropus*	LC	X	x	x
Gambian Sun squirrel	*Heliosciurus gambianus*	LC	X		
Crested porcupine	*Hystrix cristata*	LC	X		x
Brush-tailed porcupine	*Atherurus africanus*	LC	X	x	x
Long-snorted mongoose	*Herpestes naso*	LC	X	x	x
African Civet	*Civettictis civetta*	LC			x
Common genet	*Genetta genetta*	LC	X	x	x

5.2.5 Birds

5.2.5.1 Methodology

The methods described below were used to collect data on the presence, abundance and distribution of birds in and around the project area, in accordance with standard field methodologies (Bibby et al., 2000). The methods applied provided a reliable means of obtaining authentic and robust data to assess the diversity of avifauna and potential impact of the landfill project on birds. Field observations were supported by a standard field guide (Borrow and Demey, 2008) and the following sampling methods were used to collect data on birds:

- **Transect survey:** In transect survey, the observer move along a defined transect or path over one or two km, depending on the size of the habitat being assessed. All birds encountered by visual evidence or calls, during the observation are recorded. One good attribute of transect survey is the possibility of traversing a number of sub-habitats, such as a patch of grassland or swampy area within a forest zone.

- **Point surveys:** Point surveys were employed by standing or sitting quietly at a particular point along a defined transect to make keen observation of birds. Usually, survey points were located 200 to 300 meters along transects, including situations when a bird party or the breeding site of a bird or birds were encountered. For birds that are cryptic or shy, transect survey may not be effective in picking up signs of their presence and so point surveys were employed to patiently identify them.
- **Recording and playback:** This technique helped to clarify the identity species using their calls or sounds. The recorded call is played to mimic the sound made by the bird, thereby attracting it towards the observer, resulting in its identification. Recordings were also made for reference purposes in instances where a bird cannot be easily identified on the field; the calls are normally cross-checked with those of published versions by Claude Chappius' African Bird Sounds to verify the respective identity of the birds.

5.2.5.2 *Findings*

Data collected from the survey revealed a total of 122 species of birds of 31 families across all sites visited (Table 5-10, Appendix D). The diversity includes 105 species of resident birds, among which 47 (45%) are of the Guinea-Congo forest (GCF) biome restricted assemblage and one Upper Guinea forest (UGF) endemic species Sharpe's *Apalis Apalis sharpie*. Liberia accounts for 184 species of GCF species and 15 UGF species, one of which, the *Liberian Greenbul Phyllastrephus leucolepis* is endemic only to the country. Comparatively, the upstream areas accounted for a greater number of avifauna species and families recorded, including species belonging to the forest dependent categories (the CGF and the UGF assemblages). No species of IUCN threatened categories were recorded in any of the sections surveyed. However, it is important to note that a good number of species associated with closed primary forests were recorded particularly in forest patches around Gbonjema and gallery forest along Po River. This is an indication of the importance of these forests to the continued occurrence of forest-dependent categories of birds in the area.

There were six Afro-tropical and two Palaearctic migratory species. With the advent of winter in the northern hemisphere, which stimulates migratory species to move to their winter range, it is expected that the number of Palaearctic migrants will increase in the next three months (December, January and February). One of the most common Afro-tropical migrants to Liberia (Gatter, 1997), the *Cattle Egret Bulbucus ibis* was not recorded in the areas surveyed, but this may be due to the limited spatial coverage.

The proposed landfill site accounted for the least number of bird species in any of the categories listed on Table 5-10. This may be due to the fact that the area selected for the landfill is associated with extensive agricultural activities, although it has recovered some vegetation cover over the last four years after designated for landfill purposes. Some areas on the south east within the proposed landfill boundary and immediately outside have relatively mature secondary forest that apparently support a significant variety of avifauna, including forest-dependent species.

The result of the avifauna survey do not indicate any potential for the proposed landfill site or its environs to qualify as areas for global or national conservation importance, such as an Important Bird Area (IBA). The IBA concept has been applied to important sites for biodiversity conservation in Liberia (see Robertson, 2001; Evans and Fishpool, 2001). The concept takes into consideration the diversity of birds of certain criteria and threat status for a site to be considered for IBA designation. These criteria includes but not limited to:

- The presence of a significant number of globally threatened species or species of global conservation concern;
- The site support species that are considered as restricted range and in this case, restrict to the Upper Guinea Forest Endemic Bird Area;
- The site support a significant proportion of species belonging to the Guinea-Congo forest biome assemblage; and
- The site regularly holds 20,000 or more migratory waterbirds or support species with 1% of their biogeographic population.

The proposed landfill site and the surrounding areas fall short of these criteria and so cannot be considered as a critical site for bird conservation.

Table 5-10 Diversity of Avifauna in various specious richness and biogeographic categories

Species category	Up stream	Landfill site	Down stream	All sites
Number of species	81	71	70	122
Number of families	29	25	24	31
Resident species	72	61	62	105
Afrotropical migrant	5	4	2	6
Palaearctic migrants	0	1	2	2
GC biome spp	29	27	29	47
UGF endemic spp	1	0	0	1
IUCN Threatened spp	0	0	0	0

5.2.6 Reptiles and Amphibians

5.2.6.1 Methodology

The methodology used for the survey of amphibians and reptiles was mainly a combination of visual and acoustic monitoring in specific sites/habitats, consistent with methods used Heyer et al. (1994) and Rödel & Ernst (2004) and extensively used in surveying different habitat types all over West Africa. The survey was conducted to cover the varying active periods of different amphibian and reptile species. Night and day searches covered a wide range of habitats including forest, farmbush, swamps, tributaries and streams. Visual monitoring also included a thorough screening of potential hiding places (lifting rocks, logs and branches, looking into holes, screening leaf litter, etc.).

Further technique to capture additional species (especially lizards and fossorial species) was the installation of a 40-meter drift fence with 10 pitfall traps in each of the targeted sites. The traps were monitored once a day in order to identify and release captured species. In addition, amphibian calls were recorded and cross-checked with standard recorded calls to confirm species identification. Captured reptile and amphibian species were photographically documented. No voucher specimen was collected because this was not necessary at the time. It is believed that the above methods are those internationally accepted and commonly used throughout herpetological surveys.

All species encountered from the searches and traps were identified by means of field guides including, Rödel's herpetofauna of West Africa (Rödel 2000), Guide to West African

Amphibians and Reptiles (documents provided by M.O. Rödel and A. Hillers) and Guide des Serpents d'Afrique Occidentale (Trape and Mané 2006).

5.2.6.2 *Findings*

Ten species of reptiles of five families were recorded during the survey (Table 5-11). No reptile species of IUCN conservation concern was recorded from the area. Interviews with local people also show that tortoises and turtles of indeterminate species may be present within and around the proposed landfill site, although the encounter rates are becoming very rare. The Rainbow Lizard *Agama agama* was the most frequently encountered and so is the most abundant of reptile species in the survey area. The Agama lizard is widespread and highly tolerant to disturbance and so can survives adverse environmental conditions. Snake species of the family *Elapidae* (Black Mamba *Dendroaspis polylepis* and the Green Mamba *Dendroaspis viridis* and the Spitting Cobra *Naga nigricollis*) were actually encountered during the survey. These species of the family *Elapidae* are known to occur in forest and degraded forest and in areas associated with human settlements. The Nile Crocodile Crocodylus niloticus breeds along the Po River, as evidenced by the capture of two juveniles in the vicinity of Gbonjema by a local fisherman (Figure 5-15).

Table 5-11 List of reptile species recorded during the survey

Common Name	Scientific name	IUCN status	Upstream	Landfill site	Downstream
AGAMIDAE	*Agama africana*	LC	x		x
	Agama agama	LC	x		x
SCINCIDAE	*Cophoscincopus simulans*	LC		X	
	Trachylepis affinis	LC			x
VARANIDAE	*Varanus niloticus*	LC	x		
	Varanus ornatus	LC		X	x
CROCOLIIDAE	*Crocodylus niloticus*	LC	x		
ELAPIDAE	*Dendroaspis polylepis*	LC	x		
	Dendroaspis viridis	LC			x
	Naja nigricollis	*LC*	*x*		

Figure 5-15 Nile Crocodile *Crocodylus niloticus* (Juveniles)

The survey recorded a total 15 amphibians species, including three species of listed by IUCN Red List (2016) as Near Threatened - *Phrynobatrachus alleni*, *Phrynobatrachus guineensis* and *Ptychadina supercilaris* (Table 5-12 and Figure 5-16). *Phrynobatrachus alleni* was recorded in all sections of the study area surveyed while *Phrynobatrachus guineensis* and *Ptychadina supercilaris* were recorded along a small stretch of the creek on the southeastern edge of the proposed landfill site. This is an indication of the relative importance of the floodplains adjacent to small streams in the project area to the diversity and survival of amphibians. In terms of distribution *Phrynobatrachus alleni* extends from Guinea to Nigeria, but *Phrynobatrachus guineensis* and *Ptychadina supercilaris* are more or less restricted to the Upper Guinea forest region (Guinea to Ghana). All three species inhabit subtropical or tropical moist lowland forests and intermittent freshwater marshes and are threatened by habitat loss.

Table 5-12 Diversity and distribution of amphibian species in and around the proposed landfill site

Common Name	**Scientific Name**	**IUCN Status**	**Up stream**	**Landfill site**	**Down stream**
HYPEROLIIDAE					
	Hyperolius concolor	LC	x		
	Afrixalus weidholzi	LC			x
DICROGLOSSIDAE					
African Grove-crowned Frog	*Hoplobatrachus occipitalis*	LC	X		
ARTHROLEPTIDAE					
	Arthroleptis sp		X	x	
PHRYNOBATRACHIDAE					
Allen's River Frog	*Phrynobatrachus alleni*	**NT**	X	x	x
	Phrynobatrachus tokba	LC	X	x	x
	Phrynobatrachus guineensis	**NT**		x	
RANIDAE					
	Halarana albolabris	LC			x
PTYCHADENIDAE					
Broad-banded Grass Frog	*Ptychadena bibroni*	LC		x	
Mascarene Grass Frog	*Ptychadena mascareniensis*	LC		x	x
	Ptychadena pumilio	LC	X		x
	Ptychadena oxyrhynchus	LC		x	
	Ptychadena supercilaris	**NT**		x	
BUFONIDAE					
	Amietophrynus maculatus	LC	X		x
African Common Toad	*Amietophrynus latfrons*	LC	X		
Total			8	7	8

The species *Phrynobatrachus alleni* and *Phrynobatrachus guineensis* survive in undisturbed forest, but were recorded in degraded forest, part of which has already been cleared for agriculture and is expected to undergo further clearing during the establishment of the landfill site. *P. alleni* is also known to survive in small forest fragments, but usually in low numbers, and capable of breeding in small temporary puddles (Rodel, 2004). It is also considered to be widely distributed, but with its declining habitat, the likelihood is that it may become increasingly rare with increasing demand for land for settlement, agriculture and development purposes. The rest of the amphibian species recorded are common and widespread in the study area and even across many habitats in the country. From anecdotal information, *Hoplobatrachus occipitalis* (Figure 5-16) below is a delicacy among the communities in the study area and other adjacent settlements.

 *Phrynobatrachus guineensis* (NT)	 *Ptychadena supercilaris* (NT)
 *Phrynobatrachus alleni* (NT)	 *Hoplobatrachus occipitalis*

Figure 5-16 Photos of Nearly Threatened amphibian species found on the proposed landfill site and one common amphibian specie that is considered a delicacy within the nearby communities

5.2.7 Fisheries

5.2.7.1 Methodology

A number of techniques were used to sample fish at a number of locations both upstream and downstream of the Po River and in the creeks and swamps surrounding the landfill site. This was essentially a qualitative, diversity survey. The most effective methods were:

- Light-weight gill nets of 2.5 cm and 3.5cm mesh sizes, set across pools or in parallel to the current under faster flows to avoid them being swept away. They were laid alongside river banks at night to capture more nocturnal fish.
- A hand dip-net was used particularly in swamps and creeks in and adjacent to the proposed landfill site.

The use of the gill nets method allowed for a fairly standard sampling unit of gill-net/night. This was used downstream and upstream of the Po River relative to the location of the proposed landfill site, and in the Dima creek where the river is accessible enough for sampling. In smaller streams, creek and swamp with vegetation, most sampling had to be done using a hand dip-net. This had the added advantage of collecting some specific fauna adapted to live in such habitat that cannot be caught by gill nets.

Procedurally, nets were set and left overnight and checked in the morning, when the catches are then removed and recorded. The process is repeated for the period of sampling days in an area. A representative specimen of each species caught was preserved in 96% alcohol as the basis of a reference collection. A photographic record of habitats and specimens was also made. Identification of fish species was accomplished with the aid of published guides by Paugy et al (2003, 2004) and Fermon and Gsegner (2006).

A semi-structured interview was conducted with locals in selected communities in close proximity to the Po River. This was done mainly to confirm species recorded during sampling and also to obtain information on fisheries in the area.

5.2.7.2 Findings

A total of 18 fish species belonging to 11 families were recorded (Table 5-13; Table 5-14). Of these, four species are of global conservation concern and listed in the IUCN Red List Status – *Epiplatys ruhkopfi* (CR), *Callopanchax monrovae* (VU) and *Sarotherodon occidenetalis* (NT), *Monodactylus sebae* (NT) (www.iucnredlist.org).

Brycinus longipinnis constituted the largest catch (over 100 specimens) downstream and upstream of the Po River, followed by *Neolebias unifasciatus* (over 10 specimens).

Species such as *Hydrocynus foresail* (Tiger fish) and *Papyrocranus afer* recorded larger sizes of 60 cm and 70 cm maximum total lengths (TL) respectively in the river. About 80% of fish species recorded had sizes above 30 cm TL, which is an indication of good growth. Growth in length or weight of fish in a fishery system (e.g. a river) is a biological indicator of how well the fishery is doing.

Odaxothrissa mento and *Monodactylus sebae* are both Marine species and sometimes ascending over long distances into estuaries and freshwater (Gourène & Teugels, 1991; Cuvier, 1829 in Paugy et al, 2004). There has not been any accessible information on the occurrence of these two marine species in Liberia. Furthermore, the presence of these species suggests the influence of the coastal/marine waters on Po River.

Sarotherodon occidentalis is of global conservation concern and listed in the IUCN Red List category as Near Threatened and was recorded both upstream and downstream of the Po River. It is known to occur in between River Casamance in Senegal to St. John in Liberia (Daget, 1962 in Paugy et al., 2004).

In addition, four *itchyofauna* species of little or no food value, adapted to inhabit small water bodies such as streams, creeks with vegetation, swamps in forested areas as well as in pools (www.iucnredlist.org; Paugy et al,2004) were recorded. These are *Callopanchax monroviae*, *Epiplatys Barmoiensis*, *Epiplatys ruhkopfi* and *Kribia nana*. These species were collected using the hand net in the creeks and swamps at the boundaries of the landfill site. *E. barmoiensis* emerged as the most common species recorded in the creek adjacent to the landfill site.

Two of these species (*Epiplatys ruhkopfi* and *Callopanchax monrovae*) are of global conservation concern and listed in the IUCN Red List category as Critically endangered and Vulnerable respectively (www.iucnredlist.org) and are Endemic only to Liberia (www.iucnredlist.org; Paugy et al, 2004). *Epiplatys barmoiensis* and *Kribia nana* are both listed as Least Concern and are regional endemic species. *E. barmoiensis* is found in Sierra Leone, Guinea and Liberia (www.iucnredlist.org; Paugy et al, 2004). *Kribia nana* is present in many West African water basins, from Guinea to the Democratic Republic of the Congo. It is also present in the Chad basin and the Nile (www.iucnredlist.org; Paugy et al, 2004).

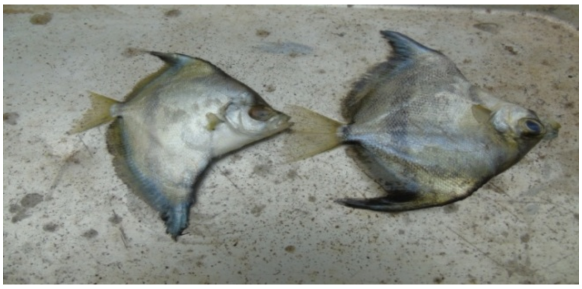
Three species invertebrates were recorded; two crustaceans' species belonging to two different families and one mollusk. All three species were recorded in the Creek on the northern side of the proposed landfill site.

Table 5-13 Fish and Invertebrate species recorded during the survey (LC-Least Concern; NT-Near Threatened; CE-Critically Endangered; V-Vulnerable)

Family	Species	Up stream	Down stream	Landfill site		IUCN Status
				Swamp	Creek	
Fish species						
Monodactylidae	*Monodactylus sebae*	x				NT
Polypteridae	*Polypterus palmas*	x				LC
Cichlidae	*Sarotherodon occidentalis*	x	x			NT
	Hemichromis fasciatus	x	x			LC
Characidae	*Hydrocinus forskali*	x	x			LC
Notopteridae	*Papyrocranus afer*	x	x		x	LC

Family	Species	Up stream	Down stream	Landfill site		IUCN Status
				Swamp	Creek	
Distichodontidae	*Neolebias unifasciatus*	x	x		x	LC
Characidae	*Brycinus longipinnis*	x	x			LC
Anabantidae	*Ctenopoma kingsleyae*	x				LC
Bagridae	*Chrysichthys johnelsi*	x				LC
Mormyridae	*Hippopotamyrus paugyi*				x	LC
	Odaxothrissa mento		x			LC
	Petrocephalus pellegrini		x		x	LC
Cichlidae	*Anomalochromis thomasi*		x		x	LC
Aplocheilidae	*Epiplatys barmoiensis*			x	x	LC
	Epiplatys rukopfi			x		CR
	Callopanchax monroviae			x		VU
	Kribia nana				x	LC
Invertebrate species						
Crab	*Potamon* sp				x	LC
Shrimp	*Machrobranchium* sp				x	LC
Molluscs	*Acatina* sp				x	LC

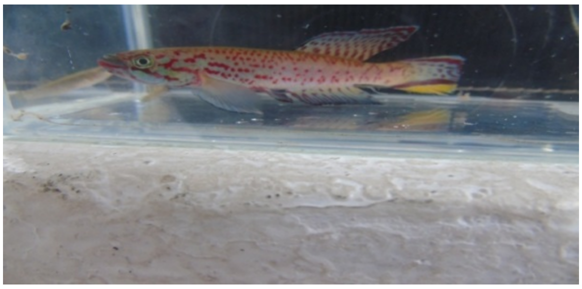
Table 5-14 Description of the biogeography of some fish species recorded during the survey



Monodactylus sebae (No empirical record for Liberia). Occurs in the West African Coast from Cape Verde to Angola. Very common in Estuaries and Lagoons where reproduction takes place, lower courses of rivers, sometimes ascending over long distances into freshwater. It loves the sea (Paugy et al, 2004). Collected upstream of Po River during this survey.

Odaxothrissa mento: Occurs in the lower reaches of the River Volta (Ghana), the Niger delta, the Benue and the Cross (Nigeria). It has not been found elsewhere (Paugy et al, 2004). Collected Downstream of Po River during this survey.

***Sarotherodon occidentalis*:** This species occurs in coastal areas, from the River Casamance in Senegal to the St. John in Liberia. Occurs in River Estuaries of Sierra Leone (Paugy et al,2004). Collected both Upstream and Downstream of Po River during this survey.

	***Epiplatys ruhkopfi****:* Near Threatened. Known only from the type locality in the drainage system of the Upper Saint John River in Northern Central Liberia (Paugy et al, 2004). Collected in Creek at point adjacent to the landfill site.
	***Epiplatys barmoiensis:*** Inhabits swampy areas and small rivers on the coastal plains, usually under forest cover, in Southern Guinea, Southern Sierra Leone and Southwestern Liberia (Paugy et al, 2004). Collected in the swamp located in the landfill site.
	***Callopanchax monrovae:*** Temporary swamps and pools, and swampy parts of forest creeks in the humid coastal rainforest. The range of distribution extends from the drainage system of the Lower Mano River to that of the Lower Saint Paul River in Southern and Southwestern Liberia. Collected in the swamp located in the landfill site.

Locals from three communities (Gbojema, Philip`s Town and Konsor Town) were interviewed during this survey. Table 5-15 shows a list of the fish species identified by the interviewed communities identified from photographic record of fish species of Liberia compiled by Fermon and Gsegner (2006) as well as the West African Fisheries guide by Paugy et al, 2004. Six species amongst the list are of global concern and listed in the IUCN Red List Status as either Near Threatened or critically endangered.

No active fishers are present in the area and fishing is done mainly for household consumption. The fishing gear used is the hook and line and is done by youths at leisure times. Notwithstanding, if fish caught is large enough to attract market value, the fish is sold for cash. Furthermore, it was reported that fishers from other nearby and far away communities including Singe, Gbee, Damebo, Wuluwen and Kordi use "kru-canoes" to migrate along the Po river for fishing". They also employ various improved fishing methods including set nets as well as cast netting.

Table 5-15 List of fish species recorded from interviews with the locals (LC-List Concern; NT-Near Threatened; CE-Critically Endangered; V-Vulnerable; DD-Data Deficient)

No.	Species	IUCN Red List Status
1	*Polypterus palmas*	LC
2	*Marcusenius thomasi*	LC
3	*Mormyrops anguiloides*	LC
4	*Papyrocranus afer*	LC
5	*Hepsetus odoe*	LC
6	*Brycinus longipinnis*	LC
7	*Labeo currei*	CE
8	*Barbus carcharhinoides*	CE
9	*Barbus inaequalis*	DD
10	*Chrysichthys maurus*	LC
11	*Malapterurus tiossnyae*	NT
12	*Malapterurus punctatus*	NT
13	*Malapterurus barbatus*	NT
14	*Scriptaphyosemon liberiense*	NT
15	*Tylochromis intermedius*	LC
16	*Tylochromis intermedius*	LC
17	*Pelvicachromis humilis*	LC
18	*Hemichromis fasciatus*	LC
19	*Tilapia brevimanus*	LC
20	*Tilapia walteri*	NT
21	*Tilapia zilli*	LC
22	*Ctenopoma kingsleyae*	LC
23	*Mastacembelus liberiensis*	LC

5.3 HUMAN ENVIRONMENT/ SOCIO-ECONOMICS

The socioeconomic baseline gives a general review of the socio-economic conditions prevailing in Liberia with a focus on the communities that are affected by the proposed landfill. These include: Montserrado and Bomi.

5.3.1 Demographics

As reported by the World Bank, the population of Liberia was 4,397 million in 2014 and the annual growth rate was 2.4%.

Liberia is presently divided into 15 major counties, each headed by a superintendent who serves as a vice juror to the President of Liberia:

- Bomi
- Margibi
- Maryland
- Montserrado
- Sinoe
- Nimba
- Grand Gedeh
- Grand Bassa
- Grand Cape Mount
- Lofa
- Bong
- Gbarpolu
- Grand Kru
- River Cess (or Rivercess)
- River Gee

The population is unevenly distributed (Figure 5-17):

- Monrovia had a population of 1,010,970 people in 2008, or 32% of the national population[15]

- Montserrado, Nimba and Bong counties held 56% of the population
- Grand Kru, Rivercess, River Gee, Bomi and Gbarpolu counties held only 10% (each with less than 2.5%)

In 2014, the population density of Liberia was 46 people/km^2 according to the World Bank.

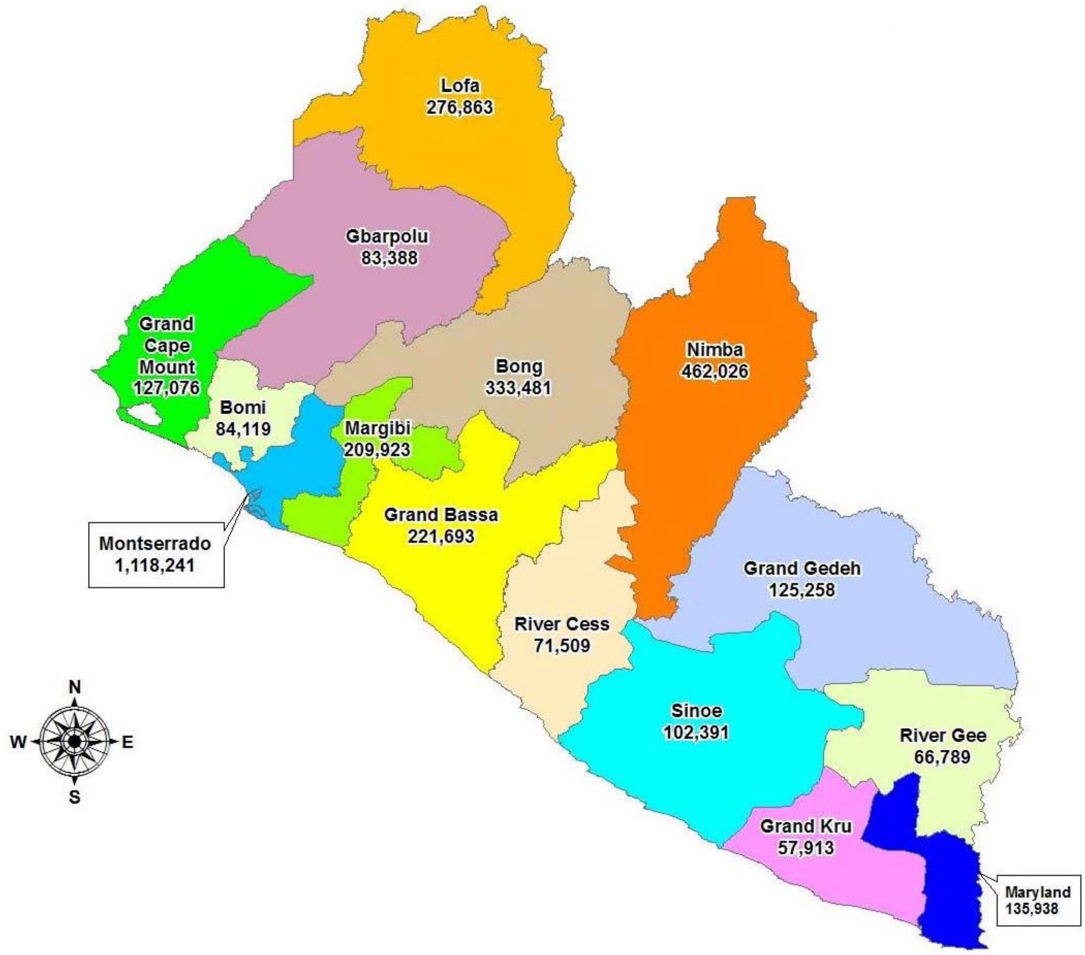


Figure 5-17 Distribution of Population by County (Source: 2008 National Population and Housing Census (LISGIS))

5.3.1.1 Demographics of Bomi County and its affected districts

Bomi County's population is estimated at 84,119 with a population density of 113 persons per square mile, thus it is considered as a densely populated region in comparison to other counties of Liberia.[16] The distribution of the county's population county's population and its

[15] Liberia Institute of Statistics and Geo-Information Services (LISGIS), 2009. National Population and Housing Census.
[16] LISGIS, 2009.

affected districts is described in Table 5-16.

Table 5-16 Distribution of Population in Margibi county and Mambah Kaba District in 2008 (LISGIS, 2009)

County/District	*Male*	*Female*	*Total*
Bomi County	**42,940**	**41,179**	**84,119**
Klay District	**11,884**	**11,513**	**23,397**

5.3.1.2 Demographics of Montserrado County and its affected Districts

Home to the country's capital Monrovia, Montserrado County presents the highest population of all the counties of Liberia although it is the smallest geographically. Regarding population density, the county is considered to be very dense with an estimated population density of 1,540 persons per square mile.[17] According to the 2008 National Population and Housing Census, around one third (32%) of the Liberian population live in Montserrado County, of which more than 85% reside in Greater Monrovia. The Greater Monrovia District, the most populous district in the nation, has a population of 970,824 people.[18] The distribution of the county's population and its affected districts is described in Table 5-17.

Table 5-17 Distribution of Population in Montserrado and Margibi counties in 2008 (LISGIS, 2009)

County/District	*Male*	*Female*	*Total*
Montserrado County	**549,733**	**568,508**	**1,118,241**
Greater Monrovia District	476,473	494,351	970,824
Careysburg	15,048	14,664	29,712
Commonwealth	5,752	6,124	11,876
St. Paul River	34,981	36,850	71,831
Todee	17,479	16,519	33,998

5.3.2 Ethnicity, Religion and Language

Of the Liberian population, 95% belong to one of the 16 tribes (Figure 5-18), whereas Americano-Liberians (descendants of immigrants from the United States) and Congo people (descendants of immigrants from the Caribbean) together comprise 2.5% of the population. There are a considerable number of Lebanese, Indian, and other West African nationals who make up a significant part of Liberia's business community.[19]

About 40% of Liberians are Christians, 40% have traditional beliefs, and 20% are Muslims.

[17] LISGIS, 2009.
[18] LISGIS, 2009
[19] Brandolini, G. V. and Tigani, M. 2006. Liberia Environmental Profile. December 2006, Monrovia.

While English is the official language, it is only spoken by 20% of the population. The remaining 80% speak one of 20 ethnic group languages.[20]

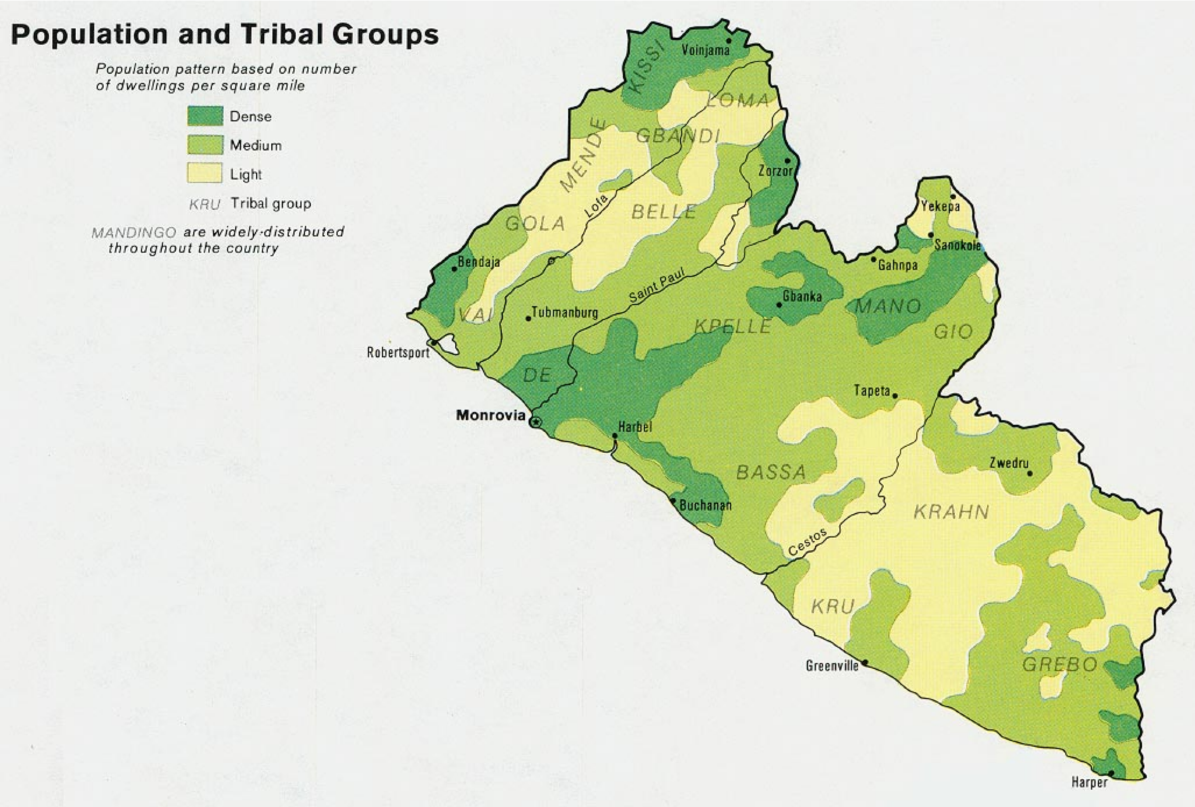


Figure 5-18 Liberia Population and Ethnic Groups (Source: CIA Map No. 501556 1973)

5.3.2.1.1 Ethnicity, Religion and Languages in Bomi County

The major ethnic groups in the County are the Gola, Vai, Kpelle and Mandingo, although all sixteen of Liberia's ethnic groups are thought to be represented. The Golas are in the majority, followed closely by the Vai and the Kpelle.The Mandingo are found under various Clans. The two main religions in the County are Islam (60%) and Christianity (40%).[21]

5.3.2.1.2 Ethnicity, Religion and Languages in Montserrado County

All of Liberia's 16 major tribes have come to populate the county, so that today Montserrado, and particularly Greater Monrovia, is considered highly diverse and representative of the population of Liberia as a whole. Bassa- and Kpelle-speaking peoples are the majority, making up 21% and 52% of the county's population respectively, but every

[20] UNEP, 2004. Desk Study on the Environment in Liberia.
[21] Republic of Liberia, 2008-2012. Bomi County Development Agenda.

other Liberian language and dialect can also be found. An estimated 68.2% of the population is Christian, while 31.8% is Muslim.[22]

5.3.3 Education

The Liberian education system is emerging from a prolonged and brutally destructive period of civil unrest. Long years of civil war, combined with constant political instability, have taken a heavy toll on the education sector in Liberia. Twenty percent of schools have been completely destroyed, while many of the remaining 80% are in urgent need of repair.23

Liberia is significantly behind most other countries in the African region in nearly all education statistics. The country is still in the process of rebuilding its educational system. Enrollement in schools and number of school levels nationally is given in Table 5-18.

According to the UNESCO, the national adult literacy rate defined as anyone above the age of 15 years who can read and write in any language was estimated to be around 47.6% (between 2005 and 2010), with more literate males (62.42%) than females (32.81%).[24] Subsequently illiteracy is high, estimated at 52.4% among the population aged 15 and over. Total Youth Literacy Rate (15-24 years) was 54.47% in 2015 (Male: 64.66%; Female: 43.97%).

Athough new schools have been constructed, the general situation remains to be improved, particularly in remote rural communities. Some buildings used as schools were former residential structures, churches, old warehouses and so forth. These structures lack adequate space : classrooms are small, lighting and ventilation are poor. Additionally, basic school necessities such as desks, chairs, reading rooms/and libraries, and cafeterias are lacking. The national student to trained teacher ratio (STTR) for the pre-primary level was 100:1 in 2012 which is a significant improvement over the 2008/2009 level of 140:1 (Table 5-19). The primary textbook-to-student ratio of 1.2 (Table 5-20) indicates that there are 12 text books for every 10 enrolled children. The problem of textbook shortage becomes worse as the education level increases with the junior high level having on average only 7 books for every 10 students; and senior high the worst case of only 3 textbooks available for every 10

[22] Republic of Liberia, 2008-2012. Montserrado County Development Agenda.
[23] Ministry of Education-Republic of Liberia, 2007. Liberian Primary Education Recovery Program.
[24] http://www.unesco.org/uil/litbase/?menu=4&programme=217

students.[25]

The University of Liberia is the oldest degree-granting school in West Africa. The school is divided into six colleges, three graduate programs, and three professional schools. The publicly funded university is divided up into three campuses. The main, original campus in downtown Monrovia, a medical campus, and the Fendall Campus, located about 22.5 km (14 miles) northeast of Monrovia. The College of Agriculture and Forestry is located at the rural Fendell Campus. Higher education is also provided through other universities, such as William V. S. Tubman University in Cape Palmas, Stellla Maris Polytechnic in Monrovia, A.M.E. Zion University, United Methodist University, A.M.E. University and St. Luke School Of Medicine in Monrovia, Cuttington University in Suacoco, and the Booker T. Washington Institute in Kakata.

Table 5-18 Enrolment and Number of School Levels by County, 2010/2011 (Source: UNESCO, UNICEF, 2012. Liberia Country Study: Profiles of Children Out of School)

County	Enrollment by Level				Number of School Levels*			
	Pre-Primary	Primary	Junior High	Senior High	Pre-Primary	Primary	Junior High	Senior High
Bomi	17,958	11,837	3,010	806	149	129	19	5
Montserrado	168,175	223,346	73,243	51,049	1,560	1,580	764	300
NATIONAL	611,807	674,534	138,029	82,049	4,918	4,934	1,586	491
* These are the number of levels rather than the actual number of schools. Some schools have multiple levels.								

Table 5-19 Student to Trained Teacher Ratio (STTR) by County and Level, 2010/2011 (Source: UNESCO, UNICEF, 2012. Liberia Country Study: Profiles of Children Out of School)

County	Pre-Primary	Primary	Junior High	Senior High	Total
Bomi	91	50	32	29	60
Montserrado	68	39	25	41	42
NATIONAL	100	48	23	41	53

Table 5-20 Textbook-to-Student Ratio by County and Level, 2010/2011 (Source: UNESCO, UNICEF, 2012. Liberia Country Study: Profiles of Children Out of School)

County	Primary	JHS	SHS
Bomi	1	0.4	0.1
Montserrado	0.6	0.5	0.3
NATIONAL	1.2	0.7	0.3

5.3.3.1 Education in Bomi County

Bomi County has a relatively low literacy rate of 46% among people over 10 years old,

[25] UNESCO, UNICEF, 2012.

compared to the national literacy rate of 56% among people of the same age group.[26] Statistics about enrollment, number of schools, students to trained teachers ratio and textbook to student ratio are given in Table 5-18, Table 5-19 and Table 5-20.

5.3.3.2 Education in Montserrado County

Montserrado County has a relatively high literacy rate of more than 70% among people over 10 years old, compared to the national literacy rate of 56%.[27] This is mainly due to the concentration of schools in the country's capital, Monrovia. However, many children are forced to walk for several hours to reach their schools to receive a sub-standard education often in dilapidated buildings. Another problem is getting qualified teachers to the remote areas. The most deprived area in Montserrado County is Todee District, where there are no high schools.[28] Statistics about enrollment, number of schools, students to trained teachers ratio and textbook to student ratio are given in Table 5-18, Table 5-19 and Table 5-20.

5.3.4 Poverty

According to the World Bank, 68.6 % of the Liberian population lives at a ratio of \$1.90 a day (data from 2007). According to a Poverty Profile Study, poor households in Liberia live on approximately \$11.32 USD per month to feed an average of six people. This means that a typical poor household lives on a daily amount less than \$0.50 USD per day. Over two-thirds of household income is spent on providing food for the family, leaving little or nothing for basic education, health care and leisure. This results in deterioration of quality of life of the citizens, with most not having jobs that can support a decent standard of living, as income-generating opportunities are limited.[29] Percentage of poor people living in poverty in Liberia is shown in Figure 5-19.

[26] LISGIS, 2009.
[27] LISGIS, 2009.
[28] Republic of Liberia, 2008-2012. Montserrado County Development Agenda.
[29] Brandolini, G. V. and Tigani, M. 2006. Liberia Environmental Profile. December 2006, Monrovia.

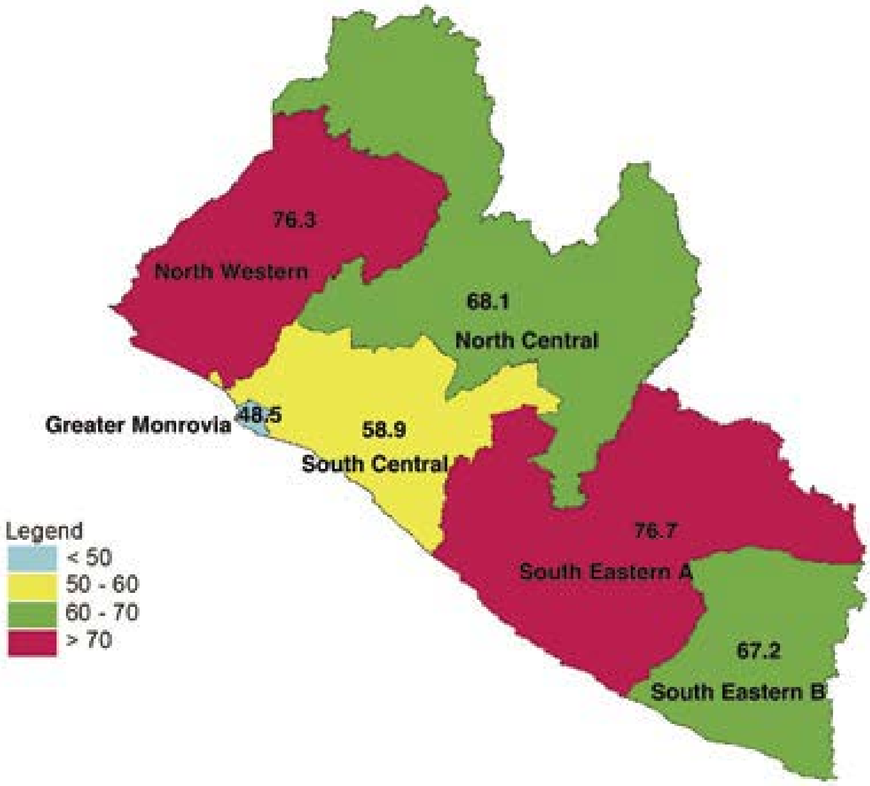


Figure 5-19 Percentages of Population Living in Poverty (Source: LISGIS, 2009)

5.3.5 Household Characteristics

According to the 2008 Population and Housing Census, Liberian households consist of an average of 5.1 persons. Almost one-third (31%) of households are headed by a woman. Household are usually overcrowded: Accordig to the 2013 Demographic and Health Survey (DHS 2013), 40% of households use one room for sleeping, 27% use two rooms, and 33% use three or more rooms for sleeping.

Data from 2008 suggests that, of the two counties of interest – Bomi and Montserrado–, Montserado County has the highest average household size at 4.8 persons, while Bomi County has an average of 4 persons.[30]

Housing conditions vary greatly. Only 9.8% of households have electricity.[31] Electricity is almost non-existent in rural areas (1%), while just 16% of urban households have power.[32]

[30] LISGIS. 2009.
[31] World Bank, 2016. Sustainable Energy for All (SE4ALL) database from World Bank, Global Electrification database.
[32] Liberia Institute of Statistics and Geo-Information Services (LISGIS), Ministry of Health and Social Welfare [Liberia], National AIDS Control Program [Liberia], and ICF International. 2014. Liberia Demographic and Health Survey 2013. Monrovia, Liberia.

98% of households use solid fuel (wood/coal/charcoal) for cooking. The major source of lighting is the plastic, battery-powered Chinese lamps. Other lighting energy sources are battery (16%), flashlight/torch (15%), electricity (10%), and oil lamp (6%).

Only 14% of households in Liberia use improved toilet facilities that are not shared with other households; 45% of households have no toilet facility at all.[33] According to DHS 2013, 47% of Liberian households have earthen floors (made of earth, sand, or mud), and 45% have concrete or cement floors. Urban households are more likely than rural households to have concrete or cement flooring.

Half of Liberian households (57%) have a radio, while 14% have a television and only 5 % own a computer. Almost three in ten households (65%) have a mobile phone, while only 4% have a refrigerator. Even the most common household goods are not universal in Liberia; only 67% of households have chairs and 72% have a table. Urban households are more likely than rural households to own each of the items.[34]

5.3.6 Health Care

The health infrastructure in the country is in poor condition. It is estimated that fewer than 10% of Liberians have access to health care[35] which accounts for the high infant and child mortality rates. According to the World Health Organization, the under-5 child mortality rate is currently 71 per 1,000 live births (in 2013). Maternal mortality rate remains very high (640 per 100,000 in 2013).[36] Full immunization coverage remains inadequate (51%). Malaria prevalence in children is 32%.[37] Malaria, diarrhea, acute respiratory infections, neonatal tetanus, measles, and malnutrition are the major causes of morbidity. The situation is exacerbated by the fact that a large portion of the population is living in temporary camps under poor sanitary conditions. Chronic malnutrition was prevalent among 36% among

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[33] Liberia Institute of Statistics and Geo-Information Services (LISGIS), Ministry of Health and Social Welfare [Liberia], National AIDS Control Program [Liberia], and ICF International. 2014.
[34] Liberia Institute of Statistics and Geo-Information Services (LISGIS), Ministry of Health and Social Welfare [Liberia], National AIDS Control Program [Liberia], and ICF International. 2014.
[35] United Nations, World Bank and International Monetary Fund. 2003-2004. Liberia Joint Needs Assessment as of February 2004. Available from: http://www.undg.org
[36] World health organization, 2015. Liberia Key Indicators. Available at: http://apps.who.int/gho/data/node.cco.ki-LBR?lang=en
[37] Republic of Liberia, Ministry of Planning and Economic Affairs, 2006-2011. Socioeconomic Achievements of the Government of Liberia 2006-2011.

Liberians in 2012.[38]

The incidence of communicable diseases e.g., HIV/AIDS, tuberculosis, and river blindness continues to increase. HIV/AIDS prevalence was estimated at 1.9% of the population between the ages of 15-49 years in 2013.[39] The lack of knowledge, exacerbated by poverty and unsafe sexual behavioral practices, continues to pose great challenges for the survival of young adolescents, especially females who have been the main victims of rape and sexual abuse.

The situation has been worsened by the emergence of the Ebola virus which had caused significant loss of life in the country since March, 2014. Case fatality rates reached up to 70%. Estimates suggested that the number of cases was 10,675, of which 4,809 resulted in mortality.[40] As of November 2015, while the large-scale epidemic has ended, sporadic new cases emerged. This is the first Ebola outbreak to reach epidemic proportions. Extreme poverty, a dysfunctional healthcare system, a mistrust of government officials after years of armed conflict, and the delay in responding to the outbreak for several months all contributed to the failure to control the epidemic. Other factors include local burial customs that involve washing of the body, and the spread to densely populated areas.[41]

5.3.6.1 Health Care in Bomi County

Less than 15% of the County's population has access to health care.[42] The county has only one hospital located in Tubmanburg. In total there are 23 health care facilities in Bomi, of which 8 are in Klay District.[43] Most of the health facilities are run by international NGOs.

5.3.6.2 Health Care in Montserrado County

Most health facilities in the county were looted and damaged during the civil war. Currently the majority of the rural population has to walk for hours or days to access a clinic. 78 health facilities were functioning in 2012, of which 8 hospitals all located in Greater Monrovia

[38] Republic of Liberia, 2012. Comprehensive Food Security and Nutrition Survey (CFSNS)
[39] Liberia Institute of Statistics and Geo-Information Services (LISGIS), Ministry of Health and Social Welfare [Liberia], National AIDS Control Program [Liberia], and ICF International. 2014.
[40] World Health Organisation, 2015. Ebola Situation Report - 16 December 2015.
[41] World Health Organisation, 2014. Ebola Response Roadmap Situation Report.
[42] Republic of Liberia, 2008-2012. Bomi County Development Agenda.
[43] Liberia Institute of Statistics and Geo-Information Services (LISGIS), 2012. Health Facilties by County, District and Town.

district. [44]

5.3.7 Economy and Employment

Liberia is a low-income country heavily reliant on foreign assistance for revenue. In the 1970s and 1980s, iron mining accounted for more than half of Liberia's export earnings[45] and it was the world's fifth largest exporter of iron ore. Prior to the civil war, other major contributors to the Liberian GDP were rice and natural rubber.[46] By the end of 2000, the economic structure had changed significantly: iron ore production had stopped completely and the rubber sector accounted for over half of export income. Civil war and government mismanagement destroyed much of Liberia's economy. Many businesses fled the country, but with the conclusion of fighting and the installation of a new government in 2006, several have returned. Richly endowed with water, mineral resources, forests, and a climate favorable to agriculture, Liberia had been a producer and exporter of basic products, primarily raw timber and rubber and is reviving those sectors. Embargos on timber and diamond exports have been lifted, opening new sources of revenue for the government. The country reached its Heavily Indebted Poor Countries initiative completion point in 2010 and nearly $5 billion of international debt was permanently eliminated.

In 2005, the Liberia economy was at about one-third of the pre-war level, with a gross domestic product (GDP) of less than $500 million USD compared to over $1 billion USD in 1988.

Table 5-21 describes the main economic figures for the year 2015.

Table 5-21 Key Economic Indicators in 2015

Economic Indicators	Values	Source
Real GDP Growth Rate (%)	0.3	World Bank, Ministry of Finance
GDP at market prices (US million)	2,04	International Montary Fund
GDP Deflator (Index)	1,933	International Montary Fund
GDP per capita (US$)	473,64	International Montary Fund
Inflation Rate, Average Consumer Prices (%)	7.74	International Montary Fund

[44] LISGIS, 2012.
[45] United States Department of State. Country background notes, Background Note: Liberia. Available from: http://www.state.gov/r/pa/ei/bgn/6618.htm
[46] UNDP. 2006. First State of the Environment Report for Liberia. Monrovia, Liberia.

Economic Indicators	Values	Source
External debt – 4th quarter 2014/2015 (US $ Million)	491.21	Ministry of Finance
Domestic Debt - – 4th quarter 2014/2015 (US $ Million)	276.44	Ministry of Finance

The real GDP growth rate for the Liberian economy in 2015 was initially projected at 0.9%. However, due to the Ebola Crisis and the the declining prices in major export commodities, mainly iron ore and rubber, on the world market, the growth rate was downgraded to an estimated 0.3%, a figure lower than the 0.7% estimated in 2014. The expected decline in real GDP growth can be attributed to the fall in mining and agriculture sectors by 17% and 1.1%, respectively. On the contrary, the manufacturing and services sectors were estimated to improve by 6.1% and 5%, respectively.[47,48]

GDP growth is projected to recover to about 3.9% in 2016. The recovery is expected to be driven by the coming on stream of a new gold mining concession, and improvements in services as rural and urban markets re-open. However, the slow economy in China and its negative impacts on the global economy will keep on weighing on the Liberian economy which relies heavily on rubber, iron ore and oil palm exports.[49] Breakdown of sectors contributing to Liberia's 2015 GDP are shown in Figure 5-20.

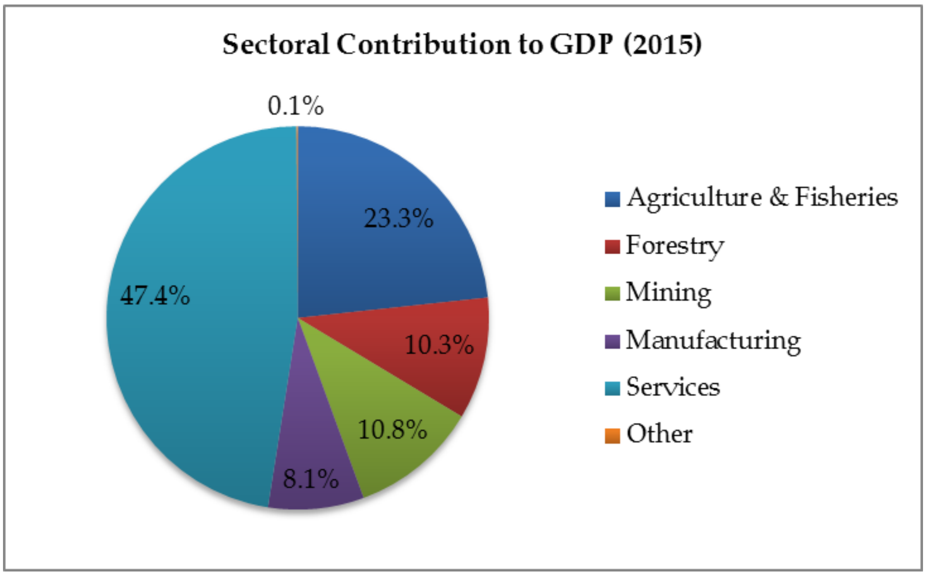

Figure 5-20 Sectoral Contribution to GDP in 2015 (Source: adapted from IMF and GoL Macro Framework)

[47] Government of Liberia, Ministry of Finance, 2016. Annual Economic Review: 2015.
[48] World bank, 2016. Liberia Overview. available from: http://www.worldbank.org/en/country/liberia/overview
[49] World bank, 2016. Liberia Overview. available from: http://www.worldbank.org/en/country/liberia/overview

5.3.7.1 Economy and Employment in Bomi County and its affected districts

Before the civil war, Bomi was essentially an agricultural zone, with 70% of the population actively engaged in subsistence agriculture and related activities. Agricultural production decreased dramatically due to the war. However, since 2005, the sector is being rehabilitated with the support of the government and international organizations. Agricultural productions in the county include mainly food crops, especially rice and cassava, in addition to rubber and palm oil.[50]

5.3.7.2 Economy and Employment in Montserrado County and its affected districts

Greater Monrovia is the center of the country's industrial and commercial activities. The majority of the population is engaged in business, mostly medium, small, and micro in nature, and mostly informal. Others commute to jobs with government ministries and agencies and with international and national organizations headquartered in Monrovia. Although a large part of the population in urban Montserrado is engaged in trade, most in the rural areas are engaged in subsistence farming. Most farmers have declared their inability to produce enough food for household consumption owing to a lack of extension services and capital for seeds, tools, and other inputs. Recently, NGOs have increased their efforts to supply basic inputs to farmers to jump-start the agricultural economy, but these efforts have not reached all areas of the county. Road conditions have not been supportive to the restoration of production capacities as rural areas remain unreachable, particularly during the rainy season.[51]

5.3.8 Infrastructure

Liberia's infrastructure was severely damaged during the civil war. Most Liberians have no access to electricity, improved water and sanitation facilities, acceptable housing, or decent roads. Weak infrastructure challenges 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

[50] Republic of Liberia, 2008-2012. Bomi County Development Agenda.
[51] Republic of Liberia, 2008-2012. Montserrado County Development Agenda.

less access to health facilities, raising the risk of child and maternal mortality. Persons with disabilities are also disproportionately disadvantaged.

5.3.8.1 Water and Sanitation

While significant progress has been made since the end of the civil war, many Liberians still, especially the rural dwellers, do not have access to safe drinking water or human waste collection and disposal facilities

According to the 2013 Demographic and Health Survey, the majority of Liberian households (73%) have access to improved drinking water sources: 3% from piped water (including public tap or standpipe), 1% from tube well or borehole, 64% from a hand pump or protected dug well, 1% from a protected spring, 4% from bottled water, and less than 1% from rainwater. Households in urban areas (86%) are more likely than those in rural areas (56%) to have access to an improved source of water. Most residents do not treat or boil their water, which has grave implications for the health status of the population. Only 14% of households appropriately treat their drinking water.[52]

The only operational sewage system is in Monrovia, with an under-capacity sewage treatment plant, and has not functioned consistently for over ten years due to disrepair and a shortage of electricity. The majority of the population uses either pit latrines, toilets connected to septic tanks, or open defecation.[53] Raw sewage has been frequently allowed to flow directly into lagoons, rivers and the sea. Occasionally the sewer mains are fractured, causing outflow on to the streets or into the sea and local rivers. Only 14% of households in Liberia use improved toilet facilities that are not shared with other households; 45% of households have no toilet facility at all.[54]

Garbage collection is minimal, with the availability of one open dump site located at the outskirts of Monrovia, at Whein Town.

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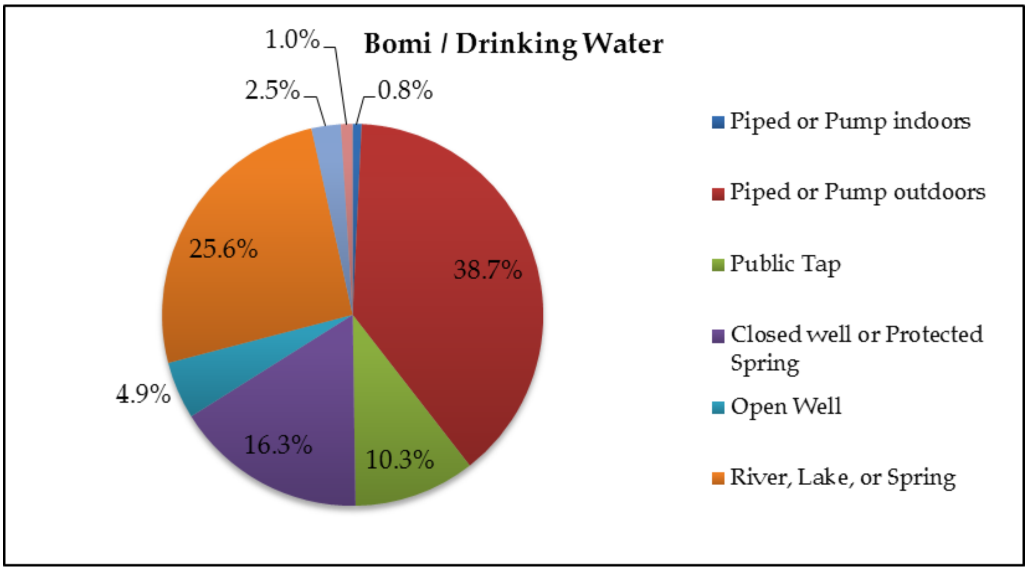
[52] Liberia Institute of Statistics and Geo-Information Services (LISGIS), Ministry of Health and Social Welfare [Liberia], National AIDS Control Program [Liberia], and ICF International. 2014. Liberia Demographic and Health Survey 2013. Monrovia, Liberia: Liberia Institute of Statistics and Geo- Information Services (LISGIS) and ICF International.
[53] UNDP. 2006. First State of the Environment Report for Liberia. Monrovia, Liberia.
[54] Liberia Institute of Statistics and Geo-Information Services (LISGIS), Ministry of Health and Social Welfare [Liberia], National AIDS Control Program [Liberia], and ICF International. 2014.

5.3.8.1.1 Water and Sanitation in Bomi County

Access to water and sanitation in the county is very poor. Progress has been made since the end of the civil war, through the support of international NGOs. However, much still needs to be done to meet the high demand in the county.[55] The majority of the population relies on outdoor pumps as wells as nearby water bodies as their main sources of water (Figure 5-21a), with less than 4% of the residents having access to in-house or shared toilet facilities (Figure 5-21b).



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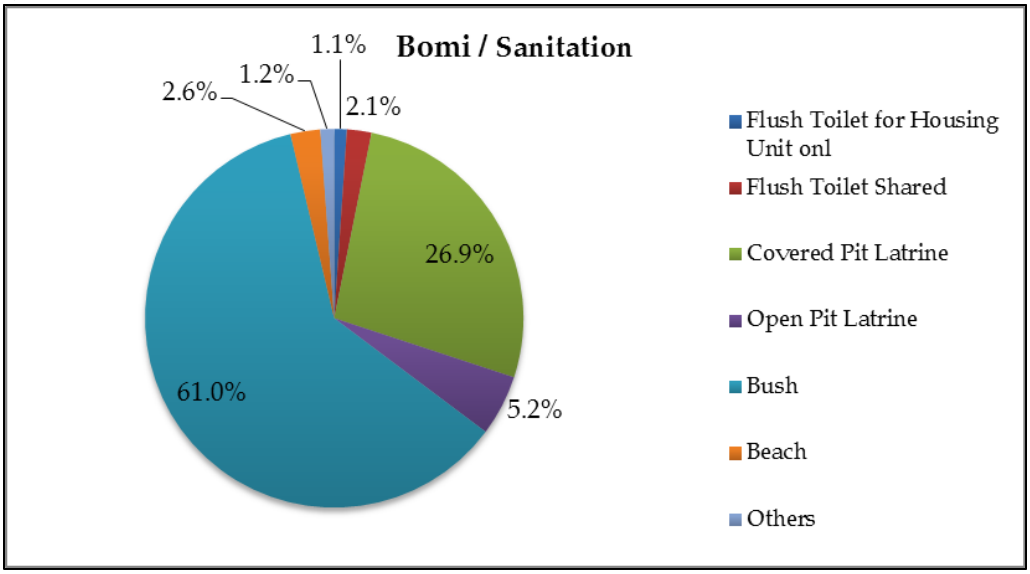


b)

Figure 5-21: Distribution of households (a) by main source of drinking water and (b) by means of human waste disposal in Bomi county (adapted from 2008 Population and Housing Census)

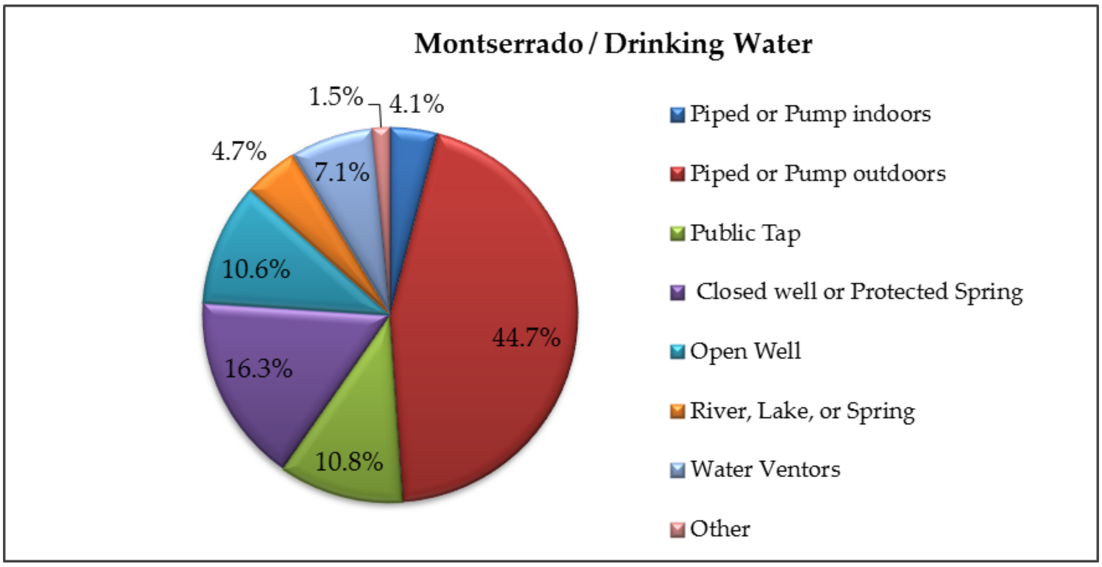
[55] Republic of Liberia, 2008-2012. Bomi County Development Agenda.

5.3.8.1.2 Water and Sanitation in Montserrado County

The Mount Coffee Hydro Electric dam (Mt. Coffee hydro dam) and the White Plains Water Treatment Plant in Careysburg District ensured a constant supply of water to the Montserrado County before the war. However, the destruction of the Mt. Coffee hydro dam during the war halted the plant's water supply. Recently, the dam has been rehabilitated for power production. The White Plains Water Treatment Plant currently supplies about 3 million gallons of water a day to parts of Monrovia. The majority of the population relies on pumps and wells as their main source of water (Figure 5-22a), with less than 30% of the residents having access to in-house or shared toilet facilities (Figure 5-22b). The Liberia Water and Sewer Corporation is working hard to restore the water and sewage services, but the current situation has often led to outbreaks of water-borne disease.[56]

In Monrovia, the water supply service is mainly based on a surface water source from the nearby St. Paul's river. The raw water is pumped to the White Plains Treatment Plant (WTP) and treated water is distributed to the population through a distribution system. Only small parts of Monrovia currently have direct access to the piped water supply while most areas depend on trucked water delivered to community collection points or household tanks, and/or on water from unprotected dug wells or hand pumps.

[56] Republic of Liberia, 2008-2012. Montserrado County Development Agenda.



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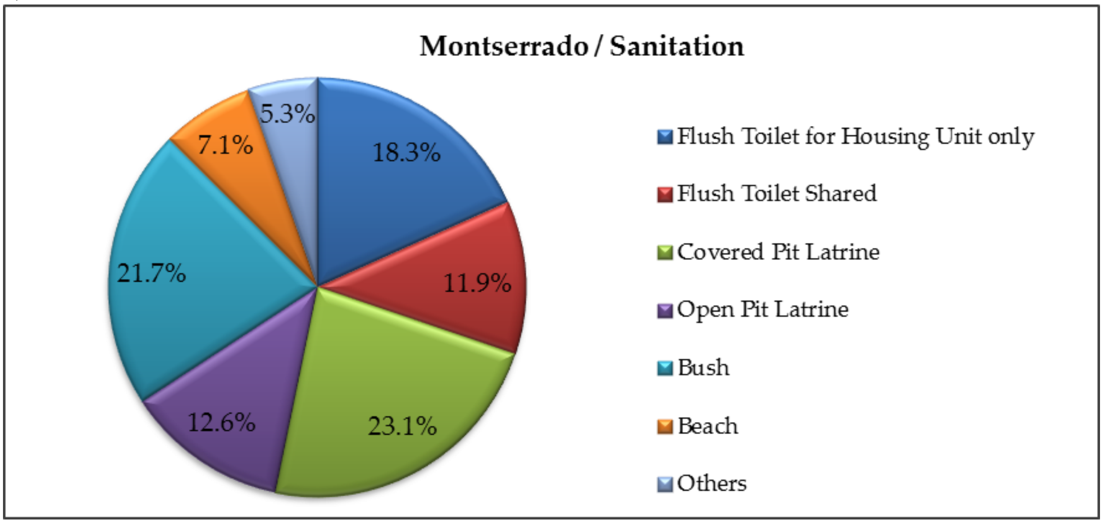


b)

Figure 5-22 Distribution of households (a) by main source of drinking water and (b) by means of human waste disposal in Montserrado county (adapted from 2008 Population and Housing Census)

5.3.8.2 Transport

Perhaps the most critical infrastructure improvement need is roads, which Liberians across the country consistently consider to be of top priority. The majority of roads are dirt roads and most paved roads are usually damaged. However, efforts are being made in this sector and major road corridors are now being, or have been rehabilitated with the support of international organizations. 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.

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 United Nations flights operating up-country. Robert International Airport is located 72 km (45 miles) from Monrovia and it caters to large aircrafts, while the Springs Payne Airport located in the heart of Monrovia caters to smaller planes and serves as a point of origin for all domestic flights. The other coastal cities of Buchanan, Greenville, Harper and Robertsport are served by gravel-surface airstrips. Presently, these airstrips are in poor conditions and need rehabilitation.[57]

Liberia has four ports: the Free Port of Monrovia, the port of Buchanan, the port of Greenville, and the port of Harper. Most of the imported goods to Liberia pass through the Free Port of Monrovia. The other ports handle mainly exports, logs, and formerly iron ore. Ships transport goods from Monrovia to Harper, Buchanan and Greenville but this transport link is sporadic due to low economic activity between these centers.

5.3.8.2.1 Transport in Bomi County

There is currently a free flow of transportation between Monrovia and Tubmanburg due to the good condition of the road. Transportation to other parts of the County is often severely hampered by the bad road conditions. Taxis and other commercial transport are nearly always overloaded, posing a hazard to human life.[58]

5.3.8.2.2 Transport in Montserrado County

Home to the country's capital, Montserrado County is the heart of the country, thus having the best transport facilities when compared to the rest of the counties. This applies particularly to the Greater Monrovia District. As stated previously, the only two commercial airports and the main seaport in the country are located in Monrovia. The roads of the city are currently rehabilitated and paved and the government has made fast progress on those projects. Other road rehabilitation and construction projects are being conducted in the rest of Greater Monrovia, Careysburg and Todee Districts.[59]

5.3.8.3 Energy

The electricity supply system in Liberia is operated by the Liberian Electricity Corporation

[57] EPAL, 2007
[58] Republic of Liberia, 2008-2012. Bomi County Development Agenda.
[59] Republic of Liberia, 2008-2012. Montserrado County Development Agenda.

(LEC). It is based on a Central Monrovia City System with radial lines extending into the country and independent isolated grids.

Prior to the civil war, a total of 11 grids were in operation while three were under construction.[60] A total installed electricity capacity of 177 MW (98% around Monrovia, serving about 35,000 customers) was also in place before the civil war.

One of the losses of infrastructure caused by the war was the Mount Coffee Hydropower Plant which supplied 63 MW during the wet season and 5 MW during the dry season. Outside Monrovia there were ten small isolated power systems supplying rural areas.

Currently, less than 10%, of the Liberian population have access to electricity.[61] The electricity access rate in Liberia is one of the lowest in the world. The electricity access rate in Monrovia is 6.7%. Expensive diesel fueled generation resources largely supply Monrovia's grid. Less than 23 Megawatts (MW) of Liberia's on-grid installed generation operate on a daily basis. Large facilities in Monrovia usually depend on self-generated power at levels estimated to be ten times greater than the existing installed generation capacity.[62]

The Government of Liberia, endorsed by development partners, is working to rebuild its electricity infrastructure. The government's objective is to reach the following by 2030:

- Connect 70% of Monrovia to the electricity grid
- Provide access to electricity to 35% of the rest of the country.

This means that the government will provide the equivalent of over one million new connections and a peak load over 300MW.

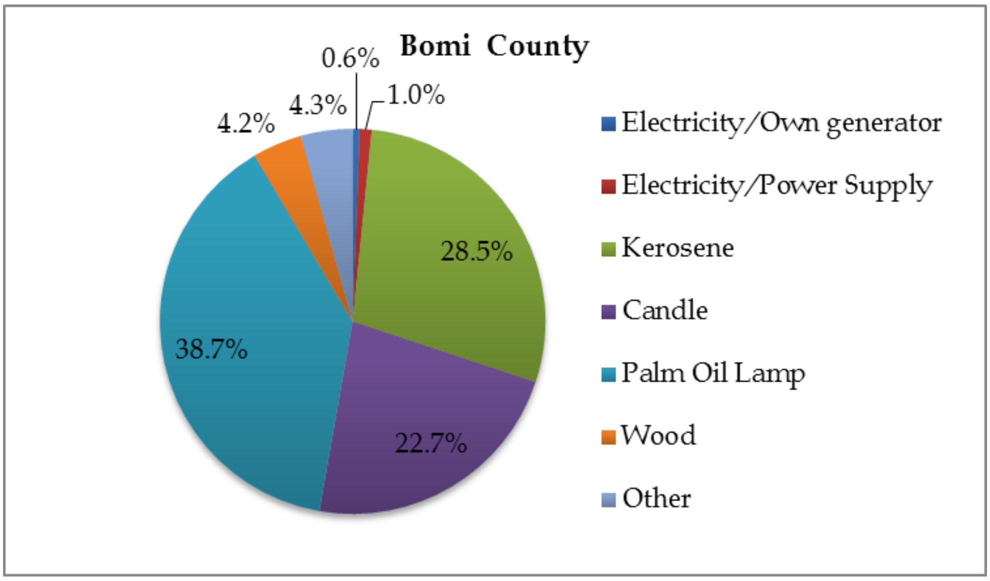
Recently the Mt. Coffee hydropower plant resumed operation. The first of four generating units was commissioned in December 2016. It is a hydropower turbine and generator unit, with an installed capacity of 22 megawatts (MW). LEC customers are currently receiving electricity that is generated fby this unit. It is expected that before the end of 2017, all four turbines will be installed and connected by high-voltage transmission lines to the LEC Bushrod Substation and Paynesville Substation. When the plant and related transmission

[60] Wiles, David. 2007. The Environment in Liberia Status and Policies. Monrovia, Liberia.
[61] World Bank, 2016. Sustainable Energy for All (SE4ALL) database from World Bank, Global Electrification database.
[62] Liberia Power Africa Fact Sheet, 2015. Available at: https://www.usaid.gov/powerafrica/partners/african-governments/liberia

lines come on line in 2016, a maximum capacity of 88 MW in Liberia will be available through the public grid.

The Government of Liberia has further intensified its commitment to the provision of energy services through the recent development of a National Energy Policy (NEP) and supportive legislation, which 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 RREA was established in 2010 as an independent agency of the Government of Liberia.

Figure 5-23 describes the utilization of the different sources of fuel for lightning in Bomi and Montserrado households.



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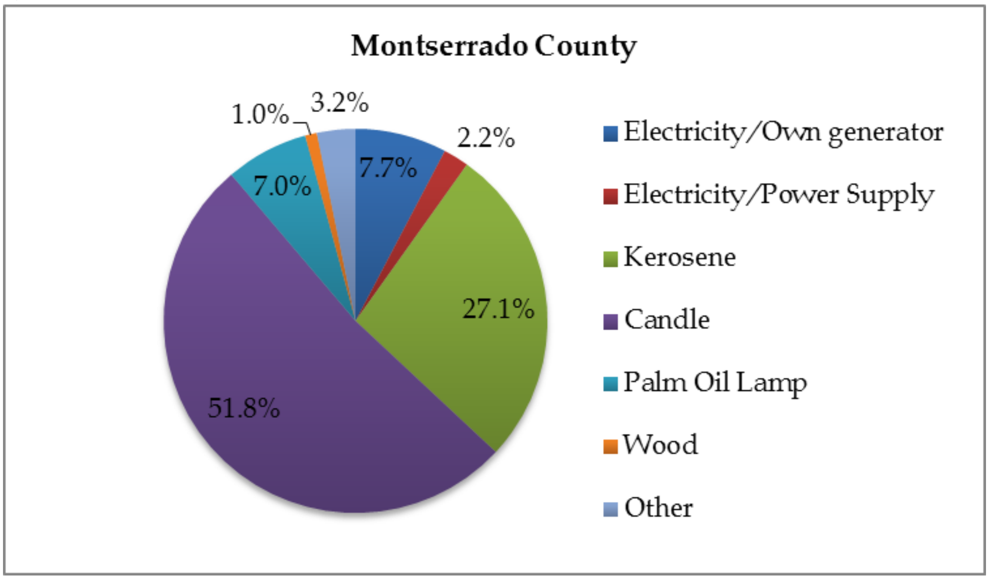

b)

Figure 5-23 Distribution of Households by Source of Fuel for Lighting in Grand Cape Mount (a), Bomi (b) and Montserrado (c) Counties in 2008 (adapted from 2008 Population and Housing Census)

5.3.9 Land Use Pattern

The territory and natural resources of Liberia face pressures from a number of competing sources, including forestry, mining, agriculture and human settlements with forests covering around 45% of the total land.[63] Land-use planning and zoning regulations are virtually non-existent. Consequently, land is not classified based on productivity.[64]

[63] UNEP, 2004.
[64] UNEP, 2004.

5.3.10 Cultural and Historically Significant Resources

Traditional and western lifestyles coexist. However, traditional values, customs, and norms influence the Western lifestyle characteristics considerably. In cities, both Western and African music and dancing styles are in vogue, but in rural areas traditional rhythms are favored. Schools instruct students in the legends, traditions, songs, arts, and crafts of African culture, and the government promotes African culture through agencies such as the National Museum in Monrovia and the Tubman Center for African Culture in Robertsport.

Africa's oldest republic, Liberia has a unique history that has always drawn foreigners to the small West African nation state. Africa's former "Grain Coast", has a wealth of mineral and natural resources, among which its virgin tourism industry represents a promising new source for economic and social development, including infrastructure development.

The Liberian culture is endowed with a wide variety of artisanal crafts that can be found anywhere across the length and breadth of the country, ranging from the intricately designed bamboo furniture to the well sculptured mahogany figurines depicting typical Liberian cultural themes.

6 IMPACT ASSESSMENT

This chapter considers the potential impacts that proposed project activities could have on the existing environment. Specifically, this chapter describes the following:

- Methodology (Section 6.1)
- Potential Impacts (Section 6.2)
- Identification of Potential Impacts (Section 6.3)
- Evaluation of Potential Impacts (Section 6.4)
- Data Gaps and Uncertainties (Section 6.5)

6.1 METHODOLOGY

6.1.1 Analysis of Impacts

To identify potential impacts, the EIA team used a two-tiered internationally applied methodology that incorporates lessons learned and best practices from sources in sanitation and solid waste management Industries.

6.1.1.1 Tier 1 - Evaluation of Hypothetical Impacts

Tier 1 starts by considering an extensive list of hypothetical impacts that may be faced by urban sanitation projects (See Section 6.3 below). A principal source of the global list of hypothetical impacts considered is documented in the World Bank Group Environmental, Health and Safety Guidelines on Environmental Waste Management[65] Using this list, the Project Team applied a set of simple criteria and/or questions to distinguish possible impacts related to the specific activities proposed from the global list of impacts. Criteria used for this first tier screening were:

- Are there sensitive resources relative to a hypothetical impact present in or around the study area? (For example, are there archaeological resources present?)
- Could the proposed activities reasonably have any influence in altering the present state (positively or negatively, and directly or indirectly) of conditions relative to the

[65] Environmental, Health, and Safety (EHS) Guidelines, General EHS Guidelines: Environmental Waste Management http://www.ifc.org/wps/wcm/connect/topics_ext_content/ifc_external_corporate_site/ifc+sustainability/our+approach/risk+management/ehsguidelines

hypothetical impact? (For example, could the proposed activities result in any change to socioeconomic conditions in communities in the local area?)

- Could the proposed activities reasonably be impacted by the conditions represented by the hypothetical impact? (For example, could existing meteorological conditions influence the project activities or other possible impact areas, such as increasing a risk of water/soil degradation?)

Having evaluated the global list and considered other possible impacts to physical, biological and/or socioeconomic conditions, based on the team's experience in evaluating the impacts of urban sanitation and solid waste management projects, a list of possible impacts was selected. These are reported in Section 6.3.

6.1.1.2 Tier 2- Evaluation of Potential Impacts

Once the Tier 1 screening was complete, a series of more specific (Tier 2) impact significance criteria was used to evaluate the severity and likelihood of the possible impacts and to characterize them in terms of the type of impacts expected (Figure 6-1). This Tier 2 evaluation took into consideration the nature of the impact, magnitude, physical extent, duration, reversibility, probability and potential cumulative effects of all proposed activities. The evaluation of potential impacts is reported in Section 6.4.

Significance criteria used to evaluate the possible impacts in Tier 2 are listed in Table 6-1, and criteria used to rate the likelihood of those impacts occurring in this project are presented in Table 6-2.

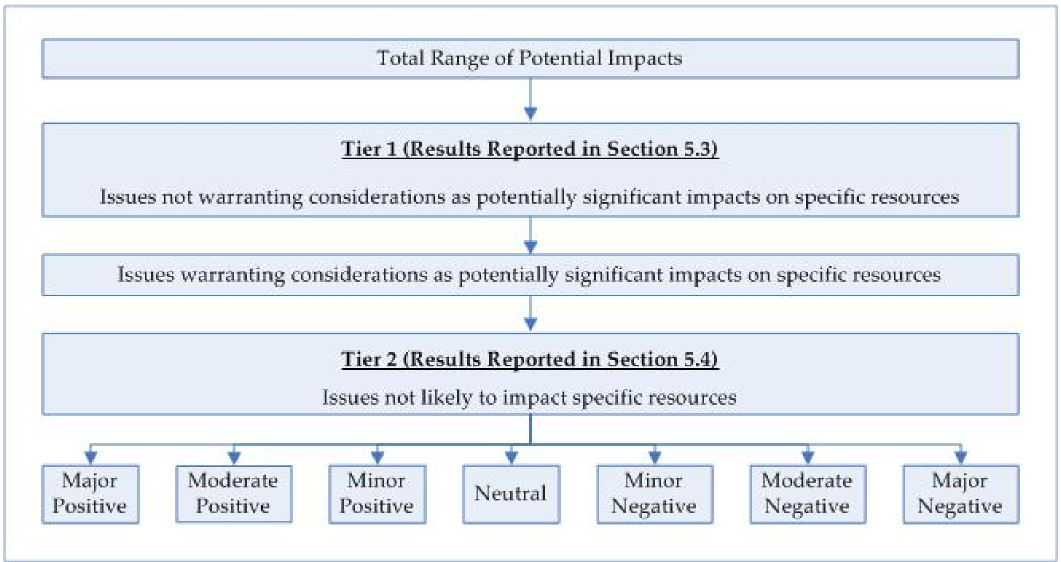

Figure 6-1 Impact Screening Technique Using 2-Tier Significance Criteria

Table 6-1 Impact Significance Criteria

CONSEQUENCE LEVEL	SIGNIFICANCE CRITERIA
Major (3)	**Employee Health and Safety:** One or more fatalities or life-threatening injuries/illnesses **Environmental and Social:** Widespread modification of extraordinary severity in physical environment or economic resources or social structure lasting more than one year, with an areal extent of impact > 1 percent of study area.
Moderate (2)	**Employee Health and Safety:** Injury requiring medical attention, or illness requiring long-term medical care or > 2 lost time instances for same or recurring incident/illness during phase of work **Environmental and Social:** Local modification of measurable severity in physical environment or economic resources, lasting from a few months to up to one year before recovery, with an areal extent of impact extending from 0.1 to 1 percent of study area; or more widespread modification of lesser severity.
Minor (1)	**Employee Health and Safety:** 1-2 lost time instances for same or recurring illness/injury **Environmental and Social:** Localized, relatively isolated change in physical environment or economic resources, lasting only a few days to a few months before recovery, with no observable residual effects; and with an areal extent extending from 0.01 to 0.1 percent of study area; impacts less significant than exerted by nature.
Negligible (0)	**Employee Health and Safety:** Negligible first-aid case (no lost time) or near miss **Environmental and Social:** Little or no change in physical environment, even temporarily, conditions consistent with background conditions.

Table 6-2 Impact Likelihood Criteria

LIKELIHOOD LEVEL	SIGNIFICANCE CRITERIA
Probable (3)	Impact or event can reasonably be expected to result from project, occur routinely for similar operations.
Occasional (2)	The impact or event has occurred in similar operations in this country/ region, or conditions could allow the impact/event to occur in the program.
Seldom (1)	The impact or event has occurred once or twice in the industry (worldwide), but conditions in this program are unlikely to allow the impact/event to occur.
Improbable (0)	The impact or event has never before occurred.

Using a standard, semi-quantitative assessment technique, the team applied a matrix to rate the overall impact significance by comparing the severity ranking with the likelihood ranking. This matrix is presented in Figure 6-2. This methodology allows the partitioning of the potential impacts by impact categories: high, medium and low. These categorizations facilitate the identification of the proposed activities that are likely to generate the most impact and the environmental elements that could be affected most. As shown in Figure 6-2, each impact category has distinct environmental management requirements, with:

- High: requiring alternative approach/design and mitigation to minimize potential impacts;
- Medium: requiring mitigation; and
- Low: requiring no mitigation other than common safeguards, but acknowledging that the Project Team needs to proceed with care.

Results of the Tier 2 impact evaluation are presented in Section 6.4 and environmental management and mitigation requirements are detailed in Chapter 7.

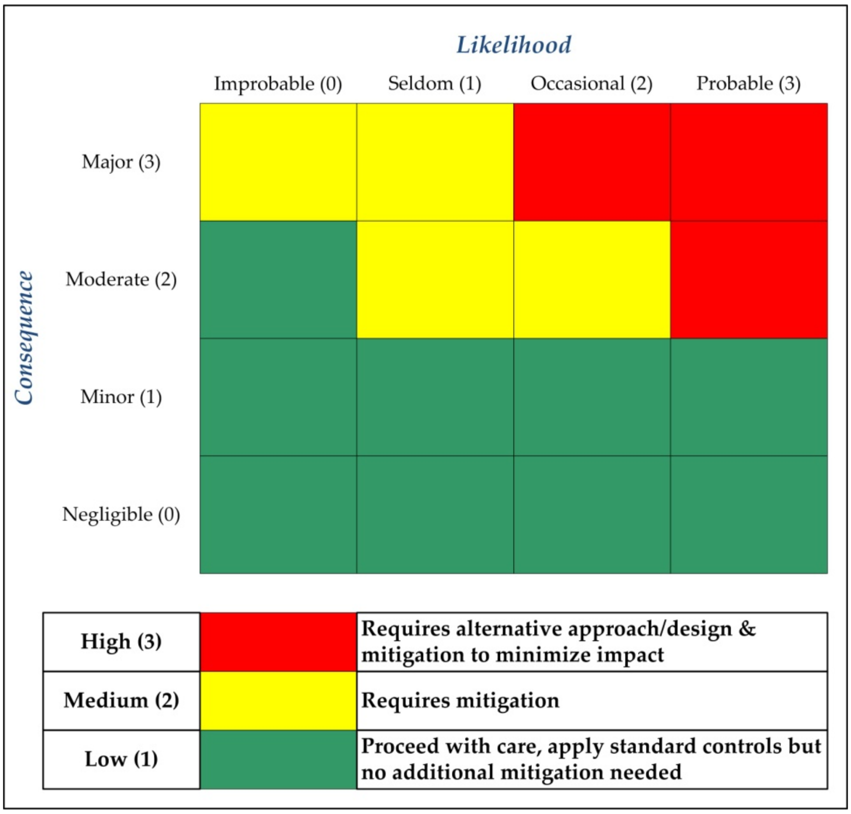

Figure 6-2 Impact Evaluation Matrix

6.2 Potential Impact

Chapter 3 described the project activities to be included in the Environmental Impact Assessment. These activities are defined according to the following Phases of the project:

1. Facility Construction and Site Preparation
2. Operation and Maintenance
3. Site Closure and Post-Closure activities

Analysis of the work proposed in each of these project elements revealed specific activities that could result in impacts. These potential impacts are highlighted in Sections 6.2.1 – 6.2.3 below.

6.2.1 Facility Construction and Site Preparation

Potential sources of impact identified in this phase are:

- Surface & groundwater quality

- Soil quality
- Air quality
- Health and Safety
- Noise
- Solid waste generation
- Landscape and visual intrusion
- Biological environment
- Landfill Stability
- Socio economics
- Traffic
- Cultural Heritage

6.2.2 Facility Operation and Maintenance

Potential sources of impact identified in this phase are:

- Surface and groundwater quality
- Soil quality
- Odors
- Air quality
- Health and Safety
- Noise
- Solid waste generation
- Landscape and visual intrusion
- Biological environment
- Landfill stability
- Socio economics

- Traffic

6.2.3 Facility Closure and Post-Closure activities

Potential sources of impact identified in this phase are:

- Surface and groundwater quality
- Soil quality
- Odors
- Air quality
- Health and Safety
- Landscape and visual intrusion
- Biological environment
- Landfill stability
- Socio economics

6.3 IDENTIFICATION OF POTENTIAL IMPACTS

As noted above, the EIA team used Tier 1 screening criteria to identify the possible impacts of proposed project activities. To do so, the team considered the possible effects of each potential source of impact identified in Section 6.2 on the baseline environmental and socioeconomic conditions of the affected environment.

The results of this screening revealed an inventory of possible impacts affecting various aspects of the physical, biotic, and social environment. Table 6-3 presents those impacts that have passed the Tier 1 screening as possible impacts that could result from the project activities (impact sources described above in Sections 6.2.1 – 6.2.3).

In Table 6-3, each potential impact has been assigned a ranking of impact consequence and likelihood. The ranking methodology and evaluation of each potential impact is discussed in Section 6.4. All potential impacts with a medium or high ranking will require mitigation to minimize potential impacts. Mitigation measures for each medium or high level impact in Table 6-3 are discussed in Chapter 7.

Table 6-3 Identification and Evaluation of Potential Impacts

Section	Source of Potential Impact	Affected Resource	Nature of Potential Impact	Intensity	Scope	Duration	Overall Consequence Level & Score	Likelihood Level and Score	Significance
Mobilization and Construction									
6.4.1.1	Stormwater runoff & accidental spills and leaks	Water Quality	Degradation of surface and groundwater	Reversible	Dispersed	Short-Term	**Moderate (2)**	**Occasional (2)**	**Medium**
6.4.1.2	Accidental Spills from equipment or mishandling of generated wastes	Soil Quality	Degradation of soil quality due to spills and mismanagement of wastes and of hazardous materials, or wastewater	Reversible	Localized	Short-Term	**Moderate (2)**	**Occasional (2)**	**Medium**
6.4.1.3	Soil Erosion	Soil Erosion Potential	Degradation of soil quality due to erosion	Irreversible	Localized	Short-Term	**Moderate (2)**	**Occasional (2)**	**Medium**
6.4.1.4	Generation of air emissions from soil movement, and combustion engines	Air quality	Degradation of local air quality due to emissions	Reversible	Localized	Short-Term	**Moderate (2)**	**Occasional (2)**	**Medium**
6.4.1.5	Site conditions or activities leading to accidents	Employees	Detrimental effect on employee safety due to injury or fatality from an accident	Irreversible	Localized	Long-Term	**Major (3)**	**Occasional (2)**	**High**
6.4.1.6	Noise from construction equipment and activities	Public/Employees	Disturbance/ injury and annoyance to public or employees	Irreversible	Localized	Short-Term	**Moderate (2)**	**Occasional (2)**	**Medium**
6.4.1.7	Generation of solid waste	Soil Quality, water quality, employee	Degradation of soil and water, effects on employee health	Reversible	Localized	Short-Term	**Moderate (2)**	**Occasional (2)**	**Medium**
6.4.1.8	Construction waste, traffic and activities	Landscape and Visual Amenity	Decrease in visual amenity	Reversible	Localized	Short-Term	**Minor (1)**	**Probable (3)**	**Low**
6.4.1.9	Landfill and site construction activities	Ecosystem and Biological Environment	Disturbance and Loss of Habitat	Irreversible	Localized	Short-Term	**Moderate (2)**	**Occasional (2)**	**Medium**
6.4.1.10	Site elevation increase during construction	Landfill stability	Employees	Reversible	Localized	Short-Term	**Major (3)**	**Seldom (1)**	**Medium**

Section	Source of Potential Impact	Affected Resource	Nature of Potential Impact	Intensity	Scope	Duration	Overall Consequence Level & Score	Likelihood Level and Score	Significance
6.4.1.11	Temporary labour influx can cause conflict	Public	Socio-economic conflict due to temporary labor influx	Reversible	Localized	Short-Term	**Moderate (2)**	**Occasional (2)**	**Medium**
6.4.1.11	Increased employment opportunities through creation of construction jobs	Public	Positive: Improvement of socio-economic situation	Reversible	Localized	Short-Term	**Minor (1)**	**Occasional (2)**	Low
6.4.1.12	Exposure to increased vehicle traffic	Public	Increased risk of accidents from vehicle traffic, nuisance from traffic flow increases	Reversible	Localized	Short-Term	**Moderate (2)**	**Occasional (2)**	**Medium**
6.4.1.13	Direct disturbance or Improper sourcing of fill material	Cultural Resources	Degradation of cultural resources	Irreversible	Localized	Short-Term	**Minor (1)**	**Seldom (1)**	Low
Operation and Maintenance									
6.4.2.1	Leachate, Liquid waste, landfill gas and domestic wastewater	Water Quality	Degradation of surface and Groundwater	Reversible	Dispersed	Long-Term	**Major (3)**	**Occasional (2)**	High
6.4.2.2	Accidental spills and leaks during operations, improper use of poor quality compost	Soil Quality	Degradation of soil	Reversible	Localized	Long-Term	**Moderate (2)**	**Occasional (2)**	**Medium**
6.4.2.3	Odors generated from waste and leachate	Public/Employees	Respiratory effects	Reversible	Dispersed	Long-Term	**Major (3)**	**Occasional (2)**	High
6.4.2.4	Generation of air emissions from the landfill, composting area, and combustion engines	Air Quality Public/Employees	Degradation of air quality/Respiratory and other health effects	Reversible	Dispersed	Long-Term	**Major (3)**	**Probable (3)**	High
6.4.2.5	Exposure to accidents and fire hazards, exposure to infectious diseases	Public/Employees	Detrimental effect on employee and public safety	Reversible	Localized	Long-Term	**Major (3)**	**Seldom (1)**	**Medium**
6.4.2.6	Exposure to noise from plant operations	Public/Employees	Detrimental effect on employee health and safety, public nuisance	Reversible	Localized	Long-Term	**Moderate (2)**	**Occasional (2)**	**Medium**

Section	Source of Potential Impact	Affected Resource	Nature of Potential Impact	Intensity	Scope	Duration	Overall Consequence Level & Score	Likelihood Level and Score	Significance
6.4.2.7	Generation of solid waste	Soil and Water Quality/Public	Degradation of soil and water quality, public nuisance	Reversible	Localized	Long-Term	**Moderate (2)**	**Occasional (2)**	**Medium**
6.4.2.8	Change in land use and operation activities	Landscape and Visual amenity	Detriment to visual amenity	Reversible	Localized	Long-Term	**Major (3)**	**Probable (3)**	**High**
6.4.2.9	Landfill operation processes and land use	Ecosystem and Biological Environment	Disturbance and Loss of Habitat, emission effects on flora and surface waters	Reversible	Localized	Long-Term	**Major (3)**	**Occasional (2)**	**High**
6.4.2.10	Landfill Settlement	Landfill stability	Public/Employees/landfill infrastructure	Reversible	Localized	Long-Term	**Major (3)**	**Occasional (2)**	**High**
6.4.2.11	Employment opportunities created for operations personnel	Public	Positive: Improvement of socio-economic situation	Reversible	Localized	Long-Term	**Moderate (2)**	**Occasional (2)**	**Medium**
6.4.2.12	Exposure to increased vehicle traffic	Public	Increased risk of accidents from vehicle traffic, nuisance from traffic flow increases	Reversible	Localized	Long-Term	**Moderate (2)**	**Occasional (2)**	**Medium**
Closure and Post Closure									
6.4.3.1	Leachate, runoff and landfill gas	Water Quality	Degradation of surface and Groundwater	Reversible	Dispersed	Long-Term	**Major (3)**	**Seldom (1)**	**Medium**
6.4.3.2	Accidental spills and leaks	Soil Quality	Degradation of soil	Reversible	Localized	Long-Term	**Minor (1)**	**Seldom (1)**	**Low**
6.4.3.3	Odours generated from waste and leachate	Public/Employees	Respiratory effects	Reversible	Dispersed	Long-Term	**Major (3)**	**Occasional (2)**	**High**
6.4.3.4	Generation of air emissions from the landfill	Air Quality Public/Employees	Degradation of air quality/Respiratory and other health effects	Reversible	Dispersed	Long-Term	**Major (3)**	**Occasional (2)**	**High**
6.4.3.5	Exposure to accidents and fire hazards, exposure to infectious diseases	Public/Employees	Detrimental effect on employee and public safety	Reversible	Localized	Long-Term	**Major (3)**	**Seldom (1)**	**Medium**

Section	Source of Potential Impact	Affected Resource	Nature of Potential Impact	Intensity	Scope	Duration	Overall Consequence Level & Score	Likelihood Level and Score	Significance
6.4.3.6	Land Use	Landscape and Visual amenity	Detriment to visual amenity	Reversible	Localized	Long-Term	**Minor (1)**	**Occasional (2)**	**Low**
6.4.3.7	Closure and post closure landfill chemical biological and physical processes	Ecosystem and Biological Environment	emission effects on flora and surface waters	Reversible	Localized	Long-Term	**Major (3)**	**Occasional (2)**	**High**
6.4.3.8	Landfill Settlement	Landfill stability	Public/Employees/landfill infrastructure	Reversible	Localized	Long-Term	**Major (3)**	**Occasional (2)**	**High**
6.4.3.9	Employment opportunities created for personnel, decrease in revenue to local region due to landfill closure	Public	Positive: Improvement of socio-economic situation	Irreversible	Localized	Long-Term	**Moderate (2)**	**Occasional (2)**	**Medium**

6.4 EVALUATION OF POTENTIAL IMPACTS

The possible impacts addressed in Section 6.3 were identified through the Tier 1 screening criteria described in Section 6.1.1. Tier 2 criteria were then used to evaluate and categorize the possible impacts. This evaluation resulted in a ranking of impact consequence (negligible, minor, moderate, major) and likelihood (improbable, seldom, occasional, probable) in order to define the overall impact rating (low, medium, or high). Impacts were also characterized in terms of other qualifying criteria, including:

- Positive or negative
- Short or long term
- Localized or dispersed

Where applicable, impacts were identified as unavoidable/avoidable, irreversible/ reversible, and able to be/not able to be mitigated.

Any impacts rated as low are considered acceptable and do not require mitigation beyond the standard operational and environmental controls that are already part of the standard methods used in similar programs.

6.4.1 Construction and Site Preparation

Impacts from construction operations and site preparation are described below. Most of the potential impacts are related to:

- Soil and construction material moving activities
- Potential discharges into the environment
- Traffic

6.4.1.1 Potential Impacts on Surface and Groundwater Quality

During facility construction and site preparation phase, the impacts on the surface and groundwater quality are relatively minor and limited to accidental chemical leakage or spillage resulting from concreting, painting, tarring, plastering, clearing, blasting, cleaning work and other similar activities along with the possibility of unintentional spillage of oils and other petroleum products. These impacts are confined to the relatively short period of construction and can be effectively mitigated.

Storm-water runoff from the construction sites can enter local surface waters overland or via the local drainage system. Construction activities such as excavation and earth moving increase the risk of soil erosion and contamination of storm-water runoff with sediment. Sediment-laden storm-water runoff can then enter surface waters and negatively impact the aquatic environment including its flora and fauna.

In addition to sediment, storm-water runoff can become polluted as a result of poor spill prevention procedures on-site. Portable latrines used temporarily on-site during the construction phase can also leak or overflow. Runoff polluted with hydrocarbons or domestic liquid effluent can further threaten aquatic ecosystems.

Impacts to water quality from the above can be described as negative, direct, temporary, intermittent, reversible, dispersed and short-term. The overall impact is moderate consequence and occasional likelihood and therefore described as Medium (C=2, L=2).

6.4.1.2 *Potential Impacts on Soil Quality*

During the facility construction and site preparation phase, potential sources of soil contamination include

- Unintentional spillage of oils and other petroleum products from machinery and equipment used in site preparation and land clearing; and
- accidental chemical leakage or spillage resulting from concreting, painting, tarring, plastering, clearing, blasting, cleaning, work and other similar activities.

Impacts of construction and site preparation phase on soil quality can be described as reversible, localized, temporary and short-term. The consequence would be moderate and likelihood occasional giving an impact evaluation of Medium (C=2, L=2)

6.4.1.3 *Potential Impact on Soil Erosion due to Soil Disturbance and Movement*

Construction activities such as excavation, earth movement and grading, and vegetation removal lead to an increased risk of soil erosion due to the resulting exposure of the soil surfaces to the rain and wind. Where the site is fairly level, there is less potential for erosion impacts with the planned activity.

The impact is projected to be negative, direct, temporary, intermittent, irreversible, localized and short-term. The overall impact is therefore described as Medium (C=2, L=2).

6.4.1.4 Impact on Air Quality

Facility construction and site preparation activities are usually associated with the release of high levels of PM generated from land clearing, excavation schemes, cut and fill operations and facility erection. In addition, air emissions from the use of construction equipment and vehicles on-site are expected to release vehicular induced pollutants (CO, NO_2, SO_2, PM and HC). Air emissions during the construction and site preparation phase are temporary in nature and tend to be confined to the immediate vicinity of the site. Owing to the random nature and short duration of construction activities, the negative impacts that may be associated with the degradation of ambient air quality in the vicinity of the construction site are expected to be minimal.

Air emissions from the above are expected to be limited due to the short duration of the activities. The impact is negative, direct, temporary, intermittent, reversible, localized and short-term. The impact is therefore described as having a moderate consequence and occasional likelihood and the overall impact is Medium (C=2, L=2).

6.4.1.5 Impact on Health and Safety

During the construction and site preparation phase, health and safety issues are mainly related to accidents resulting from the improper handling and storage of construction materials as well as accidents occurring with the operation of moving equipment and traffic. While the magnitude of this impact is difficult to quantify, adoption of proper occupational construction procedures are essential to minimize such risks. In this respect, specific health and safety guidelines for construction involved in construction projects should be adopted and stringently followed by the contractor.

In 2010, in the United States, there were 774 fatalities reported to the Bureau of Labor Statistics in the construction industry.[66] In Great Britain, in 2010/2011 there were 30 fatalities reported and 2289 major injuries. Table 6-4 presents the accidents that led to fatalities and major injuries.[67]

Table 6-4 Construction Incidents in 2010/2011 in Great Britain

Accident	Fatalities	Major Injuries
Contact with Moving Machinery	0	94
Hit by a Moving, Flying or Falling Object	4	322
Hit by a Moving Vehicle	8	67
Hit Something Fixed or Stationary	1	74
Injured while Handling, Lifting or Carrying	0	291
Slip, Trip or Fall on Same Level	0	627
High Fall Over 2 Meters	2	182
Low Fall up to and Including 2 Meters	2	413
Fall from Unknown Height	0	73
Trapped by Something Collapsing or Overturning	8	17
Exposed to or Contact with Harmful Substance	0	24
Exposed to Fire	0	4
Exposed to an Explosion		3
Contact with Electricity or Electrical Discharge	3	27
Physically Assaulted by Another Person	0	5
Other	2	66
Total	30	2289

The impact of an accident could potentially be Major (resulting in a fatality) but the likelihood of such an event is occasional but would be Seldom if correct procedures and mitigation measures are applied and followed. The impact is negative, direct, intermittent, irreversible, localized, and long-term. The overall impact is therefore described as High (C=3, L=1).

6.4.1.6 Impact on Noise

Facility construction and site preparation activities can be significant source of noise pollution with potential impacts on construction workers and nearby residents. The construction phase noise impacts are function of the excavation scheme and the machinery/equipment used on site. Typical construction activities associated with the construction of Cheesmanburg sanitary landfill include ground clearing, excavation, foundations, erection, and finishing. During this process various machinery and heavy equipment are used. The approximate noise generation level on site is expected to range between 75 dBA and 85 dBA based on typical values for these

[66] US Bureau of Labor Statistics, last accessed on October 22, 2012 at http://www.bls.gov/iif/.
[67]Health and Safety Executive (HSE – national independent watchdog for work-related health, safety and illness in Great Britain).Last accessed on October 22, 2012 at https://handson.hse.gov.uk/hse/public.

activities as represented in Table 6-5.

Table 6-5 Typical noise levels for various construction phases (USEPA, 1972 cited in Canter, 1996)

Phase	Sound Pressure Level dB(A)
Ground clearing	84
Excavation	79
Foundations	78
Erection	75
Finishing	75

According to WHO 1999, noise levels in an industrial zone during daytime should not exceed 70 dBA (Table 6-6). However, since the construction phase is generally short then adverse impacts are expected to be minimal.

Table 6-6 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

Impact as a result of noise is expected to be of limited scope and duration given the short-term nature of the construction activity. The consequence however, could be Moderate for some receptors and the likelihood of this consequence occurring is Occasional given that there will be heavy, noisy equipment in use throughout the construction period. The impact is negative, direct, irreversible, localized, and short-term. The overall impact is therefore described as Medium (C=2, L=2).

6.4.1.7 Impacts from Solid Waste Generation

Facility construction and site preparation activities are inherently associated with the generation of wastes. Possible wastes arising during the construction phase include excavated soil and rocks, construction waste[68], chemical waste and general refuse. The impact of the generated waste is dependent primarily on the management option adopted during the facility construction and site preparation phase.

Construction wastes pose adverse impacts if not well managed. The haphazard disposal of

[68] Wood from formwork and false work; Equipment and vehicle maintenance parts; Materials and equipment wrappings; Unusable/surplus concrete/grouting mixes/demolition waste/membranes

construction wastes may cause visual intrusion, increase health and safety risks as well as result in the degradation of the receiving environment and consequently decrease the property value. As such, it is important to allocate adequate disposal sites prior to the facility construction and site preparation phase. In addition, chemical wastes may be generated and may pose serious environmental, health and safety hazards if not properly stored and managed. Improper handling of chemical wastes can lead to toxic effects among exposed workers, adverse effects on air, water and land as a result of accidental spills, as well as fire hazards. Seepage of chemical wastes into the ground might also disrupt the soil, surface water as well as groundwater. It is difficult to quantify the amount of chemical waste from the construction and landfill expansion, as these amounts will be highly dependent on the contractor's on-site maintenance procedures and the number of equipment and vehicles utilized at any one time.

The presence of a construction site with an on-duty staff and site offices and canteens will result in the generation of a variety of general refuse requiring proper management. General refuse consists mainly of wastewater, food wastes, aluminum cans and waste paper, which can result in potential adverse environmental impacts. These include odor if the waste is not collected frequently, windblown litter, water quality impacts if the waste enters water bodies, and visual impact. The site may also attract pests and other disease vectors if waste storage areas are not maintained and cleaned regularly. In addition, disposal of wastes at sites other than approved landfills, can also lead to similar adverse impacts at those sites.

Impact as a result of solid waste generation during the construction phase is expected to be of limited duration given the short-term nature of the construction activity. The consequence however, could be Moderate for some receptors and the likelihood of this consequence occurring is Occasional given that there might be much waste generated due to excavation and other construction activities. The impact is negative, direct, reversible, localized, and short-term. The overall impact is therefore described as Medium (C=2, L=2).

6.4.1.8 Impacts on Landscape and Visual Amenity

During the facility construction and site preparation phase, landscape disturbance and visual intrusions are inevitable at the site particularly due to the presence of equipment, materials, soil heaps, and borrow pits. Such impacts are common to any construction site and are limited to the construction period. During this phase, visual impacts can be avoided if proper mitigation measures such as screening are implemented.

The impact on landscape and visual amenity from construction operations will be limited due to the restricted scope and short timeframe of construction operations. The impact is described as negative, direct, reversible, localized, and short-term. The Consequence is minor, and the likelihood probable. The overall impact is therefore described as Low (C=1, L=3).

6.4.1.9 Impact on Ecosystems and Biological Environment

During the facility construction and site preparation phase, the primary potential sources that may have effects on the biological environment include land-take or excavation and removal of vegetation. Potential sources of disturbance for the local biodiversity and loss of habitat may occur to a lesser extent due to litter blow, noise, exposure to gaseous emissions, accidental spillages and leakage, installation of roads, fences, drains, and various other construction activities.

An Ecological Assessment of the landfill site and surroundings was performed in November 2016 (Section 5.2). The survey studied the fauna and flora of the area and generated data for the following thematic areas:

- Vegetation and botanic characteristics found mostly to be farm bush at various stages of succession, farmlands, patches of closed forest mainly near local communities and gallery forest along the river.
- Mammals and Birds: mammals were found to be of low diversity of species and sparse distribution, and 122 Bird species were identified none of which appeared listed on the IUCN Red List 2016.
- Herpes (Reptiles and Amphibians); and
- Fish and Fisheries.

The Ecological Assessment found ten species of trees listed on the IUCN Red List 2016 as Vulnerable, three Species of Mammal (Vulnerable), three species of amphibians (Near Threatened) and four species of fish (1 Critically Endangered, 1 Vulnerable, and 2 Near

Threatened) .

Anecdotal information in the report indicates that in the proposed landfill site, the vegetation in most areas has been voluntarily left to fallow for between four and five years now, because of the fact that the area has been identified for the landfill project and all agricultural activities stopped by the authorities. The report concludes that based on the data generated and general observations, the core areas of the proposed landfill site do not have significant biodiversity entity of serious concern, and that impacts are expected to be minimal if appropriate control measures are implemented and will mainly occur in the patches of community forests around human settlements, the strips of gallery forests along the Po River, the creek running along the southeastern edge of the proposed landfill site and the swampy area within the northeastern side of the proposed landfill site.

The impact on the biological environment and ecosystems from construction operations will be limited due to the restricted scope, short timeframe, and baseline deforestation and degradation of site area location. The impact is described as negative, direct, irreversible, localized, and short-term. The Consequence is moderate, and the likelihood occasional. The overall impact is therefore described as Medium (C=2, L=2).

6.4.1.10 Land Stability

During the facility construction and site preparation phase, any planned increase in landfill height may be associated with landfill stability impacts. The impact will be limited by correct design and implementation of construction works.

The impact could potentially be major should injury occur to workers, but the likelihood of occurrence is seldom. The impact is negative, intermittent, direct, localized and short-term. The overall assessment is therefore Medium (C=3, L=1).

6.4.1.11 Socio Economic Impacts

Limited positive socio-economic impacts are associated with the construction and site preparation phase of the facility including temporary job opportunities in site preparation, facility construction and associated activities.

Although preference will be given to employ skilled and semi-skilled workers from the local communities, the main construction activities under this project will take place in a peri-urban area with limited supply of skilled workforce, and this will lead to additional workers being hired from areas outside the project communities.

Impacts resulting from this temporary labor influx include the following:

- Increased rates of criminal and illicit behavior including physical assault and gender based violence.
- Increased risk of spread of communicable diseases including HIV and Ebola Virus Disease
- Increased stress on local infrastructure including social, public and health services
- Increased volume of traffic and higher risk of accidents
- Increased social conflicts within the local community due to effect of outsider influence on local dynamics, and between the local and influx communities due to religious, cultural or ethnic differences.
- Price hiking of goods in the local area

Socio-economic impacts due to construction activities are expected to be of limited scope and duration given the short-term nature of the construction work, however, they can lead to negative social consequence where conflict due incoming labor workforce from outside areas does occur. The impact is negative, direct, reversible, localized, and short-term. The overall impact is therefore described as medium (C=2, L=2).

6.4.1.12 Impacts from Increased Traffic

Mobilization and Construction phase activities will lead to increased traffic to and from the site, thus increasing traffic flow in the local area. This will lead to an increase the risk of accidents in the local community as well as present the potential for nuisance from the increase or if the traffic presents delays to the public. Additionally, should the transport of equipment, material and construction debris in and out of the site not be secured correctly, there is a risk that this transported material could become a hazard and further increase the rates of accident and injury to the public.

The consequence of increased traffic to the public could be Moderate and the likelihood Occasional. High levels of traffic will likely fluctuate while different activities are performed. The impact is negative, direct, reversible, localized, and short-term. The overall impact is therefore described as Medium (C=2, L=2)

6.4.1.13 Impacts on Culture and Heritage

The site is not known to house any cultural heritage or archaeological remains; however, a chance find procedure is presented in Appendix E to set the steps to be followed in case of any new findings. This procedure should be must be scripted into all Contractor Contracts.

A new cemetery lies outside the site and could be impacted mainly by odor and air emissions. Careful sourcing of construction material is required so as not to impact cultural and heritage sites at the source.

The impact on construction and site preparation on culture and heritage sites is expected to be very limited due to the scope and timeframe of construction operations. The impact is negative, direct, intermittent, irreversible, localized and short-term. The overall impact is described as low (C=1, L=1)

6.4.1.14 Facility Operation and Maintenance

Impacts from Operation and Maintenance are described below. Most of the potential impacts are related to:

- Potential discharges into the environment
- Traffic

6.4.1.14.1 **Potential Impacts on Surface and Groundwater Quality**

During the operation phase, liquid waste and leachate occurrence is by far the most significant threat to ground and surface waters alike while subsurface gas migration and domestic wastewater may pose additional impacts.

Liquid waste can be generated from various sources during both operation and transportation activities including:

- Material Recovery Facility processing,
- Composting activities,
- Stored waste (exceeding the allocated storage area) during system failure or peak throughputs in unequipped, unpaved and unlined areas,
- Flushing water used in vehicle and facility cleanup activities and
- Haphazard disposal of the collected liquid waste from waste transportation vehicles. Surface water runoff that accidentally comes into contact with the facilities active areas will lead to excessive generation of liquid waste.

Leachate is generated during the landfilling process from liquid percolating through the waste and reacting with the products of decomposition, chemicals and other materials in the waste to produce the leachate.

Within the landfill site, once the leachate reaches the bottom of the landfill or an impermeable layer within the landfill, it either travels laterally to a point where it discharges to the ground's surface as a seep (or it will move through the base of the landfill into the subsurface formations if the landfill is unlined). Depending on the nature of these formations and in the absence of proper lining, drainage and collection systems, leachate has reportedly been associated with the contamination of aquifers underlying landfills as well as nearby surface water resources.

Leachate generation within the landfill is affected by several factors including

- Amount of rainfall,
- Site topography affecting the site's runoff pattern and the amount of water entering and leaving the site,
- Final landfill cover material which affects the amount of water percolating into the landfill,
- Vegetation cover which limits infiltration by intercepting precipitation directly and by taking up soil moisture and transpiring it back to the atmosphere, and
- Type of waste dumped in the landfill.

Typically organic material in solid waste is mainly responsible for most of the leachate generated in landfills. Leachate generation within the landfill is expected to be relatively small as the majority of the organic constituents from collected waste will be composted. Exposing organic/compostable materials to precipitation will also result in a marked increase in the leachate generation rate at the disposal site. However, any amount of generated leachate will present a major concern and therefore effective mitigation measures must be implemented to prevent any potential impacts on water resources.

The composition of landfill leachate can exhibit considerable spatial and temporal variations depending upon site operations and management practices refuse characteristics, and internal landfill processes. Refuse age and the corresponding landfill fermentation stage are usually major determinations of leachate composition. Many chemical compounds have been detected in landfill leachate. Table 6-7 summarizes the compositional range for a variety of leachates from landfills where only solid waste was deposited. Table 6-8 is indicative of the extent of the variation of leachate quality with landfill age. While it is difficult to generalize as to the concentration of a particular chemical in leachate at a specific time, in most cases, concentrations continually decrease with time, however, any amount of generated leachate represents a main concern, and it requires proper treatment prior to the discharge or reuse. Note that failing to line the landfill correctly and failure to treat the leachate to acceptable levels will result in surface and groundwater pollution.

Table 6-7 Chemical composition of leachate from solid waste (Source: EI-Fadel et al., 2002)

Parameter	Concentration Range mg/l
Alkalinity (as $CaCo_3$)	0 - 20,850
Aluminum	0.5 - 85.0
Antimony	0 - 3.19
Arsenic	0 - 70 .2
Barium	0 - 12 .5
Beryllium	0 - 0.36
Biochemical Oxygen Demand (BOD)	0- 195,000
Boron	0.413
Cadmium	5 - 4, 080
Calcium	11, 375
Chromium	0 - 22 .5
Chemical Oxygen Demand (COD)	0 - 89, 520
Conductivity (umho/cm)	480- 72,500
Copper	0 - 9. 9
Cyanide	0 - 6
Fluoride	0.1 - 1. 3
Hardness (as $CaCO_3$)	0.1 - 225,000
Iron	0 - 42,000

Parameter	Concentration Range mg/l
Lead	0 - 14.2
Magnesium	0 - 115,600
Manganese	0 - 05 - 1,400
Mercury	0 - 3
Organic halides	0 .320 - 3.5
Benzene	0.1 - 0.6
Ethyl benzene	0 - 4.9
Nitrogen (Ammonia)	0 - 1,250
Nitrogen (Nitrate)	0 - 9.8
Nitrogen (Nitrite)	0 - 1.46
Nitrogen (organic)	0 - 1,000
Nitrogen (Kjeldahl)	0 - 3 ,320
Nickel	0 - 7.5
Phenol	0. 17- 6.6
Phosphorus (Total)	0 - 234
Phosphate	0.01 - 154
pH	1.5 - 9.5
Potassium	0.16 - 3,370
Selenium	0 -1.85
Silver	0 - 1.96
Sodium	0 - 8,000
Thallium	0 - 0.32
Tin	0 - 0.16
Total Dissolved Solids (TDS)	584 - 55,000
Total Suspended Solids (TSS)	140,900
Total Organic Carbon (TOC)	335,000
Total Volatile Acids (TVA) (as Acetic Acid)	0 - 19,000
Turbidity	40 - 500
Sulfate	0 - 1,850
Zinc	0 - 1,000
Phenols	0 - 4
Toluene	0 -3.2

Table 6-8 Leachate concentration changes with landfill age (Farquhar, 1989)

Parameter (mg/l)	Landfill leachate age (yr)			
	0 - 5	**5- 10**	**10 - 20**	**>20**
BOD	10,000 - 25,000	1,000 - 4,000	50 - 1,000	< 50
COD	15,000 - 40,000	10,000 - 20,000	1,000 - 5,000	< 1,000
Nitrogen (Kjeldahl)	1,000 - 3,000	400 -600	75 - 300	<50
Nitrogen(Ammonia)	500 - 1,500	300 - 500	50 -200	< 30
TDS	10,000 - 25,000	5,000 - 10,000	2,000 - 5,000	< 1,000
pH	3 - 6	6 - 7	7 -7.5	7.5
Calcium	2,000 - 4,000	500 -2,000	300- 500	< 300
Sodium and Potassium	2,000 - 4000	500 - 1,500	100 - 500	< 100
Magnesium and Iron	500 - 1,5000	500 -1, 000	100 - 500	< 100
Zinc and Aluminum	100 - 200	50 - 100	10 - 50	< 10
Chloride	1,000 - 3,000	500 - 2,000	100 - 500	< 100
Sulphate	500 - 2,000	200 – 1,000	50 - 200	< 50
Phosphorous	100 - 300	10 - 100		< 10

The compost plant is an additional source of leachate that may result in environmental degradation if not properly managed. Another possible source of leachate includes stored collected solid waste (exceeding the allocated storage area) in unequipped parcels during system failure or peak throughputs.

Besides leachate, landfill gas contains trace constituents that present a groundwater pollution potential due to off-site subsurface mitigation. Several examples are documented in the literature on the presence of vinyl chloride and other volatile hydrocarbons in groundwater at distances away from municipal landfills.

Another potential source of contamination is Domestic wastewater from administrative offices and workers facilities including the toilets and kitchens if not properly collected and treated. Other minor impacts may result from the haphazard disposal of the collected leachate, 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.

In the design phase, the contractor shall estimate the amount of leachate to be collected and treated throughout the lifespan of the facility based on the final landfill layout, final height and climatic parameters.

The proposed location of the Cheeesemanburg sanitary landfill poses a significant threat on nearby surface waters as the facility will be located within seasonal rainwater drainage and course system of the Po River (and its related swamps). This situation may lead to the contamination of surface water in case of mismanagement or accidental events with the generated leachate/liquid waste and other contaminants. Consequently the risk of groundwater contamination is also considered relatively high, in the case where surface water is contaminated with leachate, or if correct landfill design parameters (especially with regards to the liner system and leachate drainage and treatment) are not followed.

Impacts to water quality from the above can be described as negative, direct, temporary, intermittent, reversible, dispersed and long-term. The overall impact could be Major if a large amount of contaminants enter surface or groundwater and the likelihood Occasional. The possible impact is therefore described as High (C=3, L=2).

6.4.1.14.2 Potential Impacts on Soil Quality

During the operation phase, leachate generated at the landfill may percolate and impact the soil quality in the case where no protective liner is used at the bottom and sides of the landfill. Other minor impact may result from:

- leachate generation from haphazard disposal of waste (exceeding the allocated storage area) during peak throughputs and equipped areas are not ready and
- Accidental spillage or mishandling of liquid waste collected from vehicles transporting waste as well as oil and lubricants generated from equipment maintenance workshops on-site.

Indirect impact on soil quality beyond the immediate site and its surrounding areas may result from improper generation and application of the generated compost. The generated compost can be used and applied as an amendment to enhance the physical, chemical, and biological proprieties of soils (Table 6-9). The production, application and/or disposal of compost not conforming to standards can adversely impact the soil quality and result in potential biological uptake and buildup of hazardous material in the environment.

Other smaller impacts may result from the haphazard disposal of the collected leachate from vehicles transporting waste, oil and lubricants generated from equipment maintenance workshop on-site.

Table 6-9 Positive impacts of compost applications to soils (Petts & Eduljee, 1994)

Enhancement Area	Properties
Physical Characteristics	• Enhance the soils’ water holding capacity • Enhance soil aeration • Enhance the soils’ structural stability • Increase the soils’ resistance to water and wind erosion • Promotes soil temperature stabilization • Helps in the root penetration process
Chemical Characteristics	• Increase macro- and micronutrient content. • Increase availability of mineral substances • Ensures the pH stability within the soil. • Provides a long-term source of nutrient input by acting as a nutrient reservoir. • Promotes nitrogen fixing
Biological Characteristics	• Promotes the activity of beneficial micro-organisms • Reduces attack by parasites • Promotes faster root development • Promotes higher yields of agricultural crops • Reduces reliance on pesticides, herbicides, and fungicides by providing and environment rich in organic matter whereby beneficial micro-

	organisms can out compete and suppress pests.

Impact on soil quality during operation and maintenance phase can be described as negative if contamination occurs, as well as positive (if compost generated of good quality and used correctly), intermittent, direct and indirect, localized and long term. The Consequence is moderate and the likelihood occasional. The overall impact is described as Medium (C=2, L=2).

6.4.1.15 Impact of Odour Generation

Odors are by far the most common cause of public complaint against waste management operations.

- **Landfill**

The operation and maintenance phases will be associated with significant potential odour impacts as a result of aerobic decomposition of freshly placed waste and anaerobic decomposition over a longer time scale within the waste body generated landfill gases. Odor generation is directly related to the landfill gas production constituents, such as waste composition, age of refuse, presence of oxygen, moisture content and temperature, carbon to nitrogen ratios, airflow control, volume as well as poor mixing. The odorous nature of the emitted gases may vary widely from relatively sweet to bitter and acrid depending on the concentration of the odorous constituents within the gas. The main landfill gas constituents that lead to odour generation include ammonia, non-methane organic compounds (NMOC), hydrogen sulfide and other sulfur compounds.

- **Sorting and Composting**

Odor generation from sorting and composting waste should not be a major concern under normal and proper facility operation and design. However improper handling of waste, facility mal-operation and inadequate composting process may result in significant odor impacts. This is due to the formation of anaerobic pockets during several stages: 1) piled wastes before their processing, 2) during the composting process, 3) as well as during the curing stage. These may lead to the generation of foul odors (resulting from the generation of H_2S, or other odorous gases including esters, organosulphurs, alkybenzenes, limonene, and other hydrocarbons). In general, odour generation is especially accentuated under conditions characterized by low carbon to nitrogen ratios, poor temperature and airflow control, excessive moisture, as well as poor mixing. The odorous nature of the emitted gases may vary widely from relatively sweet to bitter and acrid depending on the concentration of the odorous constituents within the gas. These concentrations will vary with waste composition and age, decomposition stage, rate of gas generation, and the nature of microbial populations within the waste, amongst other factors. The technology used in composting is an important parameter with respect to odor generation.

Another minor source of odor will result during the waste transportation process.

Prevailing winds in the site are an important factor in determining the impact of any odor generated from the facility on nearby residential areas. ***Monitoring shall be initiated to assess the dispersion of potential gas and odor emissions at the facility using an atmospheric dispersion modeling.***

Impact of operation and maintenance phase on odor generation and can result in a range of effect from mild annoyance and discomfort due to malodourous atmosphere to a more severe exacerbation respiratory illnesses in susceptible individuals. The impact is described as negative, intermittent, direct, dispersed and long term. The Consequence is major and the likelihood occasional. The overall impact is described as High (C=3, L=2).

6.4.1.16 Impact on Air Quality

During the operation and maintenance phase, gas emissions from the landfill and composting activities pose a significant impact on air quality. In addition, other air emissions sources during the operation phase include the machinery and combustion engines used on-site that may be 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.

6.4.2 Landfill

Landfill gas emissions may constitute significant impact on air quality. Landfill gas is composed of a mixture of hundreds of different gases with both principal and trace gases.

Table 6-10 indicates the typical composition in landfill gas and Table 6-11 indicates typical trace compounds found in landfill gas. In terms of principal gases, methane and carbon dioxide are the largest constituents by volume, in addition to small amounts of nitrogen, oxygen, ammonia, sulfides, hydrogen and carbon monoxide. In general, ambient methane concentrations ranging between 5 and 15 percent pose explosion hazards, while concentrations exceeding the 15 percent limit will result in fire risks. In addition, landfill related gases particularly volatile organic compounds are linked to a wide range of adverse human health impacts, while CO2, CH4, and other trace compounds are greenhouse gases (USEPA, 1995). In addition to impact on air quality, generated gases can precipitate or exacerbate respiratory illness in susceptible individuals.

Table 6-10 Landfill gas composition (Tchobanoglous et al., 1993; Mc Bean et al. 1995, USEPA, 1995)

Components	Percent
Methane	47.4
Carbon Dioxide	47.0
Nitrogen	3.7
Oxygen	0.8
Paraffin Hydrocarbons	0.1
Aromatic-cyclic hydrocarbons	0.2
Hydrogen	0.1
Hydrogen sulphide	0.01
Carbon Monoxide	0.1
Trace Compounds	0.5

Table 6-11 Trace compounds in landfill gas (Tchobanoglous et al., 1993; Mc Bean et al. 1995, USEPA, 1995).

Category of trace constituents	Concentration range mg/m^3
Alcohols	2 – 2,500
Organosulphur compounds	3 – 240
Halogenated Hydrocarbons	1 – 2,900
Aromatic Hydrocarbons	30 – 1,900
Aldehydes	0 – 200
Ketones	0 - 50
Esters	0 – 1,300
Ethers	0 - 250
Hydrocarbons:	
Alkanes	20 – 4,500
Alkenes	6 – 1,100
Cycloalkanes	1 – 1,000
Cycloalkenes	8 - 600

The three main processes that contribute to the production of landfill gases are:

1. *Bacterial decomposition:* Most landfill gas is produced by bacterial decomposition, which occurs when organic waste is broken down by bacteria naturally present in the waste and in the soil used to cover the landfill. Bacteria decompose organic waste in four phases, and the composition of the gas changes during each phase as indicated Figure 6-3.

2. *Volatilization:* Landfill gases can be created when certain wastes, particularly organic compounds, change from a liquid or a solid into a vapor through the process of volatilization.

3. *Chemical reaction:* Landfill gas, including NMOCs, can be created by the reactions of certain chemicals present in waste.

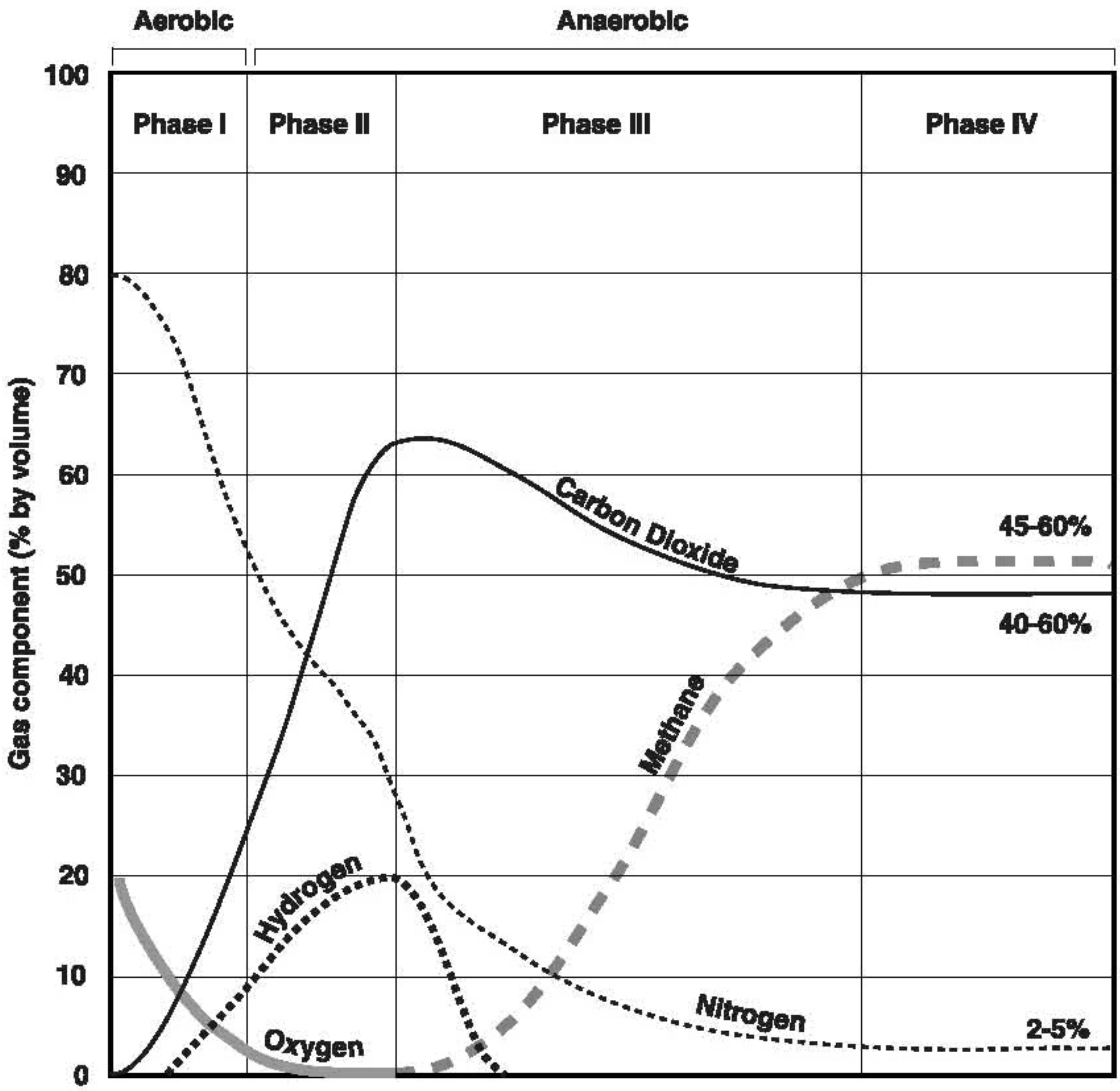

Figure 6-3 Production phases of typical landfill gas; Phase duration time varies with landfill conditions (Source: EPA, 1997)

The rate and volume of landfill gas expected to be produced at the Cheesemanburg sanitary landfill will depend on various waste characteristics and environmental factors including:

- *Waste composition:* the more organic waste present in a landfill, the more landfill gas is produced by the bacteria during decomposition. The more chemicals disposed of in the landfill, the more likely NMOCs and other gases will be produced either through volatilization or chemical reactions.
- *Age of refuse:* generally, recently buried waste produces more landfill gas through bacterial decomposition, volatilization, and chemical reactions than older waste (buried more than 10 years). Peak gas production usually occurs from 5 to 10 years after the waste is buried.
- *Presence of oxygen in the landfill:* Methane will be produced only when oxygen is no longer present in the landfill.
- *Moisture content:* the presence of moisture at unsaturated conditions increases gas production because it encourages bacterial decomposition. Moisture may also promote chemical reactions that produce gases.
- *Temperature:* as the landfill's temperature rises, bacterial activity increases, resulting in increased gas production. Increased temperature may also increase rates of volatilization and chemical reactions.

In general, organic material in solid waste is mainly responsible for most of the gas generated in landfills. Therefore the organic constituents of the collected solid wastes must be diverted from the landfill to a compost facility.

6.4.3 Composting

The operation of the composting unit may result in the emission of several air pollutants mostly generated as a result of the decomposition of the organic matter. During the aerobic digestion process, improper aeration may cause colonies of anaerobic bacteria to flourish thus releasing methane (CH_4), carbon dioxide (CO_2) and hydrogen sulfide (H_2S) or other sulfur-containing constituents. Other air emissions sources during the operation phase include the machinery and combustion engines used on-site. In general, ambient methane concentrations ranging between 5 and 15 percent pose explosion hazards, while concentration exceeding the 15 percent limit will result in fire risks.

The operation of the landfill facility will also be associated with possible gaseous emissions resulting from the combustion of fossil fuel from combustion engines in equipment and vehicles. Typical air pollutants that are expected to be emitted include CO, PM, SO2, NO2, along with HC.

Impact of operation and maintenance phase on air quality and can result in a range of effects locally due to noxious gas generation which may exacerbate respiratory illness in susceptible individuals or may be carcinogenic upon long term exposure. In addition the landfill will generate greenhouse gasses contributing to global warming. The impact is described as negative, intermittent, direct, dispersed and long term. The Consequence is major and the likelihood probable. The overall impact is described as High (C=3, L=3).

6.4.3.1 Impact on Health and Safety

Proper operations of the Cheesemanburg sanitary landfill and its facilities are expected to reduce health risks associated with the open unsanitary disposal of wastes that promotes the breeding of disease vectors and pests as well as the contamination of groundwater, surface water and soil which all lead to an increase in the incidences of parasitic infections, hepatitis, malaria, plague along with gastrointestinal disease including cholera and typhoid.

However, during the operation and maintenance phase, improper handling of waste and leachate from the landfill may lead to occupational hazards ranging from skin rashes to serious dermatological diseases to employees, and an increase in vermin such as rats and disease vectors such as mosquitoes affecting the local area.

The disposal of medical waste, industrial and hazardous construction wastes (such as asbestos), as well as slaughter-house and other hazardous waste without prior treatment may jeopardize the health and safety of workers (as well as potentially damage the landfill due corrosive leachate quality; degradation of liner system, leachate collection system, gas extraction wells;

damaging leachate treatment plants; contamination; infection; etc.).

Methane generation may pose serious fire and explosion risks if not well managed. In fact, methane has often been considered as a liability because of its flammability, its ability to form explosive mixtures with air, and its tendency to migrate away from the landfill boundaries by diffusion and advection. It is generally characterized by moving along routes that will allow it to escape from the landfill either by venting through the cover or by moving through the sides to the surrounding soil. The migrating gas finds its way into buildings and underground facilities erected on, or nearby to, a landfill site where it forms gas pockets and creates potential fire or explosive hazards. Depending on the soil characteristics, the gas may travel long distances away from the landfill prior to being discovered. As such, numerous incidents of fires and explosions due to lateral gas migration away from landfills have been reported in the literature. On-site fires may also occur in the subsurface due to air entrainment into the landfill and the formation of a mixture of methane and oxygen that can sustain a fire. In general, ambient methane concentrations ranging between 5 and 15 percent pose explosion hazards, while concentrations exceeding the 15 percent limit will result in fire risks. Note that landfill methane formation and associated risks will be minimized due to the introduction of separation/composting in the overall waste management scheme.

Furthermore, the lack or improper training of the staff in charge of the operation and maintenance could expose them to adverse health risks. In addition, the adoption of manual sorting and the presence of mechanical equipment may expose the workers to sharp objects, fans, as well as fire and explosion risks. Uncontrolled access to the facility may result in various hazards. Table 6-12 summarizes those occupational health risks typically associated with landfills.

Table 6-12 Different Occupational Health Risks Associated with landfills' operations

Type of Hazard	Source
Fire and Explosion Risk	▪ Methane generation
Incidences of parasitic Infections, Hepatitis, Malaria, Plague along with gastrointestinal disease, Cholera and Typhoid	▪ Breeding of disease vectors and pests ▪ Contamination of groundwater, surface water and soil
Skin rashes, Serious dermatological diseases and injury	▪ Improper handling of waste and leachate
Dust Inhalation	▪ Particularly during construction phase
Noise Pollution	▪ Using of mechanical equipment
Other	▪ Process activities involving the use of

	equipment ▪ Improper training

The impact of the operation and maintenance phase on health and safety can range from mild injuries or afflictions to serious detrimental risk to health both acute and chronic in nature. A positive impact will be reduction of the previous health risk levels which occurred due to unsanitary disposal of waste. The overall impact is reversible, negative, intermittent, direct, reversible and long-term. The Consequence can be Major should a serious fire incident or injury occur for example, but the likelihood is assessed as Seldom should design features, training, and mitigation measures be applied correctly. The overall impact is thus assessed as Medium (C=3, L=1).

6.4.3.2 *Impact of Noise*

The operational phase is associated with noise generation from the operation of various machinery/equipment, generators as well as loading and unloading activities that may have impact on the workers and nearby residential communities. The project area does not fall in any existing community, but it is surrounded by several communities such as Brown Town, Dolela, Lolela, Dimei and Gbonjama.

Work areas with increased noise level require that employees to wear personal protective equipment and adhere to mitigation procedures in designated high noise areas to avoid hearing damage and loss.

In addition to the noise generating activities at the site proper, the circulation of solid waste collection trucks and/or pickups may cause noise nuisance depending on the circulation schedule.

Impact from operation activities as a result of noise generation is expected to be of limited scope but of long duration given the life expectancy of the project. The consequence of noise impact is Moderate and the likelihood Occasional. The impact is negative, direct, reversible, localized, and long-term. The overall impact is therefore described as Medium (C=2, L=2)

6.4.3.3 *Solid Waste Generation /Management*

During the operation phase, the facility is expected to process the collected waste into three final products namely: 1) the compost, 2) the recyclables, and 3) the inert materials and remaining refuse. While the proposed operation plan stipulates that only the latter will be disposed of in the sanitary landfill, the compost may also be used as a soil cover particularly when generation surpasses demand or when the compost quality does not meet the EPA criteria for land application. Similarly, some recyclables may be disposed of in the landfill in case no market develops for their end-use. During system failure or peak throughputs, incoming wastes may exceed the allocated storage area thus leading to storage in unequipped parcels that may lead to groundwater, surface water, soil, odor, and health and safety risks.

The likelihood of exceeding solid waste allocations will be Occasional mainly when input exceeds operation process abilities to cope with incoming volumes of waste, and the consequence Moderate. The impact is negative, direct, reversible, localized, and long-term. The overall impact is therefore described as Medium (C=2, L=2).

6.4.3.4 Impact on Landscape and Visual Intrusion

During operation and maintenance phase, visual impacts may arise from the open storage of wastes, open landfill cells, composting additives and transport trucks as well as from the facility itself. The Cheesemanburg sanitary landfill has significant impact on the landscape by causing disruption of the natural landscape in the area. The site can be easily viewed from the main road or from higher altitudes, as such proper screening of the site is necessary to avoid impacts.

The impact on landscape and visual amenity from operations will be significant due to major change in land use and long timeframe of operations. The impact is described as negative, direct, reversible, localized, and long -term. The Consequence is major, and the likelihood probable. The overall impact is therefore described as High (C=3, L=3).

6.4.3.5 Impact on Ecosystem and Biological Environment

During the operation phase, in addition to potential impacts on the fauna due to direct loss of habitat, flora damage at or nearby sites may also occurs primarily due to oxygen deficiency in the root zone which is caused by direct displacement of oxygen by landfill gas. In the absence of gas control measures, landfill gas can migrate upward due to concentration and pressure gradients, and escape into the atmosphere by venting through the landfill cover. During this process, oxygen is displaced and plant roots are exposed to high concentrations of methane and carbon dioxide, the two major constituents of landfill gas. The lack of oxygen causes the death of plants by asphyxia. In addition improper dumping of immature compost will result in methane generation.

Direct exposure to methane may not affect the growth of plants but methane oxidation near the surface by methane-consuming bacteria (methanotrophs) is an additional factor that contributes to oxygen deficiency. Heat release during methane oxidation increases the soil temperature creating the potential for plant asphyxia. Carbon dioxide generation from methane oxidation and landfill gas can be harmful to plant growth particularly at high concentrations (30 to 45 percent). Other commonly reported factors that may affect growth of plants at landfill sites include the presence of trace toxic compounds in landfill gas and cover soil characteristics such as thickness, composition, compaction and moisture.

Surface water bodies such as the Du Creek and local swampland may be affected by contaminated surface runoff. 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 impact on Ecosystems and Biological Environment from operations will be significant if emissions from the site are not well controlled. The impact is described as negative, direct, reversible, localized, and long -term. The Consequence is major, and the likelihood occasional. The overall impact is therefore described as High (C=3, L=2).

6.4.3.6 Landfill stability and Settlement

Settlement in landfills can be caused by several processes including: 1) refuse dissolution into leachate, 2) incomplete waste compaction, 3) movement of smaller particles into larger voids created by biological and physico-chemical changes, and subsurface fires and 4) consolidation or mechanical compression due to the refuse thickness, own weight, load of construction material and structures erected on the landfill.

Long term settlements due primarily to refuse decomposition can theoretically reach 40 percent of the original thickness and occur gradually for several years after closure at a continually decreasing rate depending on stabilization process within the landfill (Edil et al, 1990, Frantzis, 1991). It has been found that 90 percent of the total settlement occurs within the first five years and in dry climates this rate is usually less (Tchobanoglous et al., 1993). Total settlements increase with the percentage of decomposable materials in solid waste. Conversely, increasing amounts of inert material tends to decrease settlements to lower magnitudes. Decomposition is strongly dependent upon moisture conditions and landfill operating procedure. Figure 6-4 provides a general illustration of landfill settlement for solid waste over time.

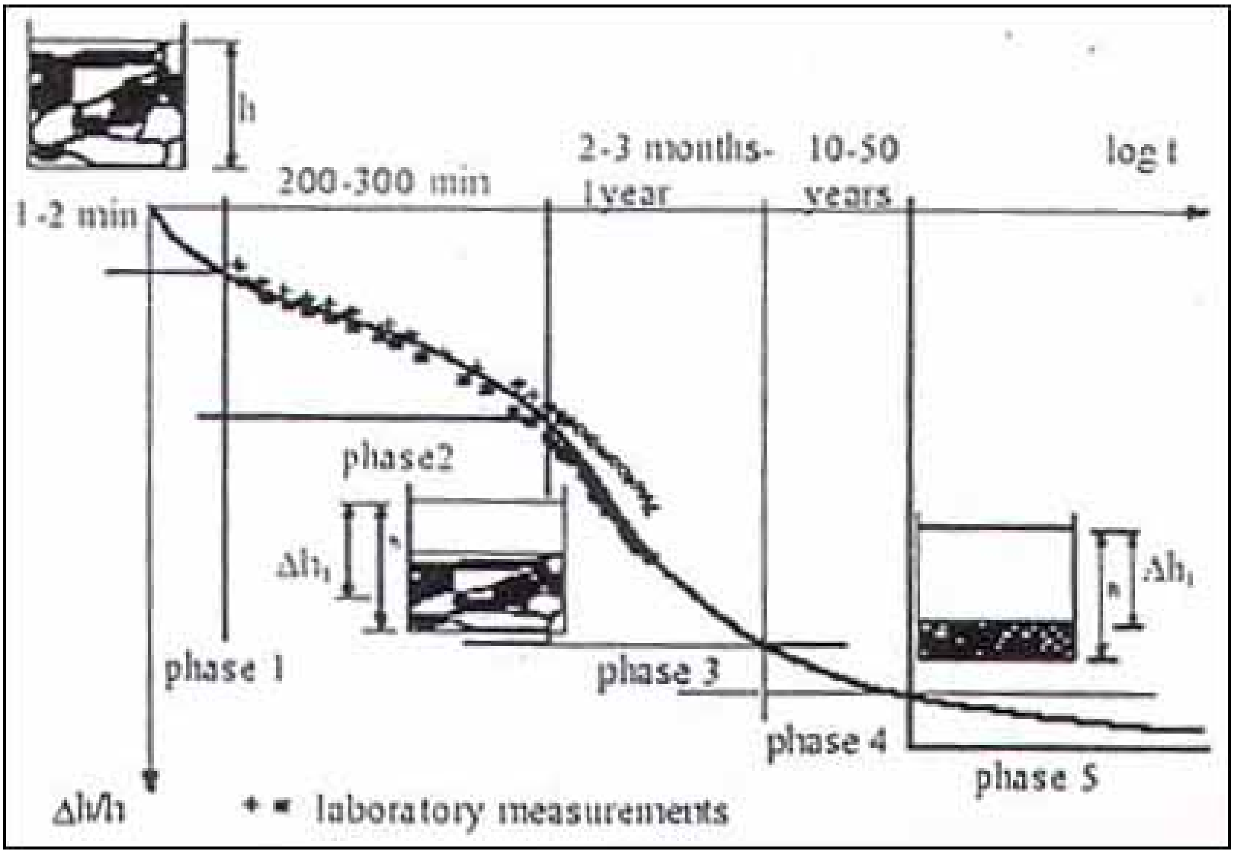

Figure 6-4 General Compression Curve for Solid Waste (Source: Manassero et al., 1996)

During the operation phase, development of the completed landfill site is invariably hindered by significant settlements caused primarily by refuse decomposition, which increases the void ratio and weakens the structural strength of the refuse within the landfill leading to a substantial loss of volume and settlement. Other causes of landfill settlement include refuse dissolution into leachate; incomplete waste compaction; movement of smaller particles into larger voids created by biological and physico-chemical changes, and subsurface fires (raveling); consolidation or mechanical compression due to the refuse thickness and own weight, and the load of construction material and structures erected on the landfill.

The rate and magnitude of landfill settlement depends primarily on the refuse composition, operational practices and factors affecting biodegradation of landfill waste particularly moisture. Estimation of the total settlement in a landfill ranges between 25 and 50 percent of the original thickness. Operation and load-related settlements typically constitute 5 to 30 percent of total settlement and occur during landfill operations or shortly after closure.

Landfills often exhibit great variations in waste composition resulting in a non-uniform settlement pattern. This creates differential settlements which can have a devastating effect on the integrity of any structure erected on the landfill, or infrastructure running through it. Structural failures of buildings, surface cracks in the final cover, damage to the surface water drainage system, piping of leachate and gas collection systems, and underground utilities are commonly attributed to differential settlements. Besides variations in waste composition, changes in the manner in which the waste is placed or compacted, localized ravelling, vertical loads, and subsurface fires contribute to differential settlements as well. Operational and maintenance practices (sorting, pre-treatment, uniform compaction) can minimize problems associated with both total and differential settlements.

Other less significant hazards include erosion potential after site closure and settlement due to consolidation and biodegradation of organic material. Both erosion and settlement hazards can be mitigated with an appropriate site management plan.

The impact of the landfill operations on stability will be significant especially if site processes are not well designed and operated, land settlement not correctly anticipated, and mitigation and monitoring measure not implemented fully. The impact is described as negative, direct, irreversible, localized, and long -term. The Consequence is major, and the likelihood occasional. The overall impact is therefore described as High (C=3, L=2).

6.4.3.7 Impact on Socio-Economics

During the operation phase, the facility will have many indirect positive socio-economic benefits to the local community. These benefits include providing compost at low prices, and generating additional revenue resulting from the sale of the compost and recovered recyclables (assuming a market is established). In addition direct impact can occur when preference will be given to train and employ skilled and semi-skilled workers from the local communities.

However, possible negative impacts include a drop in the land value in the area particularly during the construction and operation phases, limitation of agricultural and recreational activities in the direct vicinity of the facility as well as the perception of being exposed to health risks, which may lead to psychological stress, and attraction of scavengers. Table 6-13 describes general examples of potential social and economic impacts of a landfill site.

Table 6-13 Potential socio-economic impacts at a landfill (Petts & Eduljee, 1994)

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 • Reduction in waste transport costs to local communities	• Loss of agricultural income • Decrease in property value • Perception of pollution-sensitive individuals leading to out-migration • Deterrent to inward investment • Impact upon tourist or recreational income
Social	• Indirect beneficial community impacts from employment and provision of skilled workforce • Provide contracts for scavengers	• Decreased level of resident satisfaction with character and amenity of area • Perception of risk leading stress • Out-migration leading to reduced social cohesion in small communities • In-migration of temporary construction workforce • Risks of occupational and environmental health issues associated with waste scavenging.

6.4.3.8 Traffic

During the operational phase, the facility will result in significant impacts on the traffic flow along nearby highways as well as access roads where the majority of the waste transportation vehicles will converge. In addition, traffic impacts are expected along secondary and tertiary roads, depending on the collection schedule and routing. These impacts include a marked increase in congestion, noise, and air pollution.

The consequence of increased traffic to the public could be Moderate and the likelihood Occasional. The impact is negative, direct, reversible, localized, and short-term. The overall impact is therefore described as Medium (C=2, L=2)

6.4.4 Closure and Post-Closure

Landfill closure and post-closure activities involve three major design elements:

- Slope stability
- Drainage
- Gas control

Impacts from the closure and post-closure phase are described below.

6.4.4.1 Impacts on Water Quality

During the closure and the post-closure phase, leachate occurrence is the most significant threat to ground and surface waters, while subsurface gas migration may pose additional impacts. Post closure final cover design and runoff and drainage and control systems will decrease the risk of impacts on surface and groundwater quality, as will continued leachate control and treatment, continued control of generated landfill gas, and post-closure environmental monitoring.

Impacts to water quality from the above can be described as negative, direct, temporary, intermittent, reversible, dispersed and long-term. The overall impact could be Major if a large amount of contaminants enter surface or groundwater and the likelihood seldom. The impact is therefore described as Medium (C=3, L=1).

6.4.4.2 Impacts on Soil Quality

At closure, impacts on surrounding environmental soil quality are not expected to be significant unless the liner system fails. Landfill soil will continue to mature for several decades due to physical, chemical and biological processes.

The impact of closure and post closure activities on soil quality assuming no liner system failure occurs are described as of Minor consequence and Seldom likelihood for occurrence. The overall impact is negative, reversible, intermittent, localized and long-term. The Impact is thus described as Low (C=1, L=1).

6.4.4.3 Impact from Odors

The closure and post-closure phases will be associated with significant potential odor impacts as a result of aerobic decomposition of waste and anaerobic decomposition over a longer time scale within the waste body generated landfill gases. Odor generation is directly related to the landfill gas production constituents, such as waste composition, age of refuse, presence of oxygen, moisture content and temperature, carbon to nitrogen ratios, airflow control, volume as well as poor mixing. The odorous nature of the emitted gases may vary widely from relatively sweet to bitter and acrid depending on the concentration of the odorous constituents within the gas. The main landfill gas constituents that lead to odor generation include ammonia, non-methane organic compounds (NMOC), hydrogen sulfide and other sulfur compounds.

Prevailing winds in the site are an important factor in determining the impact of any odor generated from the facility on nearby residential areas. Monitoring shall be initiated to assess the dispersion of potential gas and odor emissions from the site post-closure.

Impact of closure and post-closure phase on odor generation and can result in a range of effect from mild annoyance and discomfort due to malodourous atmosphere to a more severe exacerbation respiratory illnesses in susceptible individuals. The impact is described as reversible, negative, intermittent, direct, dispersed and long term. The Consequence is major and the likelihood occasional. The overall impact is described as High (C=3, L=2).

6.4.4.4 Impacts on air quality

Landfill gas emissions may constitute significant impact on air quality during the closure and post closure phase. Landfill gas is composed of a mixture of hundreds of different gases with both principal and trace gases. Table 6-10 (in section 6.4.2.4) indicated the typical composition in landfill gas and Table 6-11 indicated typical trace compounds found in landfill gas. In terms of principal gases, methane and carbon dioxide are the largest constituents by volume, in addition to small amounts of nitrogen, oxygen, ammonia, sulfides, hydrogen and carbon monoxide. In general, ambient methane concentrations ranging between 5 and 15 percent pose explosion hazards, while concentrations exceeding the 15 percent limit will result in fire risks. Landfill related gases particularly volatile organic compounds are linked to a wide range of adverse human health impacts, while CO_2, CH_4, and other trace compounds are greenhouse gases (USEPA, 1995).

The rate and volume of landfill gas expected to be produced at the Cheesemanburg sanitary landfill will depend on various waste characteristics and environmental factors including waste composition, age of refuse, presence of oxygen, moisture content, and temperature. In general, organic material in solid waste is mainly responsible for most of the gas generated in landfills.

Impact of operation and maintenance phase on air quality and can result in a range of effect from mild annoyance and discomfort due to malodourous atmosphere to a more severe exacerbation respiratory illnesses in susceptible individuals. The impact is described as negative, intermittent, direct, dispersed and long term. The Consequence is major and the likelihood occasional. The overall impact is described as High (C=3, L=2).

6.4.4.5 Health and Safety

During the closure and post-closure phase, improper handling of buried waste and generated leachate from the landfill may lead to occupational hazards ranging from skin rashes to serious dermatological and other diseases to employees.

Methane generation may pose serious fire and explosion risks if not well managed. In fact, methane has often been considered as a liability because of its flammability, its ability to form explosive mixtures with air, and its tendency to migrate away from the landfill boundaries by diffusion and advection. It is generally characterized by moving along routes that will allow it to escape from the landfill either by venting through the cover or by moving through the sides to the surrounding soil. The migrating gas finds its way into buildings and underground facilities erected on, or nearby to, a landfill site where it forms gas pockets and creates potential fire or explosive hazards. Depending on the soil characteristics, the gas may travel long distances away from the landfill prior to being discovered. As such, numerous incidents of fires and explosions due to lateral gas migration away from landfills have been reported in the literature. On-site fires may also occur in the subsurface due to air entrainment into the landfill and the formation of a mixture of methane and oxygen that can sustain a fire. In general, ambient methane concentrations ranging between 5 and 15 percent pose explosion hazards, while concentrations exceeding the 15 percent limit will result in fire risks. Note that landfill methane formation and associated risks will be minimized due to the introduction of separation/composting in the overall waste management scheme during the previous operation phase.

Furthermore, the lack or improper training of the staff in charge of the closure and post-closure phase could expose them to adverse health risks.

The impact of the closure and post-closure phase on health and safety will mainly be due to the risks from methane gas. Correct management of the post-closure maturing landfill and correct post closure land-use assignation design are essential steps in this process.

The overall impact is negative, intermittent, direct, reversible and long-term. The Consequence can be Major should a serious fire incident or injury occur for example, but the likelihood is assessed as Seldom should design features, training, and mitigation measures be applied correctly. The overall impact is thus assessed as Medium (C=3, L=1).

6.4.4.6 Impact on Landscape and Visual Intrusion

After proper closure of the site, the effects on the landscape are typically minimal and will become positive as the land is re-vegetated, and particularly if the landfill site is later converted to a park, botanic garden, or recreational area in the later post-closure stages. Various predictive imaging methods (sketches, sight-line analysis and cross sections, view shed maps, photomontages, 3-D wire line drawings, 3-D scale models, computer modeling and/or the application of a geographic information system) can be applied to assess landscape and visual impacts after closure.

A minimal negative impact on landscape and visual intrusion may later become positive if post closure plans include conversion the local site to public use. The Impact is described as negative, reversible, continuous, localized, and long-term. The consequence is Minor, and likelihood Occasional. The impact is therefore described as Low (C=1, L=2).

6.4.4.7 Impact on Ecosystem and Biological Environment

During the closure and post closure phase, in addition to potential impacts on the fauna due to direct loss of habitat, flora damage at or nearby sites may also occurs primarily due to oxygen deficiency in the root zone which is caused by direct displacement of oxygen by landfill gas. In the absence of gas control measures, landfill gas can migrate upward due to concentration and pressure gradients, and escape into the atmosphere by venting through the landfill cover. During this process, oxygen is displaced and plant roots are exposed to high concentrations of methane and carbon dioxide, the two major constituents of landfill gas. The lack of oxygen causes the death of plants by asphyxia. In addition improper dumping of immature compost will result in methane generation.

Direct exposure to methane may not affect the growth of plants but methane oxidation near the surface by methane-consuming bacteria (methanotrophs) is an additional factor that contributes to oxygen deficiency. Heat release during methane oxidation increases the soil temperature creating the potential for plant asphyxia. Carbon dioxide generation from methane oxidation and landfill gas can be harmful to plant growth particularly at high concentrations (30 to 45 percent). Other commonly reported factors that may affect growth of plants at landfill sites include the presence of trace toxic compounds in landfill gas and cover soil characteristics such as thickness, composition, compaction and moisture.

Surface water bodies such as the Du Creek and local swampland may be affected by contaminated surface runoff. 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 impact on Ecosystems and Biological Environment from closure and post closure activities will be significant if emissions from the site are not well controlled, though the impact will gradually decrease over time. The impact is described as negative, direct, reversible, localized, and long -term. The Consequence is major, and the likelihood occasional. The overall impact is therefore described as High (C=3, L=2).

6.4.4.8 Landfill stability and Settlements

As discussed in section 6.4.2.10 settlement in landfills can be caused by several processes including: 1) refuse dissolution into leachate, 2) incomplete waste compaction, 3) movement of smaller particles into larger voids created by biological and physico-chemical changes, and subsurface fires and 4) consolidation or mechanical compression due to the refuse thickness, own weight, load of construction material and structures erected on the landfill.

Long term settlements due primarily to refuse decomposition can theoretically reach 40 percent of the original thickness and occur gradually for several years after closure at a continually decreasing rate depending on stabilization process within the landfill (Edil et al, 1990, Frantzis, 1991). It has been found that 90 percent of the total settlement occurs within the first five years and in dry climates this rate is usually less (Tchobanoglous et al., 1993). Total settlements increase with the percentage of decomposable materials in solid waste. Conversely, increasing amounts of inert material tends to decrease settlements to lower magnitudes. Decomposition is strongly dependent upon moisture conditions and landfill operating procedure. Figure 6-4 provides a general illustration of landfill settlement for solid waste over time.

Long term settlements due primarily to refuse decomposition can theoretically reach 40 percent of the original thickness and occur gradually for several years after closure at a continually decreasing rate depending on stabilization process within the landfill. On average, settlement of about 15 percent of the landfill thickness is expected due to waste decomposition.

Landfills often exhibit great variations in waste composition resulting in a non-uniform settlement pattern. This creates differential settlements which can have a devastating effect on the integrity of any structure erected on the landfill, or infrastructure running through it. Structural failures of buildings, surface cracks in the final cover, damage to the surface water drainage system, piping of leachate and gas collection systems, and underground utilities are commonly attributed to differential settlements. Besides variations in waste composition, changes in the manner in which the waste is placed or compacted, localized raveling, vertical loads, and subsurface fires contribute to differential settlements as well.

Other less significant hazards include erosion potential after site closure and settlement due to consolidation and biodegradation of organic material. Both erosion and settlement hazards can be mitigated with an appropriate site management plan.

The impact of the landfill closure and post closure phase on stability will be significant especially if site processes are not well designed and operated, land settlement not correctly anticipated, and mitigation and monitoring measure not implemented fully. Correct management of the post-closure maturing landfill and correct post closure land-use assignation design are essential steps in decreasing the impact. The impact is described as negative, direct, irreversible, localized, and long -term. The Consequence is major, and the likelihood occasional. The overall impact is therefore described as High (C=3, L=2).

6.4.4.9 Impact on Socio-Economics

The closure of the landfill may decrease the revenue coming in from the landfill to the local area. After closure of the site, a drop in the numbers of the workforce is expected when the landfill is no longer used for waste disposal though work will continue to ensure the control of landfill gases, treatment of leachate, and later to ensure the rehabilitation of the site and possible conversion to other land use designation. An Environmental monitoring system will be instituted for the post closure rehabilitation activity and workforce, and final land use designation of the site.

The impact is of Moderate consequence and Occasional likelihood. The impact is described as negative, intermittent, irreversible, and long term. The overall impact is therefore Medium (C=2, L-2).

7 ENVIRONMENTAL & SOCIAL MANAGEMENT PLAN

7.1 ENVIRONMENTAL & SOCIAL MITIGATION MEASURES

7.1.1 Introduction

This section presents the environmental mitigation and management measures considered for the Cheesemanburg Sanitary Landfill Project. As described in Chapter 6, the ESIA team used a methodology for impact evaluation that assessed the consequence and likelihood of each event to determine an overall significance rating of high, medium or low. These impact categories (Figure 7-1) are used to determine the required level of mitigation. A "low" category indicates a potential impact that is at an acceptable level assuming that standard operating procedures and best practices will be applied. A "medium" category is a potential impact that requires further mitigation in order to bring the potential impact down to an acceptable level. Finally a "high" category represents a major or moderate consequence or probable likelihood and requires either an alternative approach or design, or a mitigation measure that will minimize the potential impact if negative. Mitigation measures are proposed in this chapter for each of the medium or high level impacts identified in Chapter 6. An exception to this approach is the positive impacts (or benefits) identified in Chapter 6 that do not require mitigation and thus are not included in the discussion of mitigation measures or the ESMP. However, in order to realize, or maximize the potential positive impacts of the Project, it is important to consider enhancement measures for these positive impacts and therefore enhancement measures are also presented in this Chapter for consideration.

Figure 7-1 Impact categories and management requirements

The primary adverse environmental impacts that are associated with the facility construction and site preparation phase, operation and maintenance phase, and the closure and post-closure phase of the Cheesemanburg sanitary landfill can be avoided or minimized by:

- Careful planning and staging of facility construction and site preparation activities,
- Adopting proper management practices during all phases, and
- Relying on effective environmental monitoring and training to support management decisions.

Mitigation measures are intended to reduce the effect of potentially significant impacts on the physical, biological and social environment. Thus, they are highly dependent on the significance of the predicted impact, the nature of the impact (permanent vs. temporary), and the phase of the project (facility construction and site preparation, operation, closure and post-closure).

7.1.2 Surface and Groundwater Quality

7.1.2.1 Facility Construction and Site Preparation Phase

During facility construction and site preparation activities, the primary sources of potential impacts on water quality will be from pollutants in site runoff water, which may enter surface waters directly. As such, the surface run-off and storm water will be diverted away from the construction site and all site runoff will be directed into site-storm drains along with adequately designed sand/silt/debris removal techniques such as sand traps, silt traps and sediment basins. In addition, the rainwater pumped out from trenches or foundation excavations and wastewater generated from concreting, plastering and other similar activities will be discharged into these storm drains with silt/debris removal facilities and not directly to the environment. Silt/debris removal facilities will be maintained whereby deposited silt and grit/debris is regularly removed after each rainstorm to ensure that these systems are functioning properly at all times.

The overall site drainage plan will indicate the location of storm drains, culverts, ditches, and subsurface drains, and if necessary a storm water retention basin. Considerations in designing drainage control facilities include the following:

- Collecting and routing trenches to move the surface waters off the site in the shortest possible distance.
- Designing the drainage system to operate at high enough flow velocities to prevent deposition.

- Designing slopes in such a way so as to minimize scour, while maintaining efficient and quick removal of surface runoff.

Given the absence of wastewater network in the project area, domestic wastewater from the construction site's toilets, kitchens and similar facilities should be contained in sanitary septic tanks before being transported to the wastewater treatment station or to the wastewater disposal site approved by local authorities.

Sewage from toilets, kitchens and similar facilities will be contained in sanitary cesspools before being transported by trucks to a nearby wastewater treatment plant. As for the wastewater generated from concreting, plastering, internal decoration, cleaning work and other similar activities, it should undergo large object removal by bar traps at drain inlets.

Furthermore, open stockpiles of construction materials on-site will be covered with tarpaulin or similar fabric during rainstorm events to prevent the washing away of construction materials, while earthworks will be well compacted as soon as the final surfaces are formed to prevent erosion especially during the wet season that stretches between April and November.

Water used in vehicle and plant servicing areas, vehicle wash bays and lubrication bays will be collected and connected to foul sewers via an oil/water separator to remove oils from contaminated discharges. Oil leakage or spillage will be contained and cleaned up immediately. Spent oil and lubricants will be collected and stored for recycling or proper disposal. In addition, all fuel tanks will be provided with secondary containment areas and chemical storage areas will be provided with locks and impermeable flooring.

The contractor will prepare procedures for immediate cleanup actions following spillages of oil, fuel and chemicals.

7.1.2.2 Proper Design of the Sanitary Landfill

During the facility construction and site preparation phase, a bottom liner will be installed in the Cheesemanburg sanitary landfill. Landfill liners are materials (both natural and manufactured) that are used to line the bottom area and below-grade sides of a landfill. The objective of landfill liners is to minimize the infiltration of leachate and landfill gas into the subsurface soils below the landfill, thus eliminating the potential for soil and groundwater contamination. The basal liner should be layered from the bottom layer to the top layer per the EU Landfill Directive as follows:

- Compacted clay layer, composed of 2 layers of 25 cm (each) of clay with permeability less than 5x10-9 m/sec or equivalent geo-composite liner.
- Geomembrane HDPE, of thickness between 0.15-0.25 cm, securely welded and impermeable over the complete length of joints. The weld seams shall be checked for their impermeability and mechanical stress along their complete length.
- Drainage layer:
  - Option 1 (recommended): Sand layer of 25 cm thickness which does not react with the leachate and which allows proper drainage to the leachate collection system. This layer should contain perforated pipes in order to collect and convey the collected leachate to a central location.
  - Option 2: Geonet layer of high density polyethylene and geotextile covered with a protective layer of soil. The geonet and geotextile composite function together as a drainage layer to convey the leachate to the leachate collection system.

The liner will be laid as panels with each panel being welded to adjacent panels by prescribed and approved welding processes. Liner construction will be subject to Construction Quality Control Assurance in the of sheet inspection, weld testing and the adoption of good installation practice by an experienced workforce. Additional information on liner system is presented in Section 3.5.4.

7.1.2.3 Facility Operation and Post Closure Phases

During both the operation and closure and post closure phases, mitigation measures focus on leachate containment and management system with the main objectives to:

- Minimize the generation of leachate
- Manage all generated leachate to safeguard and protect the environmental values of water resources and
- Detect and promptly remediate pollution of water resources.

The proposed mitigation measures to be adopted include the following components: 1) intermediate/ daily cover, 2) top cover, 3) surface drainage, 4) leachate management system and 5) landfill gas management system.

7.1.2.4 *Waste Placement and Daily Cover/Intermediate*

A significant amount of water that enters a landfill and ultimately becomes leachate enters during the operational phase of the sanitary landfill. Therefore, the type and thickness of the intermediate cover material applied plays an important role in leachate management as it can limit the amount of surface water that enters the landfill.

It should be noted that significant quantities of water enter the landfill and ultimately become leachate during the operation phase. Therefore, the type and thickness of the intermediate cover material applied plays an important role in landfill management as it can limit the amount of surface water that enters the landfill. The most effective daily cover materials are soil or Grade C or Grade D compost with a thickness of at least 10 cm. In addition, the intermediate cover layer of each cell within the landfill must be sloped between 2-5% (as mentioned previously), in order to enhance surface water runoff.

Based on the final height of the landfill, it is recommended that install an intermediate drainage layer is installed after one or two lifts have been completed in order to speed up leachate collection process. The number of intermediate drainage layers and their placement within the landfill depends upon the final height of the landfill and should be proposed in the detailed design of the project by the contractor.

7.1.2.4.1 *Top Cover and Surface Runoff Drainage*

When the landfill reaches its full capacity it will be closed. This is typically carried out by capping off the landfill with a final layer or cover of top soil. As well as minimizing water infiltration from rainfall after closure thereby limiting leachate generation and protecting surface and ground water, the top cover will control landfill gas and odor emissions, potential for fires, and suppress the proliferation of vermin and disease vectors. The cover also provides a suitable surface for vegetation and rehabilitation of the site. The landfill top cover will be comprised of different components and layers from the base to top as detailed in Section 3. Furthermore, rainfall runoff from the surface of the closed landfill will be controlled and managed in order to ensure that leachate and rain water do not mix. Therefore, the final landfill cover will have suitable inclines to allow for proper rainwater diversion into recuperation canal system aqueducts feeding into collection tanks. The collected rainfall runoff from the surface of the landfill should be adequate to use for daily consumption at the facility.

7.1.2.4.2 *Leachate Management*

The Cheesemanburg sanitary landfill will have a comprehensive leachate management system that includes an effective liner system, a drainage system for the collection and removal of the generated leachate, and an on-site leachate treatment plant.

A proper leachate drainage system will be installed above the geo-membrane layer within the landfill. This is comprised of two principal components: 1) sloped terraces (gradient of 1 – 2 %) and 2) piped bottom.

The leachate collected will be directed to the leachate holding tank and will be treated by a combined biological and chemical treatment plant installed within the facility premises. This treatment will bring leachate quality parameters up to LEPA surface water discharge standards. The treated effluent will be discharged into the surface water bodies with a minimum flow of 0.1m^3/sec. In case the treated leachate does not comply with surface water standards and condition, on-site leachate treatment must at least ensure the requirements and standards of wastewater discharge into sewers for further treatment at waste water treatment plants. The minimal wastewater standards are required in order to allow safe discharge of the preliminary on-site treated leachate into the local wastewater network (once executed). Onsite leachate treatment facility should be developed as part of the project as it is more economical and safer than transferring leachate to local waste water treatment facility. Besides, there is currently no local waste water treatment facility. During the dry season, it is proposed to re-circulate the collected leachate on the active landfill cells. Leachate recirculation is generally performed in the early stages of leachate generation and is used as a method for achieving accelerated stabilization of the waste materials. It is also used to control the volumes of leachate requiring storage before treatment and is generally the most cost effective management options. Recirculation of leachate requires suitable vehicles with holding tanks, discharge pumps and spray fittings. The most important consideration for recirculation is to ensure that leachate is sprayed uniformly over the waste materials to ensure that there is wetting of the wastes; flushing of the leachable contaminants and homogenization of micro-biological activity within the waste. This will avoid the establishment of over treated pathways within the waste material and ensure that downward flowing leachate does not impair the landfill gas collection system.

Liquid waste generated from the sanitary landfill will also be collected and treated on site along with the liquid waste generated from the sorting and composting plant.

The most commonly used on-site treatment options including biological treatment (aerobic vs. anaerobic) and to a lesser extent, evaporation.

For a leachate of high biological oxygen demand (BOD), anaerobic biological treatment is most commonly used because of its energy efficiency and lower sludge generation rate. Leachate of medium BOD level may be treated in aerobic biological systems, including activated sludge, rotating biological contactors, or sequenced batch units. Reduction of 90 percent or more of BOD, suspended solids and precipitated metals is accomplished, but energy consumption may be high and comparatively larger amounts of sludge are produced (UNEP, 1996).

An aeration or facultative pond can be used to polish leachate treated by other methods, if the leachate has not yet reached a contaminant level suitable for discharge. Ponds can also be used to treat relatively low-strength leachate. Such ponds may have surface aerators depending on the BOD, retention time, and configuration. If the leachate is to be discharged to surface water, additional treatment consisting of activated carbon adsorption or membrane filtration processes will be required, and air stripping or chemical precipitation may also be needed (UNEP, 1996). This alternative may be a suitable and economic temporary solution until a leachate treatment plant is constructed on-site.

Another option, leachate recirculation, has also certain benefits, which include increasing the rate of waste stabilization, improving leachate quality, and increasing the quantity and quality of methane gas production.

Table 7-1 provides a summary of key component of a comprehensive leachate management system.

Table 7-1 Key components of a leachate management system

Component	Function
Minimization of leachate generation	• Control of surface and groundwater inputs • Minimization of amount of precipitation coming into contact with the waste • Phased waste disposal and use of daily cover • Planned landfill closure with low permeability top cover • Shaping of final landform to ensure surface water runoff away from active phases • Control of liquid waste inputs • Recirculation of leachate on active landfill cells
Containment of leachate within the landfill	• Use of a composite liner system for base and sides • retention of sufficient unsaturated zone to provide for leachate attenuation in case of leakage • Quality control of liner installation
Control of leachate quality	• Ban on specific wastes of hazardous and toxic properties • Recirculation of leachate on active landfill cells
Collection and treatment of leachate	• Drainage layer • Piping system • Collection tank • On-site treatment plant
monitoring	• Leachate volume and quality • Surface water • groundwater
Contingency plans	• Groundwater and surface water contamination detected

In addition to the above, the mitigation measures will focus on avoiding the malfunctioning, breakdown or the improper operation of the leachate treatment plant that will lead to adverse impacts resulting from the disposal of untreated leachate into the environment. Mitigation is in the form of adopting proper inspection and maintenance programs to ensure system functionality. In addition, providing appropriate training to a qualified staff is also a crucial mitigation measure. The training should incorporate basic familiarization with the operating system of the Cheesemanburg facility and its leachate treatment plant along with fundamentals of occupational health and safety in solid waste and leachate treatment facilities. In addition, implementing a monitoring program for the compost and the treated leachate effluent would ensure their environmental and health acceptability before reuse or discharge. The proposed monitoring parameters are presented in Section 7.2.

Surface water primarily as rainfall runoff, is the major contributor to leachate formation. Therefore, elimination or reduction of the amount of surface water that enters the landfill should be targeted by installing proper drainage facilities.

7.1.2.5 *Proper Design for the Sorting and Composting Plant*

All the facility units should be enclosed with roofed structures and all curing areas shall utilize permanent roof structure to control moisture and minimize liquid waste generation. The entire facility will accommodate for slightly inclined ground surface to ensure proper liquid waste drainage. Furthermore, the facility will be equipped with an adequate solid waste storage area (roofed, impermeable paving, proper drainage and ventilation) with a capacity of at least two consecutive days throughput to ensure that incoming wastes are not haphazardly stacked in cases of system failure or peak throughputs thus leading to leachate seepage.

7.1.2.6 *Operation Phase for Sorting and Composting Plant*

During operation, mitigation measures will primarily focus on collecting and treating the liquid waste that will be generated during the operation of the facility as well as preventing it from percolating into the subsurface or entering surface water bodies. Liquid waste is expected to be generated during storage, sorting, and composting activities within the facility. As such, mitigation measures will be adopted in both the facility design and liquid waste management system.

A liquid waste management system will be developed to control, collect, store, treat and monitor the liquid waste as follows:

1. *A Liquid waste barrier system* will be installed on site to prevent the pollution by liquid waste of subsoil, groundwater and surface water bodies. The recommended barrier is an impermeable flooring pad of properly mixed cement and adhesive liquid waste resistant material. This pad must be of sufficient thickness designed to withstand the loads from all machines, vehicles and equipment that are required to operate the facility.

2. *A liquid waste collection system* will be installed on site to ensure that liquid waste is collected efficiently at the composting and related processing facility for further management, thereby avoiding water pollution and odor problems. The liquid waste collection system must include a drainage system independent from the wastewater collection system to collect the liquid waste and washwater generated from the

different stages. Liquid waste from the composting process could also be re-circulated whenever possible in the composting or curing phase in case the moisture content of the organic waste is low.

The collected liquid waste will be stored and treated on-site with the collected leachate generated from the sanitary landfill

7.1.2.7 *Domestic Wastewater*

The domestic wastewater resulting from the administrative building and workers facilities will be collected in a separate septic tank. Once the collection tank reaches its full capacity, it will be transferred to the planned wastewater treatment stations (if available, otherwise a wastewater treatment plant should be established) or to a wastewater disposal site approved by local authorities. The resulting wastewater can also be discharged into sewage network (if available) if it complies with the national LEPA standards for wastewater discharge into sewers.

Other minor impacts that result from the haphazard disposal of the collected leachate from vehicles transporting waste contaminated cleaning and drainage water, as well as oil and lubricants generated from equipment maintenance workshops on-site will be mitigated to curb any surface and groundwater pollution. As such, leachate collected from the storage tanks of the vehicles transporting waste as well as cleaning water and drainage water collected from the landfill, compost plant, and vehicle washing facility will be treated on-site along with the leachate collected from the landfill and the compost plant. 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 will be placed at all workshops on-site in order to limit mixing with cleaning water. Spent motor oils will be collected in sealed containers and stored in workshops until recycled or disposed of at LEPA approved sites. Finally, the designs for the landfill and compost plant will accommodate for slightly inclined ground surface to ensure proper leachate drainage.

7.1.3 Soil and Compost Quality

The prevention of soil contamination is crucial since the restoration and treatment of soils is an expensive process.

During the construction phase the main mitigation measures relate to good housekeeping practices that include the proper storage of chemicals on site, limiting accidental spillage as well as prohibiting the open disposal of spent oils in the surrounding environments. In addition to the above, the operation of the compost facility part of the site will generate significant quantities of compost that will be sold, used as soil cover, or distributed to interested farmers. The most important mitigation measures involve monitoring the compost quality to assure that contaminant levels are lower than specified guidelines. In addition, heat treatment should be adopted in the compost facility since it is capable of destroying most pathogens present in the compost and is commonly used during the compost curing stage. Typical temperatures and heating periods used for destroying pathogens present in compost as stipulated by the WHO guidelines are presented in Table 7-2.

Table 7-2 WHO guidelines set for the destruction of common pathogens and parasites

Organism	Observations
Salmonella typhosa	No growth beyond 46^{0}C; death within 30 minutes at 55-60^{0}C and within 20 minutes at 60 ^{0}C; destroyed in a short time in compost environment
Salmonella sp.	Death within 1 hour at 55^{0}C and within 15-20 minutes at 60^{0}C
Shigella sp.	Death within one hour at 55^{0}C
Escherichia coli	Most die within 1 hour at 55^{0}C and within 15-20 minutes at 60^{0}C
Entamoeba hystolytica cysts	Death within few minutes at 45^{0}C and within a few seconds at 55^{0}C
Taenia saginata	Death within a few minutes at 55^{0}C
Trichinella spiralis larvae	Quickly killed at 55^{0}C; instantly killed at 60^{0}C
Brucella abortus or Brucella suis	Death within 3 minutes at 62-63^{0}C and within 1 hour at 55^{0}C
Micrococcus pyogenes var. aureus	Death within 10 minutes at 50^{0}C
Streptococcus pyogenes	Death within 10 minutes at 54^{0}C
Mycrobaterium tuberculosis var. hominis	Death within 15-20 minutes at 66^{0}C or after momentary heating at 67^{0}C
Corynebacterium diphtheriae	Death within 45 minutes at 55^{0}C
Necator amrericanus	Death within 50 minutes at 45^{0}C
Ascaris lumbricoides eggs	Death in less than 1 hour at temperatures over 50^{0}C

Another mitigation measure that limits the potential pollution of soils resulting from the land application of compost includes ensuring low heavy metal concentrations within the final product. This can be ensured by regular testing of the compost, and applying different separation processes such as manual sorting, mechanical sorting, as well as electromagnetic separation. Based on international experience, initiating household sorting through local and national campaigns along with in-process separation has resulted in the production of good quality compost.

Besides compost quality, the proper use and application rates of compost are crucial elements in mitigation of soil quality impacts. In this respect, compost application rates should comply with the standards indicated in Appendix F for application in areas with subtropical climates. In both cases, yearly application rates should not exceed 17 g/m^2 for total nitrogen, 6 g/m^2 phosphate, and 12 g/m^2 for potassium oxide. In order to ensure appropriate application rates, the contractor will provide assistance and training programs for end-users.

Other mitigation measures aimed at limiting soil pollution during the operational phase include:

- Adequate treatment of the leachate prior to discharge
- Installation of impermeable material at the landfill such as clay and geo-membrane (liner system) to limit contact of generated leachate with the surrounding soil.
- Adopting a proper compost and leachate monitoring program.
- Training and inform farmers about the correct frequency and volumes of application of the compost.
- Providing the facility with an adequate Solid Waste storage area (roofed, impermeable paving, proper drainage and ventilation) with a capacity of at least two consecutive day throughput to ensure that incoming wastes are not haphazardly stacked in cases of system failure or peak throughputs thus leading to leachate seepage.
- Treat the leachate collected from the storage tanks of the vehicles transporting waste on-site along with the leachate collected from the landfill and the compost plant.
- Provide oil-water separators and sand precipitators at all workshops on-site in order to limit mixing with cleaning water

7.1.4 Odor Generation

7.1.4.1 Facility Operation Phase and Post-Closure Phases

During the operational phase, adequate aeration rates during the composting process will always be maintained in order to limit the development of anaerobic pockets responsible for the generation of odorous gases such as H2S. In addition, enclosure with the correct odor control equipment will limit the atmospheric release of odor gases. Vents in the compost and sorting facilities will be fitted with biofilters (to be maintained on a yearly basis) to limit odor emissions. In addition odor emissions can be significantly reduced by ensuring that all sorting activities are conducted within 12 hours of waste delivery. Providing adequate soil cover in the landfill will also limit odors.

Mitigation measures are proposed to abate any odor generation during waste transportation activities include:

1) Proper sheeting of the trucks delivering wastes and

2) Ensuring that vehicles and containers are an adequate size for the quantity of waste transported and that they are properly maintained.

During the post closure phase, the gas collection and treatment system along with the final top cover will continue to work to limit possible emissions.

7.1.5 Air Quality

7.1.5.1 Facility Construction and Site Preparation phase

The major source of air pollution during this phase is particulate matter (PM). In general, control techniques for minimizing PM emissions during construction generally involve watering of surfaces, chemical stabilization, or reduction of surface wind speed with windbreaks or source enclosure. Watering, the most common and generally the least expensive methods, provides adequate temporary dust control. Regular watering practices cause aggregation and cementation of fine particles s to the surfaces of larger particles, thus achieving a reduction of more than 50 percent in the rate of fugitive dust emissions. 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. Continuous chemical treatment of materials loading into piles, coupled with watering or treatment of roadways, can achieve a reduction up to 90 percent in the total particulate emissions from aggregate storage operations (Jutze et al., 1974). Windbreaks and source enclosures such as trees, fences, plastic meshes, etc. are also good mitigation measures that can limit PM emissions as a result of wind erosion.

Generally, the amount of emission reduction is directly tied to reducing surface silt content;

therefore, surface improvements offer long term air pollution control techniques. 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 and thus help reduce emissions. The amount of emission reduction is tied directly to reducing surface silt content.

Other mitigation measures include, maintaining good housekeeping practices throughout the construction and site preparation phase. These low cost measures include the elimination of mud/dirt carryout on paved roads at the construction site, periodic removal of dust-producing materials, covering hauling trucks while transporting construction materials, as well as regular clean-up of spillage on paved or unpaved travel surfaces. Table 7-3 presents several housekeeping mitigation measures for the construction phase.

Table 7-3 Mitigation measures for minimizing PM emissions during the facility construction and site preparation phase (Source USEPA, 1998)

Emission source	Recommended mitigation measure
Debris handling	• Wind speed reduction through wind breaks • Wet suppression
stockpiling	• Stockpiles should be properly treated and sealed with latex, vinyl, bitumen or other suitable surface stabilizer, if a stockpile of dusty materials is more than 1.2 m high and lies within 50 m from any site boundary that adjoins a road, street, or other area accessible to the public • Stocks of more than 20 bags of cement should be covered entirely by impervious sheeting or paced in a area sheltered on the top and the 3 side • Silos used for the storage of the cement should not be overfilled
Truck transport	• Wet suppression • Enclose material transported with totally impervious sheeting • Paving heavy used haul roads • Vehicle washing facilities should be provided at every vehicle exit point • Chemical stabilization • Vehicle speed should be limited to 10 km/hr except on completed access roads
bulldozing	• Wet suppression during bulldozing activities
Cut and fill material handling	• Wind speed reduction • Wet suppression
Cut and Fill hauling	• Wet suppression • Paving heavy used haul roads
General construction activities	• Wind speed reduction • Wet suppression • Early paving of permanent roads
Quarrying	• The area to be quarried should be wetted with water within 30 m from the blasting area prior to blasting • Blasting should not be carried out when strong winds prevail

Other types of pollutants are expected as a result of construction activities. These pollutants comprise CO, NO_2, SO_2, PM and HC and are mainly emitted by combustion engines in car and truck traffic to and from the site and on-site equipment such as concrete trucks, dump trucks, excavators and backhoes. Measures to reduce truck traffic emissions include proper maintenance and the adoption of a traffic management plan while avoiding congested routes. Concerning on-site construction equipment, 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.

7.1.5.2 Facility Operation and Post-Closure Phase

The degradation of putrescible waste in a landfill generates gases such as methane, carbon dioxide and other trace gases that pose potential hazards to site safety, human health and the environment. Generation of landfill gas can continue for years after placement of the waste. Methane is explosive if present in the range of 5% and 15% by volume in air. Both methane and carbon dioxide are not only asphyxiates if present in excessive concentrations, they are also greenhouse gases. Although methane and carbon dioxide are odorless, other components of landfill gas can be very odorous. Therefore the objective of management strategies for the movement of gases generated from landfill is to:

- Reduce atmospheric emissions and therefore potential associated hazards.
- Minimize the release of odorous emissions and dust.
- Minimize subsurface gas migration.
- Allow for the recovery of energy from methane
- Comply with the Clean Development Mechanism (CDM).

Landfill gas control systems can be classified as either passive or active. In passive gas control systems, the pressure of the gas that is generated within the landfill serves as the driving force for the movement of the gas. In active gas control systems, energy in the form of an induced vacuum is used to control the flow of gas generated within the landfill. Passive gas control systems are less costly and less energy consuming than active gas control systems.

Passive control of landfill gases is proposed as the most appropriate means of controlling gas emissions at the landfill.

The passive control method is based on the fact that the lateral migration of landfill gas can be reduced by relieving gas pressure within the landfill interior. This therefore entails the installation of perforated pipes or gravel-filled columns into the landfill to provide a flow path for the gas to reach the surface. These vents are installed through the final landfill cover extending down to the liner system that will limit the movement of landfill gases. This therefore creates an impermeable barrier within the landfill, controlling the movement of the landfill gases to adjacent soil formations. The gas collection system should be constructed for each cell prior to construction of the capping.

Typically, landfill gases that have been recovered are either flared or used for the recovery of energy in the form of electricity or both. Enclosed flaring is the method proposed for the control of landfill gases, whereby methane and any other trace gases (including VOCs) are combusted in the presence of oxygen to carbon dioxide, sulphur dioxide, oxides of nitrogen and other related gases. This is usually accomplished in a specially designed enclosed flaring facility. Due to associated air pollution concerns, modern flaring facilities are designed to meet relevant operating specifications (such as minimum combustion temperature and residence time) to ensure the effective destruction of VOCs and other similar compounds that may be present in the landfill gas.

The Cheesmanburg landfill should house enclosed storage and processing areas which are mechanically ventilated. All active areas should be under a negative atmospheric pressure and the location of the facility entrance should be oriented opposite the wind direction in order to avoid the migration of any generated odors into the surrounding environment.

The composting unit should be equipped with a biofilter to significantly reduce gas emissions generated and a fabric filter as an air cleaning system for PM emissions. Another source of air pollution is airborne pathogens which include fungal spores and bacteria that are released to the air during composting. The following include recommended mitigation measures that should be adopted to minimize the emission of airborne pathogens:

- Not allowing the organics that are being processed, or products such as compost, soil conditioners and mulches, to lose too much moisture. Moisture content should be kept at approximately 25% m/n.
- Ensuring that every part of a batch of product has been subjected to stabilization

conditions during processing.

Additional measures should be adopted with regards to waste transportation including:

- sheeting of vehicles delivering wastes and removing residues,
- Ensuring that vehicles and containers are adequate for quantity of waste transported,
- properly maintaining all collection trucks and
- Ensuring that all collection trucks used should be no more than 10 years of age.

7.1.6 Health and Safety

A Health and Safety Plan will be prepared for the construction, operation and post closure phases of the Project to ensure compliance with the Ministry of Health's Guideline for Occupational Health and Safety and IFC guidelines.

The Contractor should prepare and implement a Construction Environmental and Social Management Plan (CESMP), as well as a Health and Safety Plan (H&S Plan) in compliance with OHSAS 18001:2007. For this purpose, the Contractor should recruit a qualified Environmental & Social specialist with international experience and a qualified Health & Safety specialist with a certification and experience in implementation of OHSAS 18001:2007 procedures. The Owner's Engineer by contractual arrangement will have the requirement to supervise the adequate preparation and implementation of the CESMP and H&S Plan. The Owner's Engineer should recruit for this purpose a qualified Environmental & Social specialist with international experience and a qualified Health & Safety specialist with a certification and experience in implementation of OHSAS 18001:2007 procedures.

A safety specialist will be responsible for the preparation, implementation and maintenance of a comprehensive safety program, which will be periodically evaluated. The safety specialist will be provided with written safety instructions including instructions on correct storage, handling and disposal of hazardous waste, and written contingency plans/guidelines of action for accidents, spills, and fire. The responsibility of the safety specialist includes performing safety training and conducting safety inspections, sessions and practice. The safety specialist will also be responsible for the investigation of accidents. A safety committee should be formed and regular safety meetings should be organized.

7.1.6.1 Facility Construction and Site Preparation Phase

Health and safety during the construction and site preparation phase is considered primarily in terms of potential exposure to PM and noise, as well as accident occurrence to workers on-site. Mitigation measures include but not limited to:

- Restriction of access to the facility construction and site preparation by proper fencing whereby site boundaries adjoining roads, streets or other areas accessible to the public should undergo fencing not less than 2.5 m high from ground level along the entire length except for a site entrance or exit .
- Establishing buffer areas around the site.
- Provision of guards on entrances to and exits from the site.
- Installation of warning signs at the entrance of the site to prohibit public access.
- Provision of training about the fundamentals of occupational health and safety procedures.
- Provision of appropriate personal protective equipment (PPE) (***gas detectors, impermeable latex gloves, brightly colored working overalls equipped with light reflecting stripes, safety boots, safety helmets, and ear plugs***).
- Keep uniforms and PPE clean and in good condition and replace them at least on a semi-annual basis.
- Provision of personal ID cards for all employees.
- Provision of adequate loading and off-loading spaces.
- Development of emergency response plans for the site particularly in case of fire or explosion.
- Provision of on-site medical facility/first aid.
- Provide disease surveillance and active screening of workers.
- Provide health awareness education and disease treatment training especially with relation to communicable diseases such as HIV and Ebola Virus Disease.

- Utilize proper sanitation and vector control programs to reduce mosquito and other disease vector populations.
- Installation of retaining nets to hold falling debris during site clearing, excavation, and construction.
- Provision of appropriate lighting during night-time works.
- Implementation of speed limits for trucks entering and exiting the site
- Implementation of nationally and internationally adopted health and safety guidelines.

7.1.6.2 *Facility during Operation and Post-Closure Phases*

During operations, monitoring and maintenance activities are of high priority to limit possible malfunctioning of processes and associated problems. Other mitigation measures that will reduce potential health and safety impacts include site security, site safety, enhancing safety at site facilities, environmental controls, waste transportation, waste tracking system, emergency/contingency plans, workers hygiene, personnel protection, as well as firefighting equipment and procedures.

7.1.6.2.1 *Site Security*

The contractor will develop and implement a site security plan for the site to restrict access of unauthorized personnel. This should include but not be limited to the following measures:

- Restricting access to the facilities by proper fencing.
- Maintaining the buffer areas around the facility.
- Installing warning signs in English text as well as explanatory diagrams at the entrance of the facility to warn people about the health risks associated with solid waste and leachate mishandling.
- Displaying emergency telephone numbers for police, ambulance, and fire services.
- Locking gates outside working hours.
- Erecting a fence along the perimeter of the site consisting of non-combustible wire screens, 2.5 m high, and with a mesh of 50 mm or less to intercept litter. In order to

enhance the efficiency of the fence, trees may be planted along its perimeter

- Erecting site identification board of durable material and finish at the entrance of the site giving the name of the site, and the name, address and telephone number of the site operator.
- Providing 24 hour guards for the facility.
- Keeping a daily record of persons and vehicles entering/leaving the site.

7.1.6.2.2 *Site safety*

The contractor will develop and implement a site specific safety plan to limit occupational accident risks on site. This should include but not be limited to the following measures:

- Visitors must report to the site office where they will sign-in and be issued a pass. Visitors will also sign out on departure and surrender their pass. No visitors will be permitted to access the operational areas unless they have received the express permission of the site manager(s) and they have attended the site safety course or are accompanied by a site employee.
- Staff and employees working on-site will attend a safety and operational course before commencing work.

Personnel and visitors to the operational areas of the site will wear personal protective clothing inclusive of high visibility clothing, protective footwear, and safety helmets.

7.1.6.2.3 *Enhancing Safety at Site Facilities*

Facilities on-site will have adequate safety precautions to limit potential occupational accidents. Several key safety procedures are presented below:

- Installing warning signs at the entrance of the facility to warn people about the health risks associated with solid waste and leachate mishandling.
- Site offices, stores, maintenance facilities, hygiene facilities, toilets, vehicle parking, vehicle washing, etc. will be provided at suitable locations, remote from any ingress of landfill gases. Confined spaces, such as buildings and workshops will have automated

methane monitoring equipment to be installed.

- All confined spaces where waste handling occurs in presence of workers, will be equipped with ventilation systems with air exchange rates exceeding 2 air changes per hour. The MRF will be ventilated at a rate of 40 m^3/hr/person.
- A drinking water supply will be provided at the site.
- Tanks will be clearly labeled with details of contents, potential hazards (e.g. explosive, flammable, toxic etc.), and emergency services telephone numbers.
- Compacted hardscaped service roads will be provided and maintained from the site entrances to waste reception areas.
- Site subsidiary roads of appropriate width and construction will be provided from the waste reception areas to the tipping points.
- Roads will be properly maintained and sprayed with water in dry weather to suppress dust emissions.

7.1.6.2.4 *Environmental Controls*

Key environmental controls that shall be adopted by the contractor at the site and include but are not limited to:

- A record of all types and quantities of wastes deposited.
- All refuse transportation vehicles travelling to or from site will be fully sheeted (i.e. flatbed) or well- contained from point of departure to arrival.
- All vehicles leaving the site will be cleaned of debris from chassis and underparts and will have the loading surfaces washed in an appropriate way before leaving the site. All such washing and cleaning activities will take place in properly constructed and equipped locations and all such solid and liquid effluents will be deemed as waste or leachate and liquid waste and will managed in an appropriate manner (described in section 6.1.2).
- Operations will be carried out without affecting nearby drainage systems.

- The pile up of incoming solid wastes outside the premises will not be allowed.
- Appropriate steps will be adopted to control infestation by insects' pests and vermin. The areas will be inspected at regular intervals and corrective action will be taken when required, which may include the application of insecticides and the setting of baited traps to control vermin populations.
- No waste materials will be burned within the boundaries. Any fire at the site will be treated as an emergency and immediate action will be taken to extinguish.
- A gas monitoring program will be developed and implemented to monitor build up of explosive gases at the landfill.
- Regular maintenance of gas wells, sorting equipment, and composting machinery will be conducted to prevent methane build-up and minimize fire and explosion risks.
- Stagnation of exposed water/leachate volumes will be prevented to hamper insect and vector breeding.
- No smoking will be permitted on site.
- In the processing areas, odors will be controlled through the application of appropriate products (i.e. chemical odorants).
- No medical wastes, industrial wastes, animal carcasses, or other obnoxious and environmentally hazardous materials shall be accepted at the landfill. As such, inspection of incoming wastes should be conducted at weighbridges. Any load where unaccepted wastes are identified shall be rejected. The identity of the vehicle and driver as well as the identity of the rejected wastes shall be notified to local authorities immediately. Concurrently, a temporary storage area (enclosed with proper ventilation) will be constructed to accommodate for wastes rejected at the landfill (should be stored in closed containers) until further instructions are issued from local authorities concerning the fate of such wastes.

7.1.6.2.5 *Waste Transportation*

Several key safety measures that will be adopted during the transportation of the wastes to the site and on-site include the following:

- Drivers will be issued and require to used safety equipment such as toxic gas detectors, boots, gloves, overalls, etc.
- Vehicles will be cleaned at the end of daily operations and disinfected weekly.
- Vehicles will be fitted with two way communication equipment, automatic beacon lights and warning sound device, equipment to manage a spill situation, detailed instructions prominently displayed in the cabin, for use in the case of spills, accidents, fire and other emergencies (including list of contact personnel and phone numbers).
- Vehicles will be licensed for the transportation of solid waste material, and have appropriate third party insurance.
- Drivers must always be in the possession of a current relevant truck driving license, carry proof of having attended the site safety and operation course, be trained in safe and advanced driving skills appropriate to the nature of the waste being transported, be trained in spill procedures and use of spill kit equipment, and report to site gateman upon entering and leaving the waste facilities
- A certification system will be implemented to adequately identify source and transportation path to disposal. A duplicate waste transfer note system will be operated. Transfer notes shall record drivers name, vehicle registration, description of waste, and tonnage of waste.

7.1.6.2.6 *Waste Tracking System*

- The site will maintain a computer based record of wastes delivered which includes the vehicle identification number and time of arrival at site.
- Daily quantities of incoming wastes should be recorded at the entrance of the facility. In this respect, waste delivery vehicles entering the site are required to weigh incoming and outgoing waste trucks over a weighbridge. The weighbridge should be of electronic type and linked to a personal computer to provide automatic recording of the weight loads.
- Waste records shall be kept for 15 years after closure.

7.1.6.2.7 *Emergency/Contingency Plans*

- If waste being delivered on the site catches on fire will be discharged and extinguished using water or suitable extinguishers. The generated liquid effluent will be collected and treated with the leachate.
- Contingency and Emergency Response plans will be established for emergencies which are likely to occur as a result of transporting, segregating, treatment, and disposing of solid wastes.
- The plans will address scenarios of accidents for which the facility is at most risk and serve as a reference for risk assessment and employee training.
- A contingency plan will be established to deal with fire and explosion risks that may arise either at the facility or nearby source when applicable due to the possibility of having a synergetic effect.
- The contingency plans will require establishing and maintaining occupational health and safety procedures for all aspects of operations; identification of likely accidents, outlining emergency scenarios, establishing command hierarchy, organizing communication lines, determining response actions, delegating responsibilities, designating evacuation signal and identifying meetings points mark on appropriate maps for each work area; and co-ordination with local fire service, police and ambulances services.

7.1.6.2.8 *Workers Hygiene*

- Hygiene facilities will be provided through which workers must pass to enter or leave the dirty area of the site (waste delivery drivers are exempt from this provided windows are kept closed and drivers do not leave their vehicles). The facility will be constructed in three stages: changing room for workers clothes, washing facilities with hot and cold showers, and a changing room for storage of contaminated overalls, boots, etc.
- Boot washes with fixed or hand brushes will be provided at the entrance of the facility from the dirty area to the dirty area.
- A restroom will be provided on the clean side which can only be entered by passing

through the hygiene facility.

- Eating drinking and will be prohibited near the landfill and in the MRF and compost plant.

7.1.6.2.9 *Personnel Protection*

- Individuals working within the active waste filling areas will be provided with: toxic safety Wellingtons with protected sole plates, overalls (disposable or cleaned daily), PVC type overalls for wet weather working, respiratory masks, eye protection plugs and defenders, ear protection plugs and defenders, and gloves; and high visibility waistcoats.
- Adoption of handheld toxic gas detectors is crucial.
- Uniforms and PPE will be kept clean and in good condition and replaced at least on a semi-annual basis.
- Personal ID cards will be provided for all employees
- The dirty area full time supervisors will be provided with handheld gas monitors (methane, oxygen and carbon dioxide), radio, mobile phone and list of emergency telephone numbers and contacts.
- An employee trained in first aid will be present on-site at all time during operational hours. A first aid kit will be kept in the site office. The first aid kit will be regularly inspected and any deficiencies immediately replenished.
- Workers will be advised about diseases associated with wastes such as leptospirosis, tetanus etc., inoculated against tetanus, and regularly health-monitored.
- A record will be kept of illnesses, accidents, etc. occurring on-site.
- Person feeling sick (nausea, giddiness etc.) will be asked to report it immediately to the supervisors who will take appropriate action. Cuts, grazes etc. will be immediately treated.
- Regular medical checkups will be provided for staff on a semi-annual basis.
- Debris will be cleared along walkways which will be fitted with handrails and toe boards

in the compost plant and MRF.

During both the construction, site preparation and operation phases, national and international guidelines for health and safety will be followed. The contractor is responsible for observing local safety regulations and taking all necessary measures to safeguard personnel working on site. In particular, the contractor should ensure that only properly trained contenders are employed and that the correct tools procedures are used. The contractor will provide a safety specialist responsible for the preparation, implementation, and maintenance of a safety program, which will be periodically evaluated. The responsibility of the safety specialist includes performing safety training and conducting safety inspections, sessions, and practice. They will also be responsible for the investigation of accidents. A safety committee will be formed and regular safety meetings will be organized. All safety equipment and tools will be provided and maintained by the contractor.

7.1.6.2.10 *Fire Fighting*

Fire prevention measures will be implemented to limit the potential for fire development and will adhere to International Fire Code requirements.

Good housekeeping and maintenance practices will be utilized during construction and operation of the Project to prevent the accumulation of combustible waste material such as trash and vegetation. Smoking will be prohibited, and “No Smoking” signs will be posted in these areas.

To decrease the potential for fuel-related fires, fuel oil storage areas will be located well away from areas of fire hazard such as where welding operations will be performed. Waste oil and flammable materials will be stored within impermeable bunds with a 110% volume of largest tank and at designated areas selected based on proximity to water, migration routes, fire risks and access.

Assembly points will be designated and information provided to all staff to enable them to assemble at these points during a fire emergency for further action as may be required.

A rapid response fire team should be available for each operating shift under the direction of the shift supervisor to respond to fire emergencies occurring within the project area within a reasonable time. Team personnel will be selected from nonessential operations personnel. The fire team will be trained by the certified firefighter retained on staff. Fire training will include the locations and proper use of firefighting equipment and procedures for fighting solid and liquid fuel and electrical fires. Roles and responsibilities for firefighting duty and maintenance and operation of equipment and alarm systems are outlined in further detail below in the Contingency and Emergency Preparedness and Response Plan. In the event of a fire, all plant personnel shall be trained to sound the alarm through the use of the fire alarm system and the plant communications system. Upon receipt of a fire alarm the rapid response fire team will form at a predetermined rally point and await instructions of the shift supervisor. The shift supervisor will identify the location and type of fire and deploy the fire team accordingly. The team will use hand held radios for communication during the fire event. In the event that the shift supervisor is not available or has been injured, the next rapid responder in the designated chain of command will take charge of the fire response team.

Environmentally friendly fire-fighting equipment such as dry powder extinguishers will be provided within the premises of the facility. Annual firefighting training drills for the operating staff will be conducted. Smoking and litter build-up will be prohibited as these may pose fire risks. The safety specialist will prepare, implement, and maintain a comprehensive fire protection and prevention program. The safety specialist will also be responsible for the inspection and maintenance of the fixed and portable fire protection equipment and for the investigation of fire incidents. The safety specialist will develop and implement and emergency action plan and fire hazard inspection procedures to be present on-site and available at all times for all employees.

7.1.7 Noise

The erection of noise barriers to screen noise sources is generally practiced to minimize noise emissions from construction activities. Scheduling noisy activities during the daytime periods (7:00 am to 6:00 pm) will ensure that the noise standard set for evening will not be exceeded at several instances. In order to ensure that noise generation from the facility does not significantly impact nearby communities, several monitoring stations must be installed around the facility at varying distances to take into consideration noise propagation and dissipation. These monitoring receptors must be located in such a way as to minimize the influence of external elements that might affect the noise levels at these receptors, in order to accurately correlate any potential impacts from the facility. The noise level at these receptors should not exceed the maximum accepted noise levels for residential area with few construction sites, commercial activities or on highway.

During the facility construction and site preparation phase, mitigation measures include employing good site practices for equipment and machinery, implementing noise barriers and proper scheduling of construction activities. The contractor will adopt proper on-site practices to minimize noise emissions from the works during all times including but not limited to:

- Selecting quieter equipment/machinery.
- Ensuring employees wear PPP in high noise areas.
- Ensuring that only well-maintained mechanical equipment will be operated on-site.
- Shutting down equipment that may be intermittent in use between work periods (or be throttled down to a minimum).
- Utilizing silencers or mufflers on construction equipment which will be properly maintained during construction works.
- Material stockpiles and other structures will be effectively utilized where feasible, to reduce noise from on-site construction activities.

Purpose-built noise barriers or screens constructed of appropriate material to be located along active work sites will reduce noise transmission. A movable noise barrier with a suitable footing and a small cantilevered upper portion can be located within a few meters of a static plant and within about 5 m of mobile equipment, such that the line of sight could be blocked by the barriers viewed from the noise sensitive receivers. The estimated noise reduction by means of screening, provided that the barriers are carefully located, can provide a10-dBA noise attenuation for a static plant and 5 dBA for a mobile plant.

During the operation phase, the mitigation measures include scheduling collection and transport of the solid wastes so as not to disturb the public during hours of sleep and rest.

Whenever possible, noisy operations within the facility premises will be enclosed. Noise barriers such as enclosures or partial enclosures and other noise reduction measures will be installed around air blowers, pumps, and generators to reduce noise impacts at nearby receivers. Noisy equipment on-site will be enclosed where possible. In addition, a rigorous inspection and maintenance program applicable to equipment on-site will be implemented.

7.1.8 Waste Generation

A project-specific waste management plan will be developed to ensure that all wastes from the project activities are properly managed in accordance with applicable laws and regulations, and international standards relevant to the power generation industry.

The Waste Management Plan will include:

- Description of the types of wastes that will be generated
- Waste minimization opportunities
- Waste management methods
- Recordkeeping practices, including manifest and waste tracking forms

The plan will specify the proper storage, handling and disposal procedures for each waste identified.

7.1.8.1 Facility Construction and Site Preparation Phase

During the construction phase, construction debris will be generated as a result of various construction activities. The generated materials can be used for filling purposes or may be stockpiled and stored for future use as daily cover within the landfill. Nevertheless, care will be taken to ensure absence of contaminated fill material and the adequacy of the physical and chemical properties of such material. Construction and demolition wastes can also be minimized through careful planning during the design stage, whereby reducing or eliminating over-ordering of construction materials will minimize waste generation and reduce project costs (cost of surplus materials). The contractor will carry out sorting of construction and demolition wastes into various categories and adopt re-use/recycle on-site whenever deemed feasible.

Chemical wastes generated during the construction phase include containers that were used for storage of chemical waste on-site, the chemical residue as well as contaminated material. These materials will be segregated and correctly stored and disposed of. Temporary storage of chemical and hazardous waste will take place in separate areas that have impermeable floors, adequate ventilation, and roofs to prevent rainfall from entering. In addition, all chemical wastes will be clearly labeled in English, stored in corrosion resistant containers, and arranged so that incompatible materials are adequately separated. Every effort will be made to arrange for the recycling of any chemical waste generated on-site. Since there is no disposal facility for hazardous wastes within Liberia, these wastes should be shipped to adequate locations out of Liberia. The safe disposal of any hazardous waste generated on site during construction will be a requirement for the contractor. MCC should ensure that the contractor have a plan to safely dispose of hazardous materials.

General refuse generated on-site during the construction phase will be stored in enclosed bins or compaction units separate from construction and chemical wastes. An agreement will be drafted between the contractor and the solid waste collector in the area to identify collection sites and schedule the removal of wastes to minimize odor, pest infestation and litter build-up. The burning of refuse on the construction site will be strictly prohibited and penalized. General refuse is generated largely by food service activities on-site, and as such reusable rather than disposable dishware should be promoted if feasible. Aluminum cans may be recovered from the waste stream by individual collectors if they are segregated and made easily accessible, so separate, labeled bins for their storage should be provided if feasible.

Boundary fencing will be provided around the construction site to intercept litter scattering and could consist of posts bedded in a concrete strip footing. The structural design of fences, gates, and wickets will consider the most unfavorable case of crosswind, pressing larger pieces of waste and matter flying against the fencing line.

7.1.8.2 Facility Operation Phase

Recyclables will be segregated and collected from the general refuse produced at the administrative facility units. The recyclables will be stored in dedicated areas within the facility until collection or transfer to appropriate areas. Chemical/hazardous wastes should be properly contained and disposed.

The compost generated by facility operations will be sold, or distributed to farmers, while any excess will be used as a daily cover for the landfill provided it is properly cured and low in organic and moisture content. The contractor shall provide adequate advertisement and marketing to motivate off-takers thus limiting the amounts of compost diverted into the landfill. The remaining wastes will be placed within the constructed landfill.

The facility will accommodate for an adequate storage area (roofed, impermeable paving, proper drainage and ventilation) with a capacity of at least two day throughput to ensure that wastes are not haphazardly stacked in case of system failure or peak throughputs. In case of long term unscheduled outages in any part of the facility the contractor shall ensure at their own expense alternative disposal of wastes in accordance with applicable regulations until operations are resumed. In addition, the contractor will continuously ensure the cleanliness within the facility as well as the roads within and access roads to it.

Boundary fencing will be provided around the operation site and around working cells to intercept litter scattering. The fence will 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 will take into consideration the most unfavorable case of crosswind, pressing larger pieces of waste and matter flying against the fencing line. Regular collection excursions will be conducted to collect litter from the screens around the perimeter of the site.

No medical wastes, industrial waste, animal carcasses, fish waste, or other obnoxious and environmentally hazardous materials will be accepted at the landfill. As such, inspection of incoming waste will be conducted at the weighbridge. Any load where unaccepted wastes are identified shall be rejected. The identity of the vehicle and drivers as well as the identity of the rejected waste shall be notified to local authorities immediately. Concurrently, a temporary storage area (enclosed with proper ventilation) will be constructed to accommodate for wastes rejected (should be stored in closed containers) at the landfill until further instructions are issued from the local authorities.

7.1.9 Landscape and Visual Intrusion

7.1.9.1 Facility Construction and Site Preparation Phase

During the facility construction and site preparation phase, the site will witness heavy construction activities that will be associated with the presence of the multitude of heavy construction equipment, and construction spoils. As such, the site will be enclosed with non-transparent fencing to minimize the visual impacts on nearby areas. Construction equipment, construction materials, and transport vehicles will be prohibited from parking outside the fenced boundary of the facility.

For all buildings and structures to be constructed, the architectural designs, construction materials and colors must blend with the surrounding features and background as well as help minimize the apparent height and mass of the facility.

During this phase tree planting will be initiated around the sorting and composting units of the facility to ensure proper installation of wind breaks and green belt screen for the operation phase. Trees to be planted will be of at least 1.30 – 1.50 m height. The planting scheme should avoid straight lines and should preferably employ heterogeneous cluster planting.

7.1.9.2 Facility Operation and Post-Closure Phase

Once the construction phase is over, additional random planting is recommended throughout the facility to ensure optimum visual integration of the facility. The site will witness litter blow and heavy activities associated to the presence and movement of a multitude of trucks. It is important to ensure harmonious visual integration of the entire facility within its surroundings.

Planting a green belt around the landfill is not recommended unless required for public security purposes as it might create a visual intrusion in itself by creating an unnatural setting. In addition, building within the facility should be maintained regularly to preserve their architectural and visual appeal. Moreover, landfilling activities should be conducted in small, well defined cells (covered daily) to minimize the areas of waste exposed visually.

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 7-4.

Table 7-4 Mitigation for landscape and visual intrusions

Mitigation Measures	Stage to be Implemented	
	Facility construction and site preparation	Operation
Preserve existing trees on site	√	NA
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 of existing vegetation for all project facilities including building, fencing, and signs	√	NA
Select construction materials for the buildings to help them blend with the background	√	NA
Select architectural designs that will make the buildings blend with the surrounding architectural features of the milieu	√	NA
Comply with the building codes of the area and reducing the construction of elevated structures	√	NA
Provision a greenbelt to bar any unsightly intrusion the project may have on the milieu using indigenous species whenever possible: Initiate tree planting during the construction phase, to ensure proper installation of wind brakes Trees to be planted should be at least 1.30-1.50m height, 10 cm trunk diameter	√	NA
Minimize apparent height and mass of the facility through careful choice of design, layout and colour scheme	√	
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	√	√
√ = Applicable NA = Not applicable		

During the post-closure phase, several measures may be adopted including but not limited to:

- Laying of top soil with minimum compaction to provide a satisfactory growing medium.

- Usage of appropriate gradients to ensure soil stability and prevent soil erosion.
- Ensuring compatibility of final landform with surrounding ground levels and topography.
- Prompt seeding of reclaimed area within the landfill to prevent soil erosion and desiccation as well as enhance the aesthetic property of the affected area.
- Ensuring optimum visual integration of the final landfill from into surrounding landscape through tree/shrub planting.
    - Planting will be conducted in a natural and random planting layout rather than straight line planting.
    - Planted species will be compatible with the surrounding flora.

7.1.10 Biological Environment

The objective of biological control measures is primarily the conservation of ecological features of interest which is typically accomplished through appropriate management of landfill development and rehabilitation as outlined in Table 7-5.

Local communities around the areas should be encouraged to protect the patches of close canopy forests in their vicinities and to limit the extent of agriculture in areas proximal to gallery forests, creeks and swamps. Construction of landfill facilities and the operation of the landfill sites will be limited to areas that are not contiguous with or would not directly affect sensitive sites, such as patches of forest, the creek and swamps in the vicinity of the landfill site.

A regular 3 – 5 years biodiversity monitoring program will be implemented once the landfill site becomes operational. This will serve to inform the authorities of any potential threat or depletion of the biodiversity that may be caused by the landfill operations.

Table 7-5 Biological mitigation measures

Phase	Typical Examples of Biological Mitigation Measures
Facility construction and site preparation	• Secure fencing of areas not required for land-take prior to commencement of work • Minimize the outward light emissions at the facility • Maintain a buffer zone around the site to minimize disturbance to animals • Minimize litter blow by good cover, fencing and hand-picking • Avoid any alteration of the physical and chemical components of the habitat surrounding the facility site • Limit construction to areas that are not contiguous with or would not directly affect sensitive sites, such as patches of forest, the creek and swamps in the vicinity of the landfill site.
Operation	• Maintain a buffer zone around the site to minimize disturbance to animals • Minimize litter blow by good cover, fencing and hand-picking • Minimize the outward light emissions at the facility • Avoid any alteration of the physical and chemical components of the habitat surrounding the facility site
Post-closure	• Using topsoil for the final restoration of the entire site • Lay top soil on landfill with minimum compaction to provide a satisfactory growing medium for final restoration of the entire site • Replant groundcover and trees on affected areas and/or around site boundaries using native species whenever possible. Choice of species should be directed by the following guidelines: o Species compatible with the final soil cover o Species that guarantee quick achievement of a high level of evapotranspiration to considerably reduce the amount of water percolating through the restoration layer o Species available in site surroundings o Species present in similar, comparable areas in terms of bioclimatic conditions o Species that can ensure rapid development in harsh environmental conditions • Species that are available in the commercial market

7.1.11 Landfill Stability

7.1.11.1 Facility Operation Phase and Post-Closure Phase

Mitigation measures for reducing potential landfill settlement include:

- Minimizing the organic content of the waste through effective sorting and composting.
- Ensuring the necessary compaction and uniform placement.
- Ensuring correct management of landfill gases and leachate

Landfill stability during the post-closure phase is assured by properly adhering to the design requirements for slope stabilization and by ensuring that the final cover slope does not exceed a ratio of 1 to 3 (rise : run).

7.1.12 Socio-Economics

Mitigation measures must be taken into consideration to ensure the dissemination of the positive socio-economic impacts of the project on the region both during the construction and operation phases.

During the construction phase, movement and transportation of construction machinery outside the site must be restricted to off-peak traffic hours and nighttime (if noise levels do not exceed the standards). In addition, during both construction and operation, 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 by the operator to the local community by adopting policies to recruit locally and to hire and train local contractors as far as is possible.

Nevertheless, it is projected that due to project location and the limited availability of a skilled workforce in the area, additional workers will be hired from areas outside the project communities. The impacts of the temporary labor influx will be mitigated by instituting and applying a Labor Influx Management Plan as well as a Worker's Camp Management Plan.

The Labor Influx Management Plan will include the following:

- Consultation and involvement of local communities in project planning and implementation.
- Minimizing labor influx by identifying and training local suitable labor workforce wherever possible.
- Setting up formal recruitment offices, advertising and screening potential labor workforce individuals before hiring. Prohibition of hiring "followers" and "at the gate" workers.
- Establishing effective Grievance Redress Mechanisms to manage labor influx related risks.
- Provision of cultural sensitization training for workers, and ensuring all employees understand and sign the Worker Code of Conduct. Provision of packages of information

to workers moving into the area should help them to integrate into the local community more quickly and with less negative consequences.

- Communication with local law enforcement and ensuring laws are followed by employees with provision of sanctions such as dismissal for workers involved in criminal activity. Workers will be asked to undergo mandatory and regular training on required lawful conduct and the legal consequences of failure to comply with the laws.
- Workers will be provided with opportunities to regularly return to their families for visits whenever possible.
- Paying adequate salaries to reduce incentive for theft.
- Creating a Worker's Camp Management Plan which includes provision of services such as health care and leisure activities to reduce the need for workers to use local community facilities.
- Providing information to workers about HIV and EVD prevention; Vaccination of workers against common and locally prevalent diseases.

Employment will include opportunities for both men and women. 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). An on-the-job training program should be implemented for those that do not have adequate skills.

The operation of the Cheesemanburg facility will be linked with negative social impacts that include the perception of being exposed to health risks which may lead to psychological stress. In this case, 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.

A communication plan to engage, consult and inform stakeholders, especially nearby communities of the project, its activities, timelines for operation, and rights of the communities will be developed. In addition, systematic environmental awareness campaigns may be conducted by Monrovia City Corporation to introduce the public at large to the benefits of and the need for solid waste facilities. Publication of date and reports on environmental performance can also be important in terms of providing direct evidence of commitment to effective management.

The instigation of a formal system which responds in a timely fashion to complaints is an important means of building confidence in the operations and management. A clear system of Grievance Redress Mechanisms (GRM) will be put in place by Monrovia City Corporation in order to identify assess, and resolve complaints arising from project activities. The GRM will receive and facilitate resolution of stakeholder concerns and grievances promptly and transparently and in a culturally appropriate way. A Community Liaison Officer will be recruited to communicate with stakeholders potentially affected by the project. Monrovia City Corporation will identify the key stakeholders as well as local and national institutions which may be involved in the grievance issues that may arise due to project activities. An Action Plan will be set out focusing on clear steps that may be taken to address potential grievances.

The Action Plan will include the following points[69]:

- Easily accessible, well publicized Access Points for impacted or concerned stakeholders. These include a Help Desk, a phone hotline, email, and regular mail, SMS, webpage or face to face meetings that can be set up with the Community Liaison Officer. Complainants will receive a receipt as well as an explanation of the work process of complaint resolution and when to expect further information regarding the issue at hand.
- A written Grievance Log record of complaints, including those received verbally. The log should include the type and number of complaint, when and how the complaint was resolved including whether mediation was required for conflict resolution).
- Categorization of the type of issue raised followed by a risk assessment and assignation for appropriate follow up. Responsibility for response to the grievance will depend on the risk assessment. Low risk complaints may be resolved by the project manager, while more serious complaints may need to be addressed directly by Senior Management or

[69] The World Bank's Approach to Grievance Redress in Projects (2014)

senior staff at Monrovia City Corporation. High risk grievances may need to be submitted to and addressed by the World Bank.

- A clear appeals process will be delineated and offered to the complainant should an agreement not be reached.
- A World Bank Grievance Redress Service (GRS) will also be delineated and will detail out an option for aggrieved to file complaints directly to the Bank without going through the project-level GRM. The World Bank GRS Brochure is included as Appendix G
- Resolution, monitoring reports and Follow-up of implemented and agreed plan will be noted in the Grievance Log.

As the landfill site is anticipated to attract scavengers it is strongly recommended to prohibit scavenging unless at least the following conditions are met (World Bank, 2007):

1. The scavengers are employed /registered under an entity specialized in MSW management facilities and registered and certified by the various agencies of the Government of Liberia especially MCC and EPA.
2. These entities should also be equipped with the appropriate infrastructure and scavenging tools (such as shoes, gloves, protection gear, etc.)
3. Only adults should are to be employed/registered with such entities.
4. Water supply for washing and areas for changing clothes are provided.
5. Implementation of health surveillance for workers as well as regular vaccination and health examinations.
6. Provide educational programs with regard to sanitation and hygiene.

The contractor shall examine means for potential economic benefits at the local level with EPA and local authorities (direct/indirect tax incentives, employment). In this respect, the introduction of a "host community fee" should be considered. In general, this fee consists of a set payment to the local community or municipality for each tonne of waste deposited in the area. Such approach could be successful means of helping local communities adapt to the presence of landfills in their areas, and allows facilities to be planned, constructed, and operated with maximum support from the local community.

7.1.13 Traffic

7.1.13.1 Facility Construction and Site Preparation Phase

Primary measures adopted to mitigate traffic impacts during the contraction phase include the correct dissemination of information regarding the construction schedule, as well as providing alternate routes when needed and when feasible during all phase of construction.

In this respect, proper planning and development of a traffic control plan that takes into account the reservations and inputs of nearby residents is essential to minimize the effects and potential inconvenience of construction activities on commuters as well as ensure the safety of motorists, pedestrians and workers in the vicinity of construction zones. For this purpose, adequate warning, signing, delineation, and channeling are needed at least 500 m down and up-gradient from the construction site. Preliminary routing schemes covering various construction phases must be developed and communicated early on to the public. Limiting the movement of heavy machinery during the construction phase to off-peak hours and providing prior notification are crucial measures to minimize the potential negative impacts of traffic.

The access roads to the site should be constructed to accommodate for heavy duty vehicles of up to 40 tonnes brut weight.

The contractor shall develop a traffic re-routing plan for the construction phase and take into consideration the possibility of night construction provided it does not disturb neighboring residents and commercial facilities. The contractor shall also present detailed plans for utility relocation (whenever applicable) that is approved by concerned agencies before initiation or construction activities. Without compromising the safety of workers, pedestrians, or vehicles, traffic roads shall be re-opened as early as possible to minimize the impacts on traffic during the construction period. A summary of specific measure to be undertaken to control traffic impacts during construction are presented in Table 7-6.

Table 7-6 Measures to be undertaken by the contractor

Supervising Consultant with local authority	Contractor
Dissemination of information regarding construction schedule	Guiding motorist through construction zones
Planning and development of traffic control and re-	Installation of warning signs in and around the site

routing plan during all phases of construction	
Traffic monitoring and guiding of motorist outside the boundaries of the site.	

7.1.13.2 Facility Operation and Post-Closure Phases

During operations, environmental impacts associated with waste transport 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 will be applied to site operations from the point of collection of the waste to the point of return of any vehicle having deposited the waste. As such, one-way traffic networks within the site will be favored whenever deemed possible. The contractor will develop a site-specific waste transport plan to ensure safe transportation of solid wastes to the site. 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 discharge 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 7-7 provides examples of each category.

Table 7-7 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 • Speed restrictions on vehicles hauling materials from and to the site

7.1.14 Cultural Heritage

During the facility construction and site preparation phase of the landfill, chance-find procedures should be adopted (Appendix E). In the event where archaeological remains are found, facility construction and site preparation activities should be suspended and notice should be given to concerned authorities.

7.1.15 Landfill Closure

The most important element in the long term maintenance of a completed landfill is the availability of a closure plan within which the requirements for closure are delineated clearly. A closure plan for the Cheesemanburg sanitary landfill will include provisions for:

- Cover and landscape design.
- Control of landfill gases.
- Collection and treatment of leachate.
- Environmental monitoring systems.
- Routine inspections.
- Infrastructure and landscape maintenance.
- Emergency response plan.

7.1.16 Summary of Mitigation Measures

Table 7-8 and Table 7-9 presents a summary of proposed mitigation measures during both the facility construction and site preparation phase and operation and post-closure phase. The cost of the implementation of mitigation measures will be part of the cost allocated for the facility design, construction, site preparation as well as the cost of the operation activities during the operation phase. The implementation of the mitigation measures will be the responsibility of the contractor and the Landfill owner (MCC) under supervision of a consultant, EPA, and concerned local authorities. MCC should enforce the implementation of mitigation measures and management plans specifically the Health and Safety Plans and Grievance mechanisms on all the contractors on site, by including these requirements in the contractors' contracts and adding it in the budget of the projects.

Table 7-8 Summary of facility construction and site preparation phase mitigation measures

Impact	Facility construction and site preparation phase mitigation measures

Surface and Groundwater Quality	**Landfill proper design** • Install a proper liner system based on extensive geological hydrological and geotechnical studies of the site; an example of a combined impermeable liner system consist of the following components: (1) 2 layers of compacted clay (2) geomembrane (3) drainage layer (4) geotextile and (5) soil layer. **MRF and composting plants proper design** • Minimize the amount of precipitation coming into contact with the waste during all stages. • Enclose all facility units with roofed structures and all curing areas shall utilize permanent roof structures to control moisture and minimize liquid waste generation. • Adopt designs for the MRF and compost facility that accommodate for slightly inclined ground surface to ensure proper liquid waste drainage. • Provide the facility with an adequate Solid Waste storage area (roofed, impermeable paving, proper drainage and ventilation) with a capacity of at least two consecutive days throughput. • Retain a sufficient unsaturated zone to provide liquid waste attenuation in case of a leakage. **Effective facility drainage** • Divert surface and storm water away from the facility • Direct all site runoff into site storm drains along with adequately designed sand/silt/debris removal techniques such as sand traps, silt traps and sediment basins. • Regularly maintain silt/debris removal facilities. • Discharge rainwater pumped out from trenches or foundation excavations into storm drains via silt removal units. **Facility construction and site preparation activities** • Cover open stockpiles of construction materials with tarpaulin or similar fabric during rainstorms events. • Compact earthworks as soon as the final surfaces are formed to prevent erosion. • Contain domestic wastewater from the construction site's toilets, kitchens and similar facilities in sanitary septic tanks before being transported by trucks to the wastewater treatment station or to a wastewater disposal site. • Clean up immediately any accidental spillage of oil, fuel or chemical.
Soil and Compost Quality	• Install a combined impermeable liner system to limit contact of generated leachate with the on-site and surrounding soil. Liner should consist of the following components: (1) 2 layer compacted clay (2) geomembrane (3) drainage layer (4) geotextile and (5) soil layer. • Ensure proper facility drainage in order to control surface runoff that may serve as a transport media for any potential pollutants. • Maintain proper housekeeping practices (proper storage and disposal of chemicals on site, additional to immediate clean-ups and containment).
Air Quality	**Facility construction and site preparation activities** • Install windbreaks or source enclosures (such as trees, fences, plastic mesh, etc.) to reduce surface wind speed. • Maintain good housekeeping practices including elimination of mud/dirt carried out on paved roads at the construction site, periodic removal of dust-producing materials. • Minimize PM emissions by regular watering of surfaces. **Equipment & machinery** • Ensure good quality of diesel fuel used with on-site equipment. • Turn off all equipment when not in use. **Transportation**

	• Cover the road surface with a new material of lower silt content. • Maintain roads regularly. • Maintain trucks and on-site equipment. • Adopt a traffic management plan while avoiding congested and sensitive routes.
Odour	• Removed existing waste to a temporary lined area. • Conduct initial screening and floor sorting for existing waste. • Cover existing waste with a top soil layer.
Health and Safety	• Restrict access to the construction site by proper fencing. • Establish buffering areas around the site. • Provide guards on entrances and exits to the site. • Install warning signs at the entrance of the site to prohibit public access. • Provide training to staff about the fundamentals of occupational health and safety procedures. • Provide appropriate personal protective equipment, and personal handheld gas detectors. • Keep uniforms and PPE clean and in good condition and replace them at least on a semi-annual basis. • Provide personal ID cards for all employees. • Monitor explosive and flammable gas buildup. • Provide adequate loading and off-loading space. • Develop an emergency response plan. • Provide on-site medical facility/first aid. • Provide appropriate lighting during night-time works. • Implement speed limits for trucks entering and exiting the site and from the highway. • Installing retaining nets to hold falling debris during, site clearing. excavation, and construction. • Provide environmental friendly fire-fighting equipment such as dry powder extinguishers within the premises of the facility. • Conduct annual fire-fighting and leak checks training drills for the operating staff. • Prohibit smoking as well as litter or weed build-up in the area as these may pose fire risks.
Noise	• Erect noise barriers along active work sites and along sensitive route roadside. • Operate only well-maintained equipment and machinery. • Shut down equipment that may be intermitted in use between work periods or throttle them silencers or minimum. • Utilize silencers or mufflers on construction equipment. • Use material stockpiles and other structures to screen noise from on-facility construction and site preparation activities. • Schedule noisy activities during daytime periods. • Install noise reducing road surfaces such as quiet pavements. • Select quieter equipment and machinery whenever possible.
Waste Generation	• Use to the extent possible the generated construction debris in filling activities or stockpile and store for future use as daily cover within the landfill. • Reduce or eliminate over-ordering of construction material. • Arrange for the recycling of any chemical waste generated on-site. • Hazardous waste should be properly contained. • Store general refuse generated on-site in enclosed bins or compaction units separate from construction and chemical wastes. • Prohibit burning of general refuse. • Promote reusable rather than disposable dishware. • Fence the construction site to intercept litter scattering.
Landscape and Visual Intrusion	• Select construction materials, architectural designs and colour schemes that will naturally blend into the landscape for all project facilities including buildings, fencing, and signs. • Incorporate underground utilities (to the extent possible) to house electrical, storage,

	and operational equipment. • Minimize apparent height and mass of the facility through careful choice of design, layout and colour scheme. • Enclose active site with non-transparent fencing to minimize visual impacts. • Prohibit vehicles from packing outside the fenced boundary of the site. • Preserve existing flora cover when feasible. • Initiate tree planting around sorting and composting units to ensure proper installation of wind breaks and green belt screen using indigenous species whenever possible.
Biological Environment	• Secure fencing of areas not required for land-take prior to commencement of work. • Minimize the outward light emissions at the facility. • Maintain a buffer zone around the site to minimize disturbance to animals. • Minimize litter blow by good cover, fencing and hand-picking. • Avoid any alteration of the physical and chemical components of the habitat surrounding the facility site.
Socio-Economics	• Give priority to the local community in the immediate vicinity of the site in terms of providing job opportunities. • The scavengers are employed/registered under an entity specialised in MSW management facilities that are registered and certified by the various agencies of the Government of Liberia especially MCC and EPA. • These entities should also be equipped with the appropriate infrastructure and scavenging tools (such as shoes, gloves, protection gear, etc.) • Only adults should are to be employed/registered with such entities. • Water supply for washing and areas for changing clothes are provided. • Implementation of health surveillance for workers as well as regular vaccination and health examinations. • Provide educational programs with regard to sanitation and hygiene.
Traffic	• Develop and implement a preliminary traffic plan with a detailed routing scheme that takes into consideration the possibility of night-time activities, congested areas as well as sensitive areas so as not disturb residents and commuter. • Provide and independent access road to the site accommodating for heavy duty vehicles of up to 40 tons weight and sufficient width for two moving trucks (approximately 8 m). • Disseminate information regarding the construction schedule and traffic plan. • Provide alternate routes when needed and when feasible. • Install adequate warning, signing, delineation and channelling at least 500 m down and up-gradient from the construction site. • Restrict movement and transportation of construction machinery outside the site to off-peak traffic hours and during night time.
Cultural Heritage	• Adopt chance-find procedures. • In the event where archaeological remains are found, construction activities should be suspended and notice should be given to the concerned authorities.

Table 7-9 Summary of facility construction and site preparation phase mitigation measures

<table>
<tr><th>Impact</th><th>Operation and post-closure phase mitigation measures</th></tr>
<tr><td>Surface and groundwater quality</td><td>
Liquid waste management system at MRF and Composting plants

Control, collect, store, treat and monitor the generated liquid waste on-site

The recommended liquid waste barrier system is an impermeable flooring pad of properly mixed cement and adhesive liquid waste resistant material.
The liquid waste collection system must include a drainage system independent from the wastewater collection system to collect the liquid waste and washwater generated from the different stages.
Liquid waste must be collected and stored in a tank designed to cater for a volume of liquid waste and washwater generated over a period of 3 consecutive days. The tank should also be secured through an impermeable layer of properly mixed mix cement and adhesive liquid waste resistant material.

Waste placement and daily cover at the landfill

Use intermediate/daily covers from soil or compost with a thickness of at least 10 cm and a slope ranging between 2-5% (not to exceed a gradient of 1 in 3).
Install intermediate drainage layer.

Top cover and surface runoff drainage at the landfill

Install a multi-layer top cover with low permeability cap.
Install a recuperation canal system to control and manage rainfall runoff from the surface of the closed landfill cells.

Leachate management at the landfill

Implement a leachate management system that drains, collects and treats the generated leachate.
Install a combined leachate drainage system: sloped terrace and perforated pipes.
Treat leachate on-site in a leachate treatment plant.
Minimize the amount of precipitation coming into contact with the waste.
Control liquid waste inputs.
Retain a sufficient unsaturated zone to provide leachate attenuation in case of leakage.
Implement a rigorous monitoring plan.

Domestic wastewater

Collect all domestic wastewater resulting from the administrative buildings and workers facilities and transfer them to the planned wastewater treatment station or to a wastewater disposal site, or discharge into the planned sewage network, if it complies with the national standards.

Facilities cleaning, maintenance and waste transportation

Manage any contaminated cleaning and drainage water from vehicle and plant serving areas, as well as oil and lubricants generated from maintenance workshops on-site.
Minimize water use during cleaning of working areas and vehicles (e.g. adopting dry cleaning practices prior to water cleaning.
Collect, store and treat the generated wash water “liquid waste” from facility operations and the liquid waste from storage tanks of the vehicles transporting waste with the leachate.
Contain and clean up any oil leakage or spillage.
Equip the facility with a wheelwash.
Equip all vehicles transporting waste or materials that could leak-with drainage tanks.

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Impact	Operation and post-closure phase mitigation measures
Soil and Compost Quality	**Facility operation-composting** • Monitor the compost quality to assure that contaminant levels are lower than specified guidelines. • Manage the compost to attend and then maintain a sufficiently high internal temperature for the duration required to reduce pathogens. • Assure the production of good quality compost that does not pose negative environmental impacts or health hazards. • Ensure low heavy metal concentrations within the final product through different separation processes. • Apply proper use and application rates of compost in compliance with national and international standards for application. • Send quarterly reports to the concerned authorities. • Train and inform farmers about the frequency and volumes of application of the compost. **Facility operation-landfill** • Implement a proper leachate collection, storage and on-site treatment management system. • Collect, store and treat the generated wash water "liquid waste" from facility operations and the liquid waste from storage tanks of the vehicles transporting waste with the leachate. **Waste transportation** • Sheet all vehicles delivering wastes and removing residues. • Ensure that vehicles and containers are appropriate to the quantity and quality of waste transported and that they are adequately maintained. • Equip all vehicles transporting waste or materials that could leak-out with drainage tanks. • Equip the facility with a wheelwash.
Odor	**Proper design-MRF and composting** • Ensure enclosed storage and processing area which are mechanical ventilated. Treat the ventilated air from the com posting unit with a biofilter. • Ensure that all active area should be under a negative atmospheric pressure and the location of facility entrance should be oriented opposite the wind direction in order to avoid the migration of any generated odors into the surrounding environment. **Waste handling and processing** • Ensure that all sorting activities are conducted within 12 hours following waste delivery. • Maintain adequate aeration rates during the composting process. **Leachate/Liquid waste management** • Collect, properly store and treat on-site all generated leachate and liquid waste. **Facility operation-Landfill** • Implement the gas management system to collect and flare the gas in an enclosed facility. • Use of an intermediate/daily cover. • Deploy good housekeeping practices. **Waste transportation** • Sheet of vehicles delivering wastes and removing residues. • Ensure that vehicles and containers are adequate for the quantity of waste transported and that they are properly maintained.

Impact	Operation and post-closure phase mitigation measures
Air quality	**Proper design-MRF and composting** • Ensure enclosed storage and processing area which are mechanical ventilated. • Equip the composting unit with a biofilter and a fabric filter. **Waste handling and processing** • Minimize the emission of airborne pathogens from the compost by maintaining adequate moisture levels and by ensuring homogenous stabilization. **Landfill operation** • Implement the gas management system to collect and flare the gas in an enclosed facility. • Use of intermediate/daily cover. • Deploy good housekeeping measures. • Pave or use of suppressants to mitigate dust emissions. **Waste transportation** • Sheet of vehicles delivering wastes and removing residues. • Ensure that vehicles and containers are adequate for quantity of waste transported and that they are properly maintained. • Use collection trucks that are no more than 10 years of age.
Health and safety	• Site security. • Site safety. • Site facilities. • Environmental controls. • Waste transportation. • Waste trucking system. • Emergency/contingency plans. • Workers hygiene. • Personnel protection. • Firefighting.
Noise	• Schedule collection and transport of the solid wastes either in the early morning hours or late in the afternoon. • Install mufflers and noise barriers around air blowers and pumps. • Enclose noisy equipment. • Erect noise barriers along active work sites • Implement and rigorous inspection and maintenance program applicable to all equipment and machinery.
Waste Generation	• Store collection recyclables in a dedicated area within the facility unit purchase. • Sell or distribute generated compost to farmers, while any excess should be used as a daily cover in the landfill. • Provide the facility with an adequate Solid Waste storage area (roofed, impermeable paving, proper drainage and ventilation) with a capacity of at least two consecutive days throughput. • Clean continuously litter within closed facilities as well as on all roads within the site including access roads. • No medical waste, industrial wastes, animal carcasses, fish waste, or other obnoxious and environmentally hazardous materials shall be accepted at the landfill. • Conduct regular inspection of incoming wastes at weighbridges. • Record daily quantities of incoming wastes at the entrance of the facility. • Maintain fences constructed to intercept litter scattering.

Impact	Operation and post-closure phase mitigation measures
Landscape and visual intrusion	**Structures and planting** • Maintain the buildings within the site to preserve their architectural and visual appeal. • Use appropriate gradients to ensure soil stability and prevent soil erosion. • Ensure compatibility of final landform with surrounding ground levels and topography. • Ensure storage of waste and equipment in proper location. • Planting trees throughout facility site is recommended to ensure optimum visual integration of the facility especially from top viewers while avoiding straight lines trees species. **Landfilling** • Conduct landfilling activities in small, well defined cells (covered daily) to minimize the areas of waste exposed visually. • Use appropriate gradients to ensure soil stability and prevent soil erosion. **Final landfill form** • Using appropriate gradients to ensure soil stability and prevent soil erosion. • Ensuring compatibility of final landform with surrounding ground levels and topography. • Prompt seeding of reclaimed areas within the landfill to prevent soil erosion and desiccation as well as enhance the aesthetic property of the affected area. • Ensuring optimum visual integration of the final landfill form into the surrounding landscape through trees/shrub planting. o Planting should be conducted in a natural and random planting layout rather than straight line planting. o Planted species should be compatible with the surrounding flora
Biological environment	• Avoiding any alternation of the physical and chemical components of the habitat surrounding the facility site. • Lay top soil with minimum compaction to provide a satisfactory growing medium for final restoration of the entire site. • Maintain a buffer zone around the site to minimize disturbance to animals. • Minimize litter blow by good cover, fencing and hand-packing. • Minimize the outward light emissions at the facility. • Replant groundcover and trees on affected areas and/or around site boundaries using native species whenever possible. • Using topsoil for final restoration of the entire site.
Landfill stability	• Minimize organic content through effect sorting and composting. • Ensure the necessary compaction and uniform placement of the waste. • Ensure that the final cover slope does not exceed 1 to 3 (rise: run).
Socio-Economics	• Instigate a formal complaints system which responds in a timely fashion to complaints about nuisances with clear Grievance Redress Mechanisms in place. • Publish data and reports on environmental performance of the facility. • Provide economic incentives to communities by adopting policies to recruit locally and to hire local sub-contractors when possible. • Instituting a Temporary Labor Influx Management Plan • Instituting a Worker's Camp Management Plan

Impact	Operation and post-closure phase mitigation measures
Traffic	• Develop and implement a site-specific waste transport plan to ensure safe transportation of solid waste to the site as well as minimize traffic and congestion impacts that may incur from the operation of the facility. • Provide maximum turning space and sight lines for vehicles at both the entrance and exit. • Ensure vehicle movement in the direction of predominant traffic flow. • Ensure adequate off-loading and loading space to allow vehicles sufficient area to wait on-site. • Ensure adequate off-street parking for employees. • Maintain one-way traffic within the site to prevent obstruction to vehicles entering and leaving. • Implement speed restrictions on vehicles entering and leaving the site.

7.2 Environmental Monitoring Plan

Impact and compliance monitoring are necessary during the construction and site preparation phase and the operation and post closure phases of the Cheesemanburg landfill facility with the main objectives being to:

- Monitor 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.

Monitoring of air quality, surface water quality, noise levels, groundwater quality, leachate quality, soil quality, odors, waste management practices, traffic, health and safety, landscape, and socio-economic indicators is outlined below for the Cheesemanburg facility. 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 personal 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 contractor as necessary and according to the final design of the Cheesemanburg sanitary landfill. Equivalent procedures, methods, and equipment are acceptable pending approval of concerned authorities. Flexibility in implementation is essential as long as the objectives are met.

7.2.1 Air Quality and Gas Emissions

During construction, air quality will be monitored in terms of construction dust (PM-10 and PM-2.5). During the operation and post-closure phases, the main source of air pollution will be the generated landfill gas, gaseous emissions resulting from the adopted composting scheme, as well as emissions resulting from on-site combustion sources.

7.2.1.1 Criteria

WHO standards can be adopted in the evaluation ambient air quality indicators (Table 7-10). In addition, World Bank Standards will be adopted in evaluating on-site emissions from combustion sources (Table 7-11).

Table 7-10 Recommended standards for atmospheric pollutants (WHO, 2000)

Parameter	Maximum levels in μg/m^3	Averaging Time
Sulphur Dioxide (SO_2)	500 125 50	10 minutes 24 hours annual
Nitrogen Dioxide (NO_2)	200 40	1 hour annual
Carbon Monoxide	100000 60000 30000 10000	15 minutes 30 minutes 1 hour 8 hours
Suspended Particulates PM < 10 microns	70 150	1 year 24 hours

Table 7-11 Standards for stack emissions from combustion plants (World Bank, 2007)

Parameter	Emission Limit Value (3 MWth – 50 MWth) – (mg/Nm^3)
O_2	15%
PM	NA

Parameter	Emission Limit Value (3 MWth – 50 MWth) – (mg/Nm^3)
Nitrogen Dioxide (NO_2)	200 (Spark Ignition) 400 (Dual Fuel) 1,600 (Compression Ignition)
Sulphur Dioxide (SO_2)	NA

7.2.1.2 *Methodology*

7.2.1.2.1 *Construction Phase*

The 1-hr and 24-hr Total Suspended particles (TSP) /PM-10/PM2.5 levels will be measured to delineate the temporary impact of construction dust. Both measurements will 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 ºC followed by accurate weighing. The average TSP/PM-10/ PM2.5 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 will be provided to secure the samples against gusty winds; airflow around the sampler will be unrestricted (a portable high-volume sampler can also be used).
- Any wire fence or gate to protect the sampler will not obstruct airflow.
- The distance between the sampler and an obstacle (i.e. building) will be at least twice the height that the obstacle protrudes above the sampler.
- No furnace or generator will be nearby.
- A secured supply of electricity is needed to operate the sampler.

An alternative means of measuring 1-hr averaged TSP/PM-10/ PM2.5 concentrations is through a hand-held particle counter (capable of sampling in the range of 0.1-100 mg/m^3). This method does not require laboratory analysis and gives instant TSP/PM-10/PM2.5 readings. Air samples are drawn for a period of one hour and the device provides the time-averaged TSP/MP-10/ PM2.5 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 will also be recorded at monitoring locations. Wind sensors will 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 will 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 will be recorded in detail.

7.2.1.2.2 *Operation Phase and Closure and Post Closure phase*

During operation and post closure, landfill gas monitoring will be conducted at predefined gas monitoring wells. Landfill gases including CH_4, CO_2, and trace organics will be measured using a portable gas analyzer fitted with a probe. In addition, monitoring of emissions generated from on-site machinery and generators will be conducted in terms of flue gas temperature oxygen level, combustion efficiency, flue gas concentrations of CO, NO_2, SO_2, TSP/PM-10/ PM2.5. Parameters such as weather conditions, elapsed-time meter reading for the start and stop of the sampler, date and time of sampling, and work progress of the concerned area should be recorded. A continuous meteorological monitoring station will be installed on-site to monitor wind speed and direction, ambient temperature, rainfall, and incoming solar radiation. Recorded data may be collected remotely through a central personal computer (PC) located within the facility or downloaded periodically (in the lab or in a control room).

The 1-hr and 8-hr ambient landfill gas constituents and combustion sources will be measured on-site. Landfill gas measurements will be conducted using an infrared absorption gas analyzer (hand-held or stationary) or similar. Most analyzers give instantaneous readings which are stored and averaged over the sampling period (8 or 1 hour). Flue gases will be measured using a combustion gas analyzer fitted with a probe. Equipment calibration will be conducted prior to implementation of the monitoring program, and as specified by the manufacturer. When positioning the sampler, the following points should be noted:

- Any wire fence or gate to protect the sampler should not obstruct air flow.

- No combustion source should be present in the vicinity of the sampling equipment.

Relevant data including temperature, pressure, weather conditions, elapsed-time meter reading for the start and stop of the sampler, date, and time of sampling, and work progress of the concerned area should be recorded in detail.

7.2.1.2.3 *Monitoring Locations*

TSP/PM-10 monitoring stations during the construction phase should be located at the nearby receptors and the site proper. During the operation and post-closure phases, landfill gas measurements will be conducted at gas wells while methane concentrations will be monitored within the compost plant. Emissions from combustion sources will be conducted individually at the stack of each source.

7.2.1.2.4 *Frequency*

During construction, a sampling frequency of once a month will be observed at all monitoring stations 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/PM2.5 monitoring could be conducted on a weekly basis. During operation, monthly measurements will be observed at all monitoring stations for ambient 8- hour monitoring of landfill gas. In case of complaints or whenever the highest impacts are likely to occur, 1-hour monitoring will be conducted on a weekly basis. In addition, monitoring of CH_4 will be conducted on a monthly basis during operation within the composting plant. After closure, quarterly monitoring of landfill gas will be conducted. Combustion sources will be monitored on an annual basis.

7.2.2 Noise

During both facility construction and site operation phase, noise levels will be monitored at sensitive receptors.

7.2.2.1 *Criteria*

During the facility construction and site preparation phase, noise levels will be evaluated against values indicated in Table 7-12 in order to determine any impact on the facility operators and workers.

Table 7-12 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

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 7-13), as well as the Federal Highway Administration (FHWA) noise abatement criteria (Table 7-14). In addition, occupational noise exposure should be assessed with respect to the standards promulgated by Occupational Safety and Health Administration (OSHA) (Table 7-12).

Table 7-13 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 7-14 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.

7.2.2.2 *Methodology*

Sound level meters will be used to measure noise levels in terms of Leq, in dBA. Calibration of the meters will be conducted before and after each monitoring round, using a portable calibrator or similar. Calibrated hand-held anemometers will be used for the measurement of wind speed during noise monitoring periods. Noise monitoring will 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 5m/s or wind gusts exceeding 10 m/s. The monitoring locations will 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 will be recorded concurrently with noise measurements.

7.2.2.3 Monitoring locations

During both the facility construction and site preparation phase and operation phase noise monitoring will be conducted at:

- Facility site to determine any impact on facility workers and
- 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 will be readily conducted whenever any complaints are filed.

7.2.2.4 Frequency

A sampling frequency of once a month during both the construction and operation phases 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.

7.2.3 Surface water, Groundwater, and Leachate

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

Before the initiation of any works on site, surface water and groundwater quality will 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 and post-closure phases.

In addition surface and ground water level and flow will be monitored to have a clear idea of the water flow system which helps to detect the extent and direction of any leakage or impact in case it happens.

A comprehensive surface water, groundwater, and leachate monitoring sampling program will be implemented during the operation and post-closure phases targeting several physical, chemical, and biological parameters as presented in Table 7-15.

A detailed water monitoring protocol should be developed by the Contractor in collaboration with the responsible authorities.

Table 7-15 Proposed surface, groundwater, and leachate monitoring parameters

Water resources and leachate	Monitoring indicator parameters
Surface water/ Groundwater	• Temperature • pH • Electrical Conductivity (EC) • Ammonia • Nitrate • Nitrite • Phosphate • Manganese • Total Phosphorous • Total Suspended Solids (TSS) • Biochemical oxygen demand (BOD) • Dissolved oxygen (DO) • Total Organic Carbon (TOC) • Total Coliform, Salmonellae, Fecal Coliform, Escherichia coli, Fecal Stretococus • Iron • Phenols • Metals (Chromium, Cadmium, Copper, Zinc, Nickel, Mercury, Lead)

Water resources and leachate	Monitoring indicator parameters
Leachate (before and after treatment)	• Volume • Temperature • pH • Ammonia • Nitrate • Manganese • Total Phosphorous • Total Suspended Solids (TSS) • Biochemical oxygen demand (BOD) • Dissolved oxygen (DO) • Total Coliform, Fecal Streptococcus, Salmonellae • Phenols • Metals (Chromium, Cadmium, copper, Zinc, Mercury, Lead)

7.2.3.1 Criteria

The standards or criteria against which surface water and groundwater quality will be assessed are presented in Table 7-16 and Table 7-17.

Table 7-16 Standards for drinking water quality (WHO)

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

Table 7-17 Recommended effluent standards for landfill (USEPA)

Parameter	Unit	Guideline	
		Daily	Monthly
BOD_5		140	37
pH		6-9	69
Total Suspended Solids (TSS)	mg/l	88	27
Ammonia as N	mg/l	10	4.9
Arsenic	mg/l		
Chromium	mg/l		

Parameter	Unit	Guideline	
		Daily	Monthly
Zinc	mg/l	0.20	0.11
a Terpineol	mg/l	0.033	0.016
Aniline	mg/l		
Benzoic Acid	mg/l	0.12	0.071
Naphthalene	mg/l		
p-Cresol	mg/l	0.025	0.014
Phenol	mg/l	0.026	0.015
Pyridine	mg/l		

7.2.3.2 Water level and flow methodology

Multi-level monitoring wells should be drilled on site to assess the water level and flow within the different lithology on site. One well should be installed on the highest elevation onsite and at least three other wells on different sides of the site to identify water flow directions.

Pumping tests and continuous water level probes should be installed in wells to obtain data on depth and yield of aquifers, recharge basins, groundwater flow direction.

Water level probes should also be installed on the Po River and Dima creek for continuous monitoring and monthly flow measurements should be performed monthly for at least a year to cover dry and wet seasons to be able to compare this data with the concentration of contaminants throughout the seasons.

7.2.3.3 Sampling Methodology

Surface, groundwater, and leachate samples will be collected and placed in pre-cleaned (1 liter) plastic/glass bottles depending on the target analysis. After collection, the bottles will be properly sealed and placed in a cooler at a temperature below 4 ºC and transported to the laboratory facility for analysis preferably within 24 hours after the sampling time. A Global Positioning System (GPS) will be used to approximate the geographic coordinates of each location. In addition, groundwater samples will clearly indicate the location of the well and its corresponding depth. Relevant data including monitoring location/position, depth, time, weather conditions (wind speed and direction, ambient temperature, precipitation), and work progress will be recorded concurrently. In-situ monitoring instruments will be checked and calibrated prior to usage and as per manufacturer specifications. Responses of sensors and electrodes will be checked with standards solutions before each use. In addition to on-site analysis, duplicate samples will be sent to reputable off-site laboratory facilities for quality assurance and quality control (QA/QC) purposes.

7.2.3.3.1 *Water Courses*

Sampling will 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 center current to collect the sample. When collecting a water sample for analysis in the field follow the steps below:

a. Wear sterile gloves to keep your hands safe and to make sure the sampling bottles are not contaminated.
b. Avoid touching the inside of the bottle or of the cap. If you accidentally touch the inside of the bottle, use another one.
c. Stand facing upstream.
d. Immerse the container in the water on its side before opening it.
e. Open the Container in the water
f. Push the bottle underwater into the current and away from you facing upstream.
g. Fill the container by moving it up and down in the water column, tilting the opening up slightly and trying to fill it as slowly as possible to get a depth integrated sample.
h. Put the cap back on under water and try to avoid trapped air bubbles.
i. Carefully label the sample bottle using a permanent marker, noting the date, time and monitoring location ID.
j. Store the sample in cool and dark conditions by placing the sample bottles in a cool box containing ice.
k. Fill in the appropriate information in the field data sheet.
l. If sampling in deep water, use an extension cord and a container to sample the water then fill it in the sampling bottles.

7.2.3.3.2 *Wells*

a. Wear sterile gloves to keep your hands safe and to make sure the sampling bottles are not contaminated.

b. If sampling from an actively used well or hand pump: pump the water and fill the bottles to the top avoiding overflowing and trapped air bubbles.
c. If sampling from a well/ hand pump that was not used for a significant time:
    i. Purge the well/ hand pump by pumping 3 volumes of the well before collecting the sample. (In case of water shortage and to prevent wasting water, 1 volume of the well can be purged)
    ii. Collect a sample by filling the bottles to the top and avoiding overflowing and trapped air bubbles.
d. Carefully label the sample bottle using a permanent marker, noting the date, time and monitoring location ID.
e. Store the sample in cool and dark conditions by placing the sample bottles in a cool box containing ice.
f. Fill in the appropriate information in the field data sheet.
g. Measure the water level.

7.2.3.4 Location

Surface water quality samples should be collected from the PO River, upstream and downstream of the landfill site; from the Dima creek, upstream and downstream of the landfill site; from the creeks and swamps around the landfill site and from the drainage channels to identify chemical spills or soil erosion problems during both the construction and operation phases. Water level probes and flow measurement should also be performed on the Po River and Dima creek.

At least four multi-level monitoring wells should be drilled on site to assess the water level and flow within the different lithology on site. One well should be installed on the highest elevation onsite and at least three other wells on different sides of the site to identify water flow directions. Groundwater samples will be collected from these monitoring wells. In addition, groundwater samples should be collected from wells in the surrounding communities.

Leachate samples will be collected during the operation and post closure phases from monitoring wells within the site and at the discharge points of the leachate collection system. Additional samples may be required (during the operational phase) to monitor the water quality of the leachate receiving water bodies.

7.2.3.5 Frequency

The testing frequency of surface and groundwater that should be followed is defined in Table 7-18, while the testing frequency for leachate during operation and post-closure is presented in Table 7-19.

Table 7-18: Surface and groundwater sampling frequency.

Stage	Frequency
Pre Works	Once
Construction and Site Preparation	Three times
Operational Landfill	Monthly
Post-Closure	Quarterly for ten years thereafter or as agreed with the concerned authorities

Table 7-19 Leachate sampling frequency

Stage	Parameter	Frequency
Operation	Leachate Volume	Weekly
	Leachate Quality	Weekly for pH, temperature, electrical conductivity
	Leachate Quality	Monthly for all parameters defined in Table 7-15.
Post Closure	Leachate Volume	Quarterly for ten years
	Leachate Quality	Quarterly for ten years for all parameters defined in Table 7-15

7.2.4 Solid Waste Generation

Following the initiation of construction activities, construction spoils and construction-related materials will be monitored on a quarterly basis during the construction phase.

During the operation phase, site audits on the general refuse streams will be conducted to examine existing waste management and handling procedures that include storage, segregation, composting, recycling, transport, as well as deposal. The objectives of the audit are to ensure that the incoming 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.

The contractor/operator shall adopt a scientifically proven leachate treatment option in consultation with the EPA.

During operation, daily quantities of incoming wastes will be recorded at the entrance of the facility. In this respect, all waste delivery vehicles entering the site are required to weigh incoming and outgoing waste trucks over a weighbridge. The weighbridge will be of electronic type and linked to a PC to provide automatic recording of the weight loads. A random solid waste sampling program will also be implemented during the operation phase, whereby two representative samples of minimum 500 kg each are analyzed on a quarterly basis. Analysis will determine the percent composition by weight and volume (paper, cardboard, plastic bottles, plastic bags, other plastics, multi-material packing, textiles, composite materials, non-ferrous metals, construction waste and soils, fine waste<10 mm, hazardous wastes). Another representative sample will be chemically analyzed on a quarterly basis for the parameters presented in Table 7-20. These tests help in maintaining a record to establish trends of solid waste characteristics delivered to the site.

Table 7-20 Solid waste sampling parameters

pH	Cyanide
Arsenic	Mineral Oil
Lead	Manganese
Cadmium	Iron
Chromium	Magnesium
Copper	Calcium
Nickel	Potassium
Mercury	Sodium
Zinc	Total Organic Carbon
Phenols	Chlorite
Moisture Content	

7.2.5 Soil and Compost Quality

The generated compost will be monitored regularly to assure compliance with the national and international standards (Appendix F) and to provide credibility for potential future compost users (farmers, landscapers, municipalities). As such, 12 samples (5 to 10 liters per sample) will be taken at 12 different stops of the final compost heap. The collected samples will then be preserved and analyzed according to the methodologies stipulated in Appendix F. Compost quality will be monitored for Salmonellae, fecal Coliform, impurities (stones and plastics), moisture content, organic matter, pH, salt content, nutrients (nitrogen, soluble phosphate, soluble potassium, soluble chloride, soluble sodium), heavy metal content (mercury, lead, chromium, copper, nickel, Zinc and cadmium). The monitoring frequency during the operational phase of the compost plants is a function of plant input capacity as shown in Table 7-21.

Table 7-21 Compost monitoring frequency

Plant Input Capacity (tons/year)	Number of Analysis during First Year	Number of Analysis per Year after First Year
Up to 2,000	4	4
2,001 to 5,000	5	4
5,001 to 10,000	10	8
More than 10,000	12	12

In addition, soil samples will be collected in areas that may accidentally get exposed to solid waste or leachate. Samples will be collected in the same manner defined above. Note that in case the compost or soil samples fail to achieve at least the quality stipulated by the Compost-Ordinance for Grade D as presented in Appendix F, then the corresponding batch should be landfilled.

7.2.6 Odor

During the facility construction and site preparation and operation phases, odors will be monitored daily through olfactory test at the facility site and nearby receptors. Complaints should be investigated immediately with official reporting and documentation, also applicable during the post-closure phase. Special attention will be paid to any pungent odor detected which may indicate the presence of sulphur containing compounds including hydrogen sulphide (H_2S).

7.2.7 Health and Safety

During facility construction and site preparation phase and operation phase, continuous monitoring of health and safety indicators will be conducted to ascertain the application of mitigation measures and health and safety guidelines. The proper use of PPD will be checked in addition to the presence of signs, first aid kits, firefighting devices, etc. Record keeping of injuries/illnesses and major occupational accidents will be continuously conducted and filed at the facility. Traffic signs, safety instruction signals, security fencing, as well as firefighting equipment will be monitored through systematic inspections on a semi-annual basis.

7.2.8 Biological Environment

Field investigation and surveys with photographic documentation will 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 will be conducted once before and during facility construction and site preparation phase, annually during operation phase and annually during the post closure phase for 5 years.

7.2.9 Landscape and Visual Intrusions

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 will be conducted on a monthly basis during construction and site preparation phase and bi-annually during both operation and post-closure phases. The results from the field visits will be used to continuously refine and calibrate the output of the predictive imaging methods used in the EIA process, if any. However, frequent inspection of the landfill perimeters and surroundings, including approach roads, for blown litter should be conducted once or twice a day.

7.2.10 Landfill Settlement

In order to monitor the occurrence of settlement within the landfill cells, settlement plates will be placed at intermediate waste grades as well was design grade. These plates will be surveyed quarterly to determine the degree and rate of settlement occurring. Estimates of additional capacity gained due to settlement should be calculated to determine more precisely the lifespan of the facility. The monitoring results from the settlement plates will be validated by performing annual topographic surveys and volume calculations. The use of topographical methods combined with weight-based disposal data provides a useful method for determining the density (weight/volume) ratio for disposed waste.

7.2.11 Socio-Economics

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

7.2.12 Summary of Monitoring Plan

A summary of the monitoring parameters with corresponding location, and frequency is presented in Table 7-22. It is recommended that the monitoring plan be implemented by an entity independent of but in coordination with the contractor and consultant involved in any component or task of the project to ensure quality control and uniformity.

A general cost for implementing the Environmental Management Plan, including the monitoring plan, bi-annual auditing, capacity building, awareness campaign and environmental consultancy cost is $US 958,000 as summarized in Table 7-23.

Table 7-22: Summary of the proposed monitoring plan

Impact	Monitoring means	Parameters	Phase	Location	Frequency	App. Cost
Local climatic conditions	Permanent weather monitoring station	• Temperature, humidity, rainfall and wind speed and direction • Volume of precipitation • Evaporation (lysimeter) • Atmospheric humidity	• Pre-works • Facility construction & site preparation • Operation • Post-closure	• Facility site	• Daily	• $7,000/ weather station
Ambient Air Quality	Portable sampling	• Total suspended particulates (TSP) • Particulates < 10 microns (PM10)	• Facility construction & site preparation	• Facility site • Nearby receptors	• Once	• $7,000/portable sampling device
	Gas analyzer and flow meter	• Methane (CH_4) • Carbon monoxide (CO) • Sulfur dioxide (SO_2) • Nitrogen oxide (NO_2) • Total suspended particulates (TSP) • Particulates < 10 microns (PM10)	• Operation phase	• Facility site • Landfill, composting area, MRF plant • Nearby receptors	• Monthly • Upon Complaint	• $25,000/unit
			• Post-closure	• Facility site • Landfill • Nearby receptors	• Bi-Annually for 10 years • Upon complaint	
Landfill surface gas emissions	Portable sampling	• Methane (CH_4)	• Operation phase	• Filled areas in the landfill	• Monthly	• Included in the above portable device
			• Post-closure		• Bi-Annually for 10 years	
Subsurface (Soil gas)	Permanent morning stations	• Methane (CH_4) • Carbon dioxide (CO_2) • Nitrogen (N) • Sulfides • NMOC's	• Facility construction & site preparation	• Monitoring wells perimeter of the site • Exact location should be determined prior to work initiation by the contractor collaboration with the Ministry of Environment and local authorities	• Once	• Included in above portable device
			• Operation phase		• Monthly	
			• Post-closure		• Bi-Annually for 10 years	

Impact	Monitoring means	Parameters	Phase	Location	Frequency	App. Cost
Air emissions	Gas analyzer and flow meter	• Pre-flaring (CH_4, CO_2, N, O_2, NH_4, NMOC's, sulfides, CO) • Post-flaring (O_2, dust, CO, NO_2, SO_2)	• Operation phase • Post-closure	• Gas flaring unit	• Monthly • Bi-Annually for 10 years	• $25,000/unit
Noise levels	Sampling	• Leq (dBA)	• Facility construction & site preparation • Operation	• Facility site • 3 monitoring locations around the perimeter of the site	• Monthly • Upon Complaints	• $15,000/ portable sampling device
Surface water quality	Sampling	• Temperature • pH • Electrical Conductivity (EC) • Ammonia • Nitrate • Nitrite • Phosphate • Manganese • Total Phosphorous • Total Suspended Solids (TSS) • Biochemical oxygen demand (BOD) • Dissolved oxygen (DO) • Total Organic Carbon (TOC) • Total Coliform, Salmonellae, Fecal Coliform, Escherichia coli, Fecal Stretococus • Iron • Phenols • Metals (Chromium, Cadmium, Copper, Zinc, Nickel, Mercury, Lead)	• Pre-works • Operation • Post Closure	• On the Po river upstream and downstream of the landfill site • On the Dima creek upstream and downstream of the landfill site • From the creeks and swamp areas surrounding the landfill site • From the surface drainage recuperation canal • Exact location will be determined prior to work initiation by the contractor in collaboration with local authorities	• Once • Monthly • Bi-Annually for 10 years	• $675/sample

Impact	Monitoring means	Parameters	Phase	Location	Frequency	App. Cost
Surface water Level and Flow	• level probes • Flow meter	• Water Level • Water Flow	• Pre works	• Po River ad Dima Creek	• Continuous • Monthly	• $1800/ level troll • $ 11,000 / flow meter
Groundwater Level	• Permanent monitoring wells • Level Probes	• Water Level	• Pre works	• Drilling of at least 4 wells on site (One well should be installed on the highest elevation onsite and at least three other wells on different sides of the site)	• Continuous	• $1800/ level troll • $6000/ well (actual final cost depends on well depth)
Groundwater quality	Sampling	• Temperature • pH	• Pre works	• Permanent monitoring wells	• Once	• $675/sample
			• Operation		• Monthly	

Impact	Monitoring means	Parameters	Phase	Location	Frequency	App. Cost
		• Electrical Conductivity (EC) • Ammonia • Nitrate • Nitrite • Phosphate • Manganese • Total Phosphorous • Total Suspended Solids (TSS) • Biochemical oxygen demand (BOD) • Dissolved oxygen (DO) • Total Organic Carbon (TOC) • Total Coliform, Salmonellae, Fecal Coliform, Escherichia coli, Fecal Stretococus • Iron • Phenols • Metals (Chromium, Cadmium, Copper, Zinc, Nickel, Mercury, Lead))	• Post-closure	• Exact location should be determined prior to work initiation by the contractor in collaboration with local authorities • Wells in the surrounding communities	• Bi-Annually for 10 years	
Leachate Quality (before and after on-site	Sampling & Measurement	• Volume • Temperature • pH • Ammonia	• Operation • Post-closure	• Leachate collection tank	• Weekly	• $675/sample
				• Leachate extraction wells	• Monthly	

Impact	Monitoring means	Parameters	Phase	Location	Frequency	App. Cost
treatment)		• Nitrate • Manganese • Total Phosphorous • Total Suspended Solids (TSS) • Biochemical oxygen demand (BOD) • Dissolved oxygen (DO) • Total Coliform, Fecal Streptococcus, Salmonellae • Phenols • Metals (Chromium, Cadmium, copper, Zinc, Mercury, Lead)		• After treatment	• Weekly	
Waste generation	Generated waste checklist	• Quantity and composition	• Facility construction & site preparation	• Facility site	• Quarterly	• Priced within construction
	Incoming waste assessment	• Quantity	• Operation	• Incoming wastes (Weighbridge)	• Daily	
	Incoming waste assessment (upon need)	• Categorization: quantity and percent composition by weight and volume of organic waste, paper, cardboard, plastic products, glass, fabrics/textiles, metals	• Operation	• Uploading area	• Quarterly	

Impact	Monitoring means	Parameters	Phase	Location	Frequency	App. Cost
Compost quality	Sampling	Salmonellae, Fecal Coliform, impurities (stones and plastics), moisture content, organic matter, pH, salt content, nutrients (nitrogen, soluble phosphate, soluble potassium, soluble chloride, soluble sodium), heavy metal content (mercury, lead, chromium, copper, nickel, zinc and cadmium)	• Operation	• Final compost heap	• 12 samples/year	• $675/sample
Odor emissions	Olfactory test	• Unpleasant/noxious smells	• Operation	• Facility site • Sensitive receivers	• Daily • Upon complaints	
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	• Facility construction & site preparation • Operation	• Facility site	• Continuous	
Socio-economics	Field questionnaires and interviews	• Population perception • Employment record • Reported cases of affected psychological stresses	• Pre-works	• Region of influence	• Once	• $500/visit
			• Facility construction & site preparation		• Once	
			• Operation		• Annually	
			• Post-closure		• Annually for 5 years	
Biological environment	Field investigation, survey and photographic documentation	• Pre-works basic assessment • Ensure use of recommended plant species on site • Visual assessment of	• Pre-works	• Facility site • Surrounding habitats	• Once	• $500/visit
			• Facility construction & site preparation		• Once	
			• Operation		• Annually	

Impact	Monitoring means	Parameters	Phase	Location	Frequency	App. Cost
		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	• Post-closure		• Annually for 5 years	
Landscape and visual intrusion	Visual inspection and photographic documentation	• Ensure the effective implementation of mitigation measures	• Pre-works	• Entire area	• Once	• $500/visit
			• Facility construction & site preparation		• Once	
			• Operation		• Annually	
			• Post-closure		• Bi-Annually for 5 years	
Landfill settlement	Topographic surveys and settlement plates	• Monitor decomposition process and rate of settlement graphically • Quantity additional capacity gained in active cells by accelerated settlement	• Operation	• Entire Landfill	• Quarterly (active cells) • Bi-Annually (closed cells)	
			• Post-closure		• Annually for 10 years	

Table 7-23 Approximate cost of implementing an ESMP for the landfill project

Category	Budget (US$)
Capital cost for equipment (includes well drilling, water monitoring equipment, air quality and dust monitoring equipment, weather station, Noise monitoring equipment)	135,000
Annual Cost of Sampling including water, soil and leachate samples, annual visits of Biologist, sociologist and field experts to the site	75,000
Contracting of consultancy firm to provide monitoring and environmental consultancy services	200,000
Contracting consulting firm for carrying out environmental/social audit for the project performance and recommending improvement measures (2 audits/ years)	150,000
Hiring an environmental and social expert, with international experience of environmental and social (per year)	84,000
Hiring qualified Health & Safety specialist with a certification and experience in implementation of OHSAS 18001:2007 (per year)	84,000
Capacity Building and training courses	150,000
Awareness Campaign	80,000
Total Approximate Budget for ESMP implementation	**958,000**

7.3 Organizational Arrangement

During construction and operation, The Contractor should prepare and implement an Environmental and Social Management Plan (ESMP), as well as a Health and Safety Plan (H&S Plan) in compliance with OHSAS 18001:2007. The arrangements in place for environmental management and community liaison will be subject to full-scale management review (with a view to revision as appropriate). The scope of the review of environmental management and community liaison requirements will focus on ensuring that suitable arrangements are in place for the long-term operation of the plant, to:

- Engage effectively with the range of organizations with a direct stake in the operation of the project, including local communities, local government agencies, EPA, and others;
- Address the multidisciplinary nature of the potential operational impacts of the Project, and to implement and monitor the required mitigation measures;
- Establish day-to-day responsibilities for environmental management, and reporting;
- Define and implement requirements for independent monitoring and reporting on environmental performance;
- Identify needs for external professional advice on engineering, environmental and social issues.

For this purpose, the Contractor should recruit an environmental and social expert, with international appropriate experience of environmental and social management and sufficient training in specific topic areas under their responsibility, who have adequate equipment and access to further training as may be required; and a qualified Health & Safety specialist with a certification and experience in implementation of OHSAS 18001:2007.

The contactor should also put in place a plan and process for effective, regular communication with and reporting to EPA, and a suitable process for regular feedback and communication with local communities and other stakeholders.

The Owner's Engineer by contractual arrangement will have the requirement to supervise the adequate preparation and implementation of the ESMP and H&S Plan. The Owner's Engineer should recruit for this purpose a qualified Environmental & Social specialist with international experience and a qualified Health & Safety specialist with a certification and experience in implementation of OHSAS 18001:2007 procedures.

The implementation of the mitigation measures will be the responsibility of the contractor and the Landfill owner (MCC) under supervision of a consultant, EPA, and concerned local authorities (relevant ministries and organizations). MCC should comply by all the mitigation measures and management plans and enforce the implementation of these measures and plans specifically the Health and Safety Plans and Grievance mechanisms on all the contractors on site, by including these requirements in the contractors' contracts and adding it in the budget of the projects.

7.4 DATA MANAGEMENT

The collected monitoring data from the Cheesemanburg facility will be important for future environmental management in the various sectors upon which the proposed project touches. It will formulate the background to determine the accuracy of environmental quality predictions and provide the scientific basis for establishing or modifying environmental measures in the future. Therefore, it is proposed to develop a database of the monitoring data collected during construction and operation of the various components of the facility. In addition, it is recommended that the owner of the landfill (MCC) undergo a survey to collect data on waste generation and collection including sources of waste generated (for example, how much of the waste generated comes from households/residential houses, market stalls, offices, and other facilities). Assessment of waste pickers is also recommended; information such as their demographic information, Risks and hazards to their health and other social issues including exploitation etc, earnings and livelihoods can identify potential impacts and help provide measures and prospects to address these issues.

Periodic environmental monitoring reports will be prepared to ensure the effectiveness of the environmental monitoring plan during the project's lifetime. It is recommended that the Environmental and Social Monitoring Plan be carried out by or under the responsibility of this E&S specialist, or by a specialist company. However, initially two times a year an Environmental and Social Audit should be carried out by an independent and qualified auditor.

7.5 REPORTING

The shift leaders in charge of operation during the 24-hour day will prepare a daily facility monitoring report during both the facility construction and site preparation phase and operation phase containing the following information:

- Personal log
- Quantity of leachate and gas generation
- In-coming waste (total daily quantity)
- Waste transportation truck information (truck number, truck type, arrival time, departure point, total weight, net waste weight)
- Staff accidents and failure during operation
- Equipment and machinery monitoring data

Monitoring reports will be submitted quarterly during both the construction and operation phases.

In addition, yearly comprehensive reports will be generated to present results of the monitoring activities and assess the adequacy of environmental control measures. Monitoring reports will be submitted to the EPA, and the respective local authority for feedback on the overall monitoring program. These reports will summarize monitoring data with full interpretation illustrating the acceptability or otherwise of environmental impacts and identification or assessment of the implementation status of agreed mitigation measures. The annual monitoring reports will include at least the following sections/information:

a. Executive summary

b. Transportation vehicles

    - Days used/not used
    - Reasons for non-usage of vehicles
    - Average payloads
    - Incoming vehicle IDs, weights (with incoming wastes, empty, with outgoing wastes or products)

- Distance driven
- Replacement of vehicles, containers or staff
- Log of problems, outages, breakdowns, etc.

c. Sorting facility

- Received waste types and quantities
- Material types separated and products produced and their qualities
- Replacement of vehicles, machinery or staff
- Report on marketing activities
- Log of problems, outages, breakdowns, etc.

d. Composting facility

- Received waste types and qualities
- Compost qualities produced
- Compost qualities on store
- Compost qualities sold/taken off
- Results of compost analysis (to be submitted to EPA and concerned authorities)
- Qualities of leachate collected and treated
- Monthly results and analysis of discharged leachate
- Replacements of vehicles, and machinery or staff
- Report of marketing activities
- Log of problems, outages, breakdowns, etc.

e. Landfill operation

- Emplaced waste types and qualities
- Qualities of leachate collected and treated
- Monthly results of analysis of discharged leachate
- Qualities of landfill gas collected and treated

- Quarterly result of gas analysis
- Results on annual survey
- Remaining volume and lifetime of landfill
- Replacements of vehicles, machinery or staff
- Log of problems, outages, breakdowns, etc.

f. Landfill construction and site preparation

- Implementation schedule and achieved position
- Achievements in construction
- Construction materials used
- Log on problems and solutions
- Status of complete landfill

g. Mass balance and ratios

- Mass balance, showing all mass flows within the disposal services
- Ratios of landfilled waste to received MSW qualities

h. Environmental parameters

- Location of sensitive receivers and monitoring stations
- Implementation of status of environmental mitigation measures as recommended in the EIA
- Monitoring results
- Monitoring methodology
- Parameters monitored
- Monitoring date, time frequency, and duration
- Weather conditions during the period
- Monitoring results tabulated with maximum and minimum values
- Diagrams showing the performance of the works

i. Other parameters

- Daily consumption figures of electricity and chemicals
- Statistics of staff members and labor utilization
- Report of all non-compliance or exceeding of the environmental standards
- Record of all complaints received including location, nature, actions, and follow-up procedures
- Records of health and safety accidents on-site

Regular control measure will be adopted at the facility to ensure proper operations and environmental protection. Appendices H and I respectively provide checklists for regular control and materials recovery facilities and regular control at composting plants.

7.6 INSTITUTIONAL STRENGTHENING

Institutional strengthening in environmental management falls within several area encompassing solid waste and wastewater (leachate) management, atmospheric environment (air quality and noise), transportation (traffic), as well as water resources management (surface and groundwater protection). Appropriate environmental management dictates that construction, operation, and post closure activities be implemented in accordance to the current state of the art and knowledge regarding environmental protection. This can be accomplished by hiring competent personnel with the appropriate educational professional background, instituting periodic training programs, and developing sit-specific plans that are adequate for protecting the general public and the environment as well as contributing to the mitigation of potential environmental impacts. These plans should include:

- Site specific management plan including security and safety procedures
- Waste transportation plan addressing vehicle containment elements, requirements of driving, routing, and waste tracking
- Waste placement operations plan
- Health and safety plan including emergency and contingency procedures, facility requirements for employees and personnel protection

- Personnel qualification and training plans

For this purpose, contractors and consultants who will be involved in the construction, operation, and post closure of the various components of the Cheesemanburg landfill facility will be required to attend an environmental training course prior to the initiation of project activities. The objective of this training course is to ensure appropriate environmental awareness, knowledge, and skills for the implementation of environmental management plans. Environmental training sessions will be conducted for a two-day period on a semi-annual basis during the construction and operation phases, and on an annual basis during the post closure phase.

In an effort to strengthen institutional capacity and environmental awareness, training sessions will be opened for individuals from concerned ministries and agencies. In addition, the scope of the training sessions may not be limited to just issues related to solid waste management. Other environmental management topics can also be introduced. Public education in itself creates a valuable positive feedback in environmental management. Training sessions may address various topics including:

- Environmental laws, regulation, and standards
- Pollution health impacts
- Pollution prevention measures
- Sampling techniques and environmental monitoring guidelines (air, noise, water/ wastewater, soil)
- Solid waste management
- Air quality management
- Wastewater management
- Traffic and pedestrians safety measures
- The fundamentals of occupational health and safety procedures
- Risks associated with handling of solid wastes
- Procedures for the dealing with spillage, fires and other accidents

- Instructions on the use of protective clothing
- Operating procedures at the facility

In addition, training on the proper use and land application rates of the different grades of generated compost should be established targeting compost end-users. Training workshops are the responsibilities of the contractor.

It is recommended that the training and institutional strengthening plans be implemented by an entity independent of but in coordination with the contractor and consultant involved in any component or task of the project to ensure quality control and uniformity. Guidelines, specifications, and content for systematic and comprehensive environmental training and awareness program shall be developed with the final design for the facility. Such guidelines will define the contribution of the facility to potential institutional strengthening and capacity building in environmental management in its area of influence in particular and at the country's scale in general.

7.7 Statement of Compliance and Commitment

The contractor will confirm his adherence to the environmental requirements and obligations of this ESIA during the facility construction and site preparation, operation and post closure phases of the landfill facility. The contractor will comply with the national regulations/standards stipulated and will adopt the proposed mitigation measures and monitoring plans of the environmental management plan (EMP). The contractor will coordinate and technically liaise with the EPA for the proper application of the proposed environmental management plan.

7.8 Capacity Building

The proper implantation of environmental management plan is highly dependent on the available existing capacity and awareness of the facility staff, surrounding community and concerned stakeholders.

7.8.1 Training Workshops

A training workshop is required to increase environmental awareness of all individuals concerned with the facility (facility construction and site preparation, operation, mitigation, monitoring) and to train and follow-up with the workers who are specifically involved in the facility operation.

7.8.2 Environmental Awareness Workshop

The personnel involved in the operation of the facility, and the mitigation and monitoring plans will be required to attend environmental training workshops prior to project initiation and throughout the project activities. The objective of these workshops is to ensure appropriate environmental awareness, knowledge, and skills for the implementation of environmental mitigation and monitoring measures. In order to increase local environmental awareness, the workshops will also be opened for individuals from the local community. They will be conducted twice a year during the actual operation phase. The workshops will increase environmental awareness of the participants by covering at least the following topics:

- Environmental laws, regulations, and standards
- Pollution health impacts
- Pollution prevention and mitigation measures
- Sampling techniques and environmental monitoring guidelines
- Integrated solid waste management (source reduction, separation, processing, etc)
- Compost quality and usage (land application, standards and application rates)
- Health and safety measures

7.8.3 Facility Operation Training Workshop

Facility operators should receive appropriate training to assume the duties of managing the facility, 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:* the contractor is responsible for ensuring adequate

training of all facility operators. This could be achieved by small workshops conducted, in the facility, mainly during the operation phase for one day on a quarterly basis.

- *Waste separation:* workers will be informed about appropriate waste separation techniques required to prevent the production of contaminated compost. Furthermore, they should be able to identify all hazardous material, which could contaminate the compost such as batteries, and glass, and that should not enter the composting drums.

7.8.4 General Environmental Awareness Campaigns

General environmental awareness campaigns will be conducted targeting all the local inhabitants and concerned stakeholders. The campaigns should focus on:

- Pollution heath impacts
- Integrated Solid Waste Management (reduction, separation, composting, landfilling)
- Waste reduction: minimizing consumption, re-using, and source waste separation
- Recycling
- Compost usage

The core objective of these campaigns is to increase general environmental awareness, induce source separation, which will lead to waste volume reduction, and especially a reduction in the amount of generated inert material for landfilling (subsequently, increasing the life span of the landfills around the facility), material recovery, and better quality compost, and inform the locals about the uses of compost.

Community acceptance of the project and participation in waste separation is a vital component of successful landfilling operation as well as waste reduction. The negative perception associated with the re-use of waste material should be overcome by explaining to the local community the role of composting as a component of an integrated solid management plan, and the utilities associated with compost application (separation options were presented in the impact mitigation section).

8 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 the assessment should not be just to assess impacts and complete an environmental and social impact statement; 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 landfill facility, 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 8-1 represents some example of effective public participation techniques that can be utilized by the contractor.

Table 8-1: 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, MCC has 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.

8.1 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 ESIA has been completed. This requirement is also in line with the Guidelines for ESIA Administrative Procedures set by the EPA.

A Notice of Intent (NOI) (Appendix J) was published on November 16, 17, and 18, 2016 to inform the public about the Project and the availability of the Project Brief for review on November 16, 17, and 18, 2016

A series of meetings were also performed with the communities around the landfill site to inform them of the project, brief them on the impacts that might arise from the project and register the public opinion, suggestions and complaints to be included and taken into consideration in the ESIA report.

Three meetings were held with the stakeholders on November 9 and November 10, 2016 as detailed in Table 8-2. Records of the meeting minutes are included as Appendix K.

Table 8-2 Stakeholder consultations meeting plan

Meeting Venue	Meeting Date	Participating Communities
Quendee	November 9, 2016	Quendee, Korsor, Gbonjemah and Vanjah
Dolela	November 9, 2016	Dolela and Deimeh
Vincent Town	November 10,2016	Vinvent Town

8.2 ISSUES ARTICULATED DURING SCOPING PROCESS

The main concerns raised by the stakeholders are listed below.

- Leakage of leachate and waste water into the ground and water system.
- The public is concerned regarding leakage of leachates from the liners and pipes used and are worried about the quality of material use and if it is trusted.
- They also emphasized on the monitoring aspect of the project that will allow the project owner to detect any impact caused by the project activities at early stages allowing enough time to address the problem.
- Relocation due to uncontrolled pollution from the project or to overfilling of the landfill before its expected closure time.
- The public suggested building clinics so that people would have direct access to health care in case of pollution caused by the project.
- Job opportunities and Health and safety and training of employees.
- Controlled Access to the site to prevent people from entering and dumping unauthorized material.
- Procedures to follow if there are complaints from the communities in case of pollution.
- What would happen to the site at closure?

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APPENDIX A MCC PROPOSED SOLID WASTE COLLECTION & DISPOSAL SYSTEM (2017)

Proposed Solid Waste Collection & Disposal System (2017)
Monrovia City Corporation (MCC)
November 10, 2016

1.0 Background

Monrovia City Corporation did re-institute the Solid Waste Management system in Monrovia after it had collapsed during the war. The Corporation with assistance from partners has implemented waste collection and disposal activities and constructed sanitary landfill engineered to high standards and two transfer stations. Secondary waste collection has been outsourced to the private sector under PPP arrangements through the Emergency Monrovia Urban Sanitation (EMUS) project since 2010. The funding which allowed MCC to strengthen primary collection in communities in and around Monrovia as well entered into a formal waste collection contracts with private waste collection companies ends December 31, 2016.

MCC has a mandate to administer the affairs of the City of Monrovia and provide urban services to guests and resident of the City. MCC is also mandated to ensure good governance, effective city management, solid waste collection and disposal, as well as ensure a cleaner, safer and greener City. Monrovia has a population of approximately 1.5 million people.

A new strategy to waste collection and disposal in Monrovia is been proposed to ensure a cleaner and greener environment for all residents of the City beginning January 1, 2017.

2.0 Rationale & Objectives

The EMUS project managing waste collection and disposal in and around the City of Monrovia come to an end 30th December 2016. Collection and Disposal contracts also end on 30th December 2016. Waste collection and disposal in Monrovia becomes a 100 percent responsibility of MCC as at 1st January 2017.

The concept tend to provide a road map to ensure continuous and effective waste collection and disposal with limited or no private waste collection contractor in the provision of solid waste collection & disposal services to residents of Monrovia. It tends to provide MCC a clearer direction to waste collection and disposal as well strengthen the Solid Waste Management (SWM) sector of Monrovia.

3.0 Proposed System

3.1 General Disposal and Collection

MCC will maintain shared waste containers in communities. Containers (skip buckets) will be placed at specific locations in the City or at designated points in communities to allow residents to dispose trash/waste at a particular time of the day- late evenings and early mornings.

For effective monitoring and supervision purposes, the City of Monrovia will be divided into 3 Collection Regions: (a) Northern Region, (b) Central Region, and (c) Southern Region.

Skip Locations: Southern Region will consist of twenty (20) skip locations (attached as Annex 1), the Central Region will consist of twenty-five (25) skip locations (attached as Annex 2) while Northern Region will consist of forty (40) skip locations (attached as Annex 3) totaling eighty-five collection points/skip locations. Each skip location will have an attendant whose Job Description will include: Clearing around skip bucket and placing of phone calls to a regional supervisor whenever skip bucket is filled ahead of collection time or more than a day. All skip attendants will be familiar with collection schedule and activities.

Collection locations in in the three (3) regions will be cleaned in accordance with approved daily work schedule to be developed by supervisors and approved by their respective Directors in consultation with Director General of Program Services.

3.2 Transfer Station Management

MCC will manage both the Fiamah and Stockton Creek Solid Waste Transfer Stations. The transfer stations will operate 7 days (8:30am to 5:30pm) in a week. Night schedule will run from 8:30pm to 6:00am on Mondays Thursdays and Saturdays. Waste will be removed from the Fiamah Transfer Stations during the day on Tuesdays, Wednesday, Thursdays, and Sundays while removal of waste from the Stockton Transfer Stations will be done on Mondays, Fridays, and Saturdays during the day.

3.3 Landfill Site Management

The day-to-day operations of the landfill will be carried out by MCC. A Landfill Manager will be appointed by MCC to manage the facility and all operational activities. Technical activities such as waste pushing, compartment, covering, and water testing will be outsourced to a private contractor. MCC will work closely with the contractor and endeavor to purchase a D4 Machine for waste pushing and compacting. The site opening time shall be the same as the transfer stations. It shall run from Monday to Sunday and shall accommodate extra work schedule as instructed by MCC the Director General.

3.4 Community Based Enterprises (CBEs)

MCC will demarcate contract areas to be larger than the existing contract areas and through a competitive process select the most suitable/prefer bidders (at least two CBEs) and license them to compete in the delivery of door-to-door services to residents in a defined locality of the City of Monrovia. MCC will regulate and monitor collection fees and rules as well endeavor to standardize competition in collection areas licensed to CBEs.

MCC will provide technical and managerial trainings to CBEs. MCC will engage and support CBEs to get involved with recycling of identifiable and marketable wastes. Sorting of reusable waste items will be carried out at the level of the house, skip bucket/location, and at transfer stations.

3.5 Collection Schedule and Frequency

MCC will promote both Day and Night Work. Day work will occur mainly at Hot Spots (HS) in each of the three collection regions while Night Work will occur at both Hot Spots (HS) and Non Hot Spots (NHS) in the three regions. Waste collected during the Day from Hot Spot will be disposed at a designated site or the nearest transfer station. Removal of waste from the transfer stations to the Landfill will be done mainly at night to prepare the transfer station for dumping the following day.

3.6 Collection Equipment

Collection equipment for secondary collection shall include: Skip Trucks, Tipper Truck and Front- End- Loaders (FEL). Skip trucks and tipper trucks will be used for collection at skip locations in the City while FEL with tipper trucks will be used at transfer stations. Timely removal/pick-up of skip buckets will be encouraged in order to prevent the use of FEL at skip locations.

At the landfill, a D4 Machine will be used for pushing waste into the waste cells while compactor will be used to compact waste disposed and pushed into the waste cell regularly.

Primary collection equipment shall include: Wheelbarrow, Push Cart/“Push-Push” and Manual or Motorized tricycles. These equipment will be allowed to take waste from homes and small businesses to a collection site designated by MCC in the community.

4.0 Sector Appraisal

Currently, there are functional waste sectors with at least four secondary waste companies and over 35 Community Based Enterprises (CBEs). There is a sanitary landfill with a lifespan of about 1year. Hundred (100) acres of land has been purchased by the Government of Liberia for the construction of a new landfill in Cheesemanburg beginning 2017. Funding for Design and Construction Work is still being sourced.

At the moment, there is no market for plastic and organic waste which constitutes about 80 percent of waste generated in and around Monrovia. There is an existing market for scrap metal, aluminum and metal cans. Recycling or waste value addition is still developing. As the result, employment in the waste sector is relative low. Majority of waste employees are sweepers and waste collectors- dominantly, females above the age of 35 years.

Considering the huge rural urban migration and the effect of the prolonged civil war on many youths, the waste sector has the potential of creating massive employment opportunities for unskilled residents of Monrovia and its environs. MCC has a 5yrs. Strategic Plan that is aimed at creating a cleaner, safer, and productive environment for residents of the City of Monrovia to improve living standards.

5.0 Structure & Resources

4.1 Coordination and Supervision

The proposed three (3) regions will be coordinated by directors of MCC. These staff will work in close consultation with the Director General of Program Services, Director General for Beautification, and the Office of the Mayor in planning solid waste collection and disposal activities. He/she will take initiative of ensuring timely removal of skip buckets from collection points in his/her assigned area. He/she will help monitor skip attendants, and supervise collection trucks, Front- End-Loaders and skip trucks assigned and working in consultation with other critical stakeholders. He/she will be solely responsible for the collection region assigned.

4.2 Fueling of Equipment

It is proposed that there be an arrangement with a reputable fuel supply company (TOTAL Liberia, SRIMEX, MTC, etc) to allow the placement and regular supply of agreeable fuel quantity (eg. 5000 gallons) fuel tanker on the compound of MCC. Fuel supply will be instructed, and monitored from the Compound of the MCC under the watchful eyes of the supervisor through a structural fueling procedure to be designed and instituted to allow MCC fuel equipment from the MCC Compound. This will provide an effective management of fuel as well prevents back and forth movement of collection equipment and long fueling time at the TOTAL filing station.

Movement log indicating fuel supplied be introduced and tracked to ensure fuel consumption and accountability. Truck drivers and supervisors will be mandated to fill log to account for fuel consumption based on location traveled (mileage). An analysis of movement logs will be done and submitted weekly for informed decision making purposes.

6.0 Conclusion

MCC has the statutory mandate to create a clean Monrovia. A 5yr. Strategic Plan approved by the Monrovia City Corporation that is aimed at achieving a cleaner, greener, and safer Monrovia.

The World Bank funded waste collection and disposal project (EMUS) through which private waste companies were contracted to collect and dispose waste in Monrovia and its environs ends 30th December 2016. The proposed approach to solid waste collection and disposal in Monrovia is designed to allow MCC to take full (100 percent) responsibility of waste collection and disposal in Monrovia. A change in approach is required to ensure continuous waste collection geared toward creating a cleaner, healthier, and safer Monrovia.

A. COLLECTION POINTS- SOUTHERN REGION

#	DESCRIPTION	STATUS	COLLECTION TIME
1	JAMAICA ROAD JUNCTION		
2	VIA TOWN		
3	STEPHEN TOLBERT ESTATE		
4	CHICKEN SOUP FACTORY		
5	BARNERSVILLE JUNCTION		
6	GARDNERVILLE SUPERMARKET		
7	NEW GEORGIA JUNCTION		
8	NEW GEORGIA ESTATE		
9	CHOCOLATE CITY JUNCTION		
10	BARNERSVILLE BEND AND STOP		
11	FRONT STREET OLD R.C. BIN		
12	LIPTRACO, WEST POINT JUNCTION		
13	SLIPWAY JUNCTION		
14	DUALA MARKET		
15	DOE COMMUNITY JUNCTION		
16	LPRC JUNCTION, GARDNERVILLE		
17	LOGAN TOWN TRAIN TRACK		
18	PAITY TOWN, CLARA TOWN		
19	GEGRATA, CLARA TOWN		
20	CLARA TOWN MARKET		

B. COLLECTION POINT- NORTHERN REGION

#	DESCRIPTION	STATUS	COLLECTION TIME
1	IRON GATE		
2	BANJOR COMMUNITY		
3	RED HILL FIELD, VIRGINIA		
4	BANJOR JUNCTION		
5	ST. PAUL BRIDGE		
6	TWEH FARM		
7	NEW KRU TOWN POLICE ATATION		
8	NEW KRU TOWN LAGOON		
9	CALDWELL ROAD		
10	D. TWEH HIGH SCHOOL		
11	DUALA MARKET		
12	BONG MINES BRIDGE		
13	COAST GUARD BASE COMMUNITY		
14	LIPFOCO, LOGAN TOWN		
15	LOGAN TOWN CINEMA		
16	LOGAN TOWN RICE STORE		
17	LOGAN TOWN MARKET		
18	BLOWIEN, LOGAN TOWN		
19	JAMAICA ROAD JUNCTION		
20	COW FACTORY		
21	ISI FREEPORT		
22	CLARA TOWN R.C. BIN		
23	VIA TOWN		
24	DOE COMMUNITY JUNCTION		
25	LOGAN TOWN TRAIN TRACK		
26	PAITY TOWN, CLARA TOWN		
27	GEBRATA, CLARA TOWN		
28	CLARA TOWN MARKET		
29	TOPOE VILLAGE		
30	IRAN FACTORY		
31	GARDNESVILLE SUPERMARKET		
32	NEW GEORGIA JUNCTION		
33	NEW GEORGIA ESTATE		
34	CHOCOLATE CITY JUNCTION		
35	STEPHEN TOLBERT ESTATE JUNCTION		

36	**CHICKEN SOUP FACTORY**		
37	**BARNESVILLE JUNCTION**		
38	**BARNESVILLE BEND AND STOP**		
39	**LPRC JUNCTION**		
40	**GBANDI TOWN, LOGAN TOWN**		

C. COLLECTION POINTS- CENTRAL REGION

#	DESCRIPTION	STATUS	COLLECTION TIME
1	12TH STREET		
2	WROTO TOWN		
3	WEST POINT, DEAD END OF THE ROAD		
4	WEST POINT, FISH TOWN		
5	WEST POINT KRU BEACH		
6	AIRFIELD COMMUNITY		
7	OLD ROAD		
8	PERRY STREET		
9	CENTER STREET NEAR THE CEMETERY		
10	ASHMUN AND ROBERT STREETS		
11	BUCHANAN AND CAREY STREETS		
12	BROAD STREET, UP DUCOR HOTEL		
13	CENTER STREET SOUTH BEACH		
14	CENTER STREET PRISON COMPOUND		
15	CLAY AND BENSON STREETS		
16	MECHLIN STREET		
17	GURLEY STREET CEMETERY		
18	LYNCH STREET SONIWEIN		
19	SONIWEIN COMMUNITY		
20	RALLY TIME MARKET		
21	RANDALL STREET, SOUTH BEACH		
22	LYNCH STREET, PHP COMMUNITY		
23	REDEMPTION ROAD, BEHIND BTC		
24	REDEMPTION ROAD NEAR THE DRAINAGE		
25	CAPITOL BUILDING		

Collection Work Schedule/Plan

SOLID WASTE COLLECTION SCHEDULE
Monrovia City Corporation (MCC)
1ST Street Tubman Blvd. Sinkor, Monrovia

COLLECTION REGION:

DATE: **SHIFT: DAY( ) NIGHT ( )** **SUPERVISOR:**

MAIN ACTIVITY			
OUTCOME:			
ACTIVITIES/COLLECTION POINTS	COLLECTION PLAN/SCHEDULE		
	COLLECTION TIME *(Waste pick-up time)*	INPUTS *(Truck/Sweeper /Material assigned)*	LEAD PERSON/DRIVER *(Specify staff responsible)*
1.1			
1.2			
1.3			
1.4			
1.5			
1.6			
1.7			
1.8			
1.9			
1.10			
1.11			
1.12			

Comments: ---

Prepared by: Name: ____________________________ Signature______________________ Date: ___________________

Approved by: Name: ____________________________ Signature______________________ Date: ___________________

APPENDIX B LABORATORY RESULTS

ALcontrol Laboratories

Unit 7-8 Hawarden Business Park
Manor Road (off Manor Lane)
Hawarden
Deeside
CH5 3US
Tel: (01244) 528700
Fax: (01244) 528701
email: customerservices@alcontrol.com
Website: www.alcontrol.com

Earthtime Inc.
Earthtime Building
U.N. Drive
Clara Town
Monrovia
Liberia

Attention: Basma Shamas

CERTIFICATE OF ANALYSIS

Date:	01 December 2016
Customer:	H_EARTH_LIB
Sample Delivery Group (SDG):	161117-88
Your Reference:	
Location:	Liberia
Report No:	388540

We received 12 samples on Thursday November 17, 2016 and 12 of these samples were scheduled for analysis which was completed on Thursday December 01, 2016. Accredited laboratory tests are defined within the report, but opinions, interpretations and on-site data expressed herein are outside the scope of ISO 17025 accreditation.

Should this report require incorporation into client reports, it must be used in its entirety and not simply with the data sections alone.

Chemical testing (unless subcontracted) performed at ALcontrol Laboratories Hawarden (Method codes TM) or ALcontrol Laboratories Aberdeen (Method codes S).

Approved By:

Sonia McWhan
Operations Manager

mCERTS
THE ENVIRONMENT AGENCY'S MONITORING CERTIFICATION SCHEME

ilac-MRA

UKAS TESTING 1291

ALcontrol Laboratories

Validated

CERTIFICATE OF ANALYSIS

SDG:	161117-88	**Location:**	Liberia	**Order Number:**	
Job:	H_EARTH_LIB-1	**Customer:**	Earthtime Inc.	**Report Number:**	388540
Client Reference:		**Attention:**	Basma Shamas	**Superseded Report:**	

Received Sample Overview

Lab Sample No(s)	Customer Sample Ref.	AGS Ref.	Depth (m)	Sampled Date
14548563	BOLELAW1			10/11/2016
14548562	DIMAH			10/11/2016
14548566	MCC1		0.50 - 0.80	10/11/2016
14548568	MCC4		0.50 - 0.80	10/11/2016
14548567	MCCC CENTER		0.50 - 0.80	10/11/2016
14548564	PO01			09/11/2016
14548558	PO03			09/11/2016
14548557	PO-DWST			10/11/2016
14548565	SWAMP S		0.50 - 0.80	10/11/2016
14548560	SWAMP W			10/11/2016
14548559	VAR_HP			09/11/2016
14548561	VT HP1			10/11/2016

Only received samples which have had analysis scheduled will be shown on the following pages.

12:17:33 01/12/2016

ALcontrol Laboratories

Validated

CERTIFICATE OF ANALYSIS

SDG:	161117-88	**Location:**	Liberia	**Order Number:**	
Job:	H_EARTH_LIB-1	**Customer:**	Earthtime Inc.	**Report Number:**	388540
Client Reference:		**Attention:**	Basma Shamas	**Superseded Report:**	

LIQUID

Results Legend

- X — Test
- N — No Determination Possible

Lab Sample No(s)	14548563	14548562	14548564	14548558	14548557	14548560
Customer Sample Reference	BOLELAW1	DIMAH	PO01	PO03	PO-DWST	SWAMP W
AGS Reference						
Depth (m)						

Analysis		
Ammoniacal Nitrogen	All	NDPs: 0 Tests: 8
Anions by Kone (w)	All	NDPs: 0 Tests: 8
Conductivity (at 20 deg.C)	All	NDPs: 0 Tests: 8
Dissolved Metals by ICP-MS	All	NDPs: 0 Tests: 8
Dissolved Oxygen by Probe	All	NDPs: 0 Tests: 8
Dissolved Tin by ICPMS	All	NDPs: 0 Tests: 8
Mercury Dissolved	All	NDPs: 0 Tests: 8
Metals by iCap-OES Dissolved (W)	All	NDPs: 0 Tests: 8
Nitrite by Kone (w)	All	NDPs: 0 Tests: 8
pH Value	All	NDPs: 0 Tests: 8
Phenols by HPLC (W)	All	NDPs: 0 Tests: 8
Silicon Dissolved by ICP-OES	All	NDPs: 0 Tests: 8
Sulphur Total*	All	NDPs: 0 Tests: 8
Suspended Solids	All	NDPs: 0 Tests: 8
Total Organic and Inorganic Carbon	All	NDPs: 0 Tests: 8

14548563 – Container	0.5l glass bottle (ALE227)	500ml Plastic (ALE208)	Dissolved Metals Preser	H2SO4 (ALE244)	HNO3 Filtered (ALE204)	NaOH (ALE245)
Ammoniacal Nitrogen				X		
Anions by Kone (w)		X				
Conductivity (at 20 deg.C)		X				
Dissolved Metals by ICP-MS					X	
Dissolved Oxygen by Probe		X				
Dissolved Tin by ICPMS					X	
Mercury Dissolved			X			
Metals by iCap-OES Dissolved (W)					X	
Nitrite by Kone (w)						X
pH Value		X				
Phenols by HPLC (W)				X		
Silicon Dissolved by ICP-OES					X	
Sulphur Total*		X				
Suspended Solids	X					
Total Organic and Inorganic Carbon	X					

14548562 – Container	0.5l glass bottle (ALE227)	500ml Plastic (ALE208)	Dissolved Metals Preser	H2SO4 (ALE244)	HNO3 Filtered (ALE204)	NaOH (ALE245)
Ammoniacal Nitrogen				X		
Anions by Kone (w)		X				
Conductivity (at 20 deg.C)		X				
Dissolved Metals by ICP-MS					X	
Dissolved Oxygen by Probe		X				
Dissolved Tin by ICPMS					X	
Mercury Dissolved			X			
Metals by iCap-OES Dissolved (W)					X	
Nitrite by Kone (w)						X
pH Value		X				
Phenols by HPLC (W)				X		
Silicon Dissolved by ICP-OES					X	
Sulphur Total*		X				
Suspended Solids	X					
Total Organic and Inorganic Carbon	X					

14548564 – Container	0.5l glass bottle (ALE227)	500ml Plastic (ALE208)	Dissolved Metals Preser	H2SO4 (ALE244)	HNO3 Filtered (ALE204)	NaOH (ALE245)
Ammoniacal Nitrogen				X		
Anions by Kone (w)		X				
Conductivity (at 20 deg.C)		X				
Dissolved Metals by ICP-MS					X	
Dissolved Oxygen by Probe		X				
Dissolved Tin by ICPMS					X	
Mercury Dissolved			X			
Metals by iCap-OES Dissolved (W)					X	
Nitrite by Kone (w)						X
pH Value		X				
Phenols by HPLC (W)				X		
Silicon Dissolved by ICP-OES					X	
Sulphur Total*		X				
Suspended Solids	X					
Total Organic and Inorganic Carbon	X					

14548558 – Container	0.5l glass bottle (ALE227)	500ml Plastic (ALE208)	Dissolved Metals Preser	H2SO4 (ALE244)	HNO3 Filtered (ALE204)	NaOH (ALE245)
Ammoniacal Nitrogen				X		
Anions by Kone (w)		X				
Conductivity (at 20 deg.C)		X				
Dissolved Metals by ICP-MS					X	
Dissolved Oxygen by Probe		X				
Dissolved Tin by ICPMS					X	
Mercury Dissolved			X			
Metals by iCap-OES Dissolved (W)					X	
Nitrite by Kone (w)						X
pH Value		X				
Phenols by HPLC (W)				X		
Silicon Dissolved by ICP-OES					X	
Sulphur Total*		X				
Suspended Solids	X					
Total Organic and Inorganic Carbon	X					

14548557 – Container	0.5l glass bottle (ALE227)	500ml Plastic (ALE208)	Dissolved Metals Preser	H2SO4 (ALE244)	HNO3 Filtered (ALE204)	NaOH (ALE245)
Ammoniacal Nitrogen				X		
Anions by Kone (w)		X				
Conductivity (at 20 deg.C)		X				
Dissolved Metals by ICP-MS					X	
Dissolved Oxygen by Probe		X				
Dissolved Tin by ICPMS					X	
Mercury Dissolved			X			
Metals by iCap-OES Dissolved (W)					X	
Nitrite by Kone (w)						X
pH Value		X				
Phenols by HPLC (W)				X		
Silicon Dissolved by ICP-OES					X	
Sulphur Total*		X				
Suspended Solids	X					
Total Organic and Inorganic Carbon	X					

14548560 – Container	0.5l glass bottle (ALE227)	500ml Plastic (ALE208)	Dissolved Metals Preser	H2SO4 (ALE244)	HNO3 Filtered (ALE204)	NaOH (ALE245)
Ammoniacal Nitrogen				X		
Anions by Kone (w)		X				
Conductivity (at 20 deg.C)		X				
Dissolved Metals by ICP-MS					X	
Dissolved Oxygen by Probe		X				
Dissolved Tin by ICPMS					X	
Mercury Dissolved			X			
Metals by iCap-OES Dissolved (W)					X	
Nitrite by Kone (w)						X
pH Value		X				
Phenols by HPLC (W)				X		
Silicon Dissolved by ICP-OES					X	
Sulphur Total*		X				
Suspended Solids	X					
Total Organic and Inorganic Carbon	X					

12:17:33 01/12/2016

ALcontrol Laboratories

Validated

CERTIFICATE OF ANALYSIS

SDG:	161117-88	**Location:**	Liberia	**Order Number:**	
Job:	H_EARTH_LIB-1	**Customer:**	Earthtime Inc.	**Report Number:**	388540
Client Reference:		**Attention:**	Basma Shamas	**Superseded Report:**	

LIQUID

Results Legend

X Test

N No Determination Possible

Lab Sample No(s)			14548559						14548561					
Customer Sample Reference			VAR_HP						VT HP1					
AGS Reference														
Depth (m)														
Container			0.5l glass bottle (ALE227	500ml Plastic (ALE208)	Dissolved Metals Preser	H2SO4 (ALE244)	HNO3 Filtered (ALE204)	NaOH (ALE245)	0.5l glass bottle (ALE227	500ml Plastic (ALE208)	Dissolved Metals Preser	H2SO4 (ALE244)	HNO3 Filtered (ALE204)	NaOH (ALE245)
Ammoniacal Nitrogen	All	NDPs: 0 Tests: 8				X						X		
Anions by Kone (w)	All	NDPs: 0 Tests: 8		X						X				
Conductivity (at 20 deg.C)	All	NDPs: 0 Tests: 8		X						X				
Dissolved Metals by ICP-MS	All	NDPs: 0 Tests: 8					X						X	
Dissolved Oxygen by Probe	All	NDPs: 0 Tests: 8		X						X				
Dissolved Tin by ICPMS	All	NDPs: 0 Tests: 8					X						X	
Mercury Dissolved	All	NDPs: 0 Tests: 8			X						X			
Metals by iCap-OES Dissolved (W)	All	NDPs: 0 Tests: 8					X						X	
Nitrite by Kone (w)	All	NDPs: 0 Tests: 8						X						X
pH Value	All	NDPs: 0 Tests: 8		X						X				
Phenols by HPLC (W)	All	NDPs: 0 Tests: 8				X						X		
Silicon Dissolved by ICP-OES	All	NDPs: 0 Tests: 8					X						X	
Sulphur Total*	All	NDPs: 0 Tests: 8		X						X				
Suspended Solids	All	NDPs: 0 Tests: 8	X						X					
Total Organic and Inorganic Carbon	All	NDPs: 0 Tests: 8	X						X					

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CERTIFICATE OF ANALYSIS

SDG:	161117-88	**Location:**	Liberia	**Order Number:**	
Job:	H_EARTH_LIB-1	**Customer:**	Earthtime Inc.	**Report Number:**	388540
Client Reference:		**Attention:**	Basma Shamas	**Superseded Report:**	

SOLID

Results Legend

- X — **Test**
- N — **No Determination Possible**

Lab Sample No(s)			14548566	14548568	14548567	14548565
Customer Sample Reference			MCC1	MCC4	MCCC CENTER	SWAMP S
AGS Reference						
Depth (m)			0.50 - 0.80	0.50 - 0.80	0.50 - 0.80	0.50 - 0.80
Container			250g Amber Jar (ALE21	60g VOC (ALE215)	250g Amber Jar (ALE21	250g Amber Jar (ALE21
Alkali Metals by iCap-OES (Soil)	All	NDPs: 0 Tests: 4	X	X	X	X
Ammonium Soil by Titration	All	NDPs: 0 Tests: 4	X	X	X	X
Anions by Kone (soil)	All	NDPs: 0 Tests: 4	X	X	X	X
Conductivity (at 20 deg.C)	All	NDPs: 0 Tests: 4	X	X	X	X
Metals in solid samples by OES	All	NDPs: 0 Tests: 4	X	X	X	X
NO3, NO2 and TON by KONE (s)	All	NDPs: 0 Tests: 4	X	X	X	X
pH	All	NDPs: 0 Tests: 4	X	X	X	X
Phenols by HPLC (S)	All	NDPs: 0 Tests: 4	X	X	X	X
Phosphate (Ortho as PO4) (s)	All	NDPs: 0 Tests: 4	X	X	X	X
Sample description	All	NDPs: 0 Tests: 4	X	X	X	X
Silver	All	NDPs: 0 Tests: 4	X	X	X	X
Total Organic Carbon	All	NDPs: 0 Tests: 4	X	X	X	X
Total Sulphate	All	NDPs: 0 Tests: 4	X	X	X	X

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CERTIFICATE OF ANALYSIS

SDG:	161117-88	**Location:**	Liberia	**Order Number:**	
Job:	H_EARTH_LIB-1	**Customer:**	Earthtime Inc.	**Report Number:**	388540
Client Reference:		**Attention:**	Basma Shamas	**Superseded Report:**	

Sample Descriptions

Grain Sizes

very fine	fine	medium	coarse	very coarse
<0.063mm	0.063mm - 0.1mm	0.1mm - 2mm	2mm - 10mm	>10mm

Lab Sample No(s)	Customer Sample Ref.	Depth (m)	Colour	Description	Grain size	Inclusions	Inclusions 2
14548566	MCC1	0.50 - 0.80	Light Brown	Sandy Loam	0.063 - 2.00 mm	Stones	Vegetation
14548568	MCC4	0.50 - 0.80	Dark Brown	Sandy Clay	0.063 - 2.00 mm	Stones	None
14548567	MCCC CENTER	0.50 - 0.80	Red	Sandy Loam	0.063 - 2.00 mm	Stones	Vegetation
14548565	SWAMP S	0.50 - 0.80	Orange	Sandy Loam	0.063 - 2.00 mm	Stones	Vegetation

These descriptions are only intended to act as a cross check if sample identities are questioned, and to provide a log of sample matrices with respect to MCERTS validation. They are not intended as full geological descriptions.

We are accredited to MCERTS for sand, clay and loam/topsoil, or any of these materials - whether these are derived from naturally ocurring soil profiles, or from fill/made ground, as long as these materials constitute the major part of the sample.

Other coarse granular materials such as concrete, gravel and brick are not accredited if they comprise the major part of the sample.

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CERTIFICATE OF ANALYSIS

SDG:	161117-88	**Location:**	Liberia	**Order Number:**	
Job:	H_EARTH_LIB-1	**Customer:**	Earthtime Inc.	**Report Number:**	388540
Client Reference:		**Attention:**	Basma Shamas	**Superseded Report:**	

Results Legend

- # ISO17025 accredited.
- M *m*CERTS accredited.
- aq Aqueous / settled sample.
- diss.filt Dissolved / filtered sample.
- tot.unfilt Total / unfiltered sample.
- * Subcontracted test.
- ** % recovery of the surrogate standard to check the efficiency of the method. The results of individual compounds within samples aren't corrected for the recovery
- (F) Trigger breach confirmed
- 1-5&+§@ Sample deviation (see appendix)

Customer Sample Ref.			BOLELAW1	DIMAH	MCC1	MCC4	MCCC CENTER	PO01
Depth (m)			.	.	0.50 - 0.80	0.50 - 0.80	0.50 - 0.80	.
Sample Type			Water(GW/SW)	Water(GW/SW)	Soil/Solid	Soil/Solid	Soil/Solid	Water(GW/SW)
Date Sampled			10/11/2016	10/11/2016	10/11/2016	10/11/2016	10/11/2016	09/11/2016
Sample Time			.	.	.	.	.	.
Date Received			17/11/2016	17/11/2016	17/11/2016	17/11/2016	17/11/2016	17/11/2016
SDG Ref			161117-88	161117-88	161117-88	161117-88	161117-88	161117-88
Lab Sample No.(s)			14548563	14548562	14548566	14548568	14548567	14548564
AGS Reference								
Component	**LOD/Units**	**Method**						
Sulphur, Total*	<10 mg/l	SUB	<10	<10				<10
Suspended solids, Total	<2 mg/l	TM022	<2 #	4 #				6.5 #
Oxygen, dissolved	<0.3 mg/l	TM046	10.2 @ #	10.1 @ #				10.3 @ #
Organic Carbon, Total	<3 mg/l	TM090	<3 @ #	3.08 @ #				4.08 @ #
Ammoniacal Nitrogen as NH4	<0.3 mg/l	TM099	<0.3 #	<0.3 #				<0.3 #
Conductivity @ 20 deg.C	<0.005 mS/cm	TM120	0.106 #	0.012 #				0.0151 #
Silicon (diss.filt)	<0.05 mg/l	TM129	1.43	2.44				2.67
Aluminium (diss.filt)	<2 µg/l	TM152	9.63 #	22.2 #				93 #
Antimony (diss.filt)	<0.16 µg/l	TM152	<0.16 #	<0.16 #				<0.16 #
Arsenic (diss.filt)	<0.51 µg/l	TM152	0.644 #	0.591 #				0.554 #
Barium (diss.filt)	<0.2 µg/l	TM152	9.06 #	7.34 #				13.5 #
Beryllium (diss.filt)	<0.1 µg/l	TM152	<0.1 #	<0.1 #				<0.1 #
Boron (diss.filt)	<5 µg/l	TM152	9.58 #	<5 #				<5 #
Cadmium (diss.filt)	<0.08 µg/l	TM152	<0.08 #	<0.08 #				<0.08 #
Chromium (diss.filt)	<1.2 µg/l	TM152	<1.2 #	<1.2 #				<1.2 #
Cobalt (diss.filt)	<0.15 µg/l	TM152	<0.15 #	0.186 #				<0.15 #
Copper (diss.filt)	<0.85 µg/l	TM152	<0.85 #	<0.85 #				<0.85 #
Lead (diss.filt)	<0.1 µg/l	TM152	0.141 #	<0.1 #				<0.1 #
Lithium (diss.filt)	<1 µg/l	TM152	<1 #	<1 #				<1 #
Manganese (diss.filt)	<0.76 µg/l	TM152	18.4 #	9.43 #				3.96 #
Molybdenum (diss.filt)	<0.62 µg/l	TM152	<0.62 #	<0.62 #				<0.62 #
Nickel (diss.filt)	<0.44 µg/l	TM152	<0.44 #	<0.44 #				<0.44 #
Phosphorus (diss.filt)	<15 µg/l	TM152	<15 #	<15 #				<15 #
Selenium (diss.filt)	<0.81 µg/l	TM152	1.21 #	<0.81 #				<0.81 #
Strontium (diss.filt)	<0.4 µg/l	TM152	30.3 #	6.28 #				6.81 #
Tellurium (diss.filt)	<7 µg/l	TM152	<7	<7				<7
Thallium (diss.filt)	<2 µg/l	TM152	<2	<2				<2
Titanium (diss.filt)	<1.5 µg/l	TM152	<1.5 #	<1.5 #				2.75 #
Uranium (diss.filt)	<0.5 µg/l	TM152	<0.5	<0.5				<0.5
Vanadium (diss.filt)	<1.3 µg/l	TM152	<1.3 #	<1.3 #				<1.3 #
Zinc (diss.filt)	<1.3 µg/l	TM152	15.9 #	6.05 #				<1.3 #
Bismuth (dis.filt)	<0.1 µg/l	TM152	<0.1 #	<0.1 #				<0.1 #

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CERTIFICATE OF ANALYSIS

SDG:	161117-88	**Location:**	Liberia	**Order Number:**	
Job:	H_EARTH_LIB-1	**Customer:**	Earthtime Inc.	**Report Number:**	388540
Client Reference:		**Attention:**	Basma Shamas	**Superseded Report:**	

Results Legend

- # ISO17025 accredited.
- M *m*CERTS accredited.
- aq Aqueous / settled sample.
- diss.filt Dissolved / filtered sample.
- tot.unfilt Total / unfiltered sample.
- * Subcontracted test.
- ** % recovery of the surrogate standard to check the efficiency of the method. The results of individual compounds within samples aren't corrected for the recovery
- (F) Trigger breach confirmed
- 1-5&♦§@ Sample deviation (see appendix)

Component	LOD/Units	Method	BOLELAW1	DIMAH	MCC1	MCC4	MCCC CENTER	PO01
Depth (m)			.	.	0.50 - 0.80	0.50 - 0.80	0.50 - 0.80	.
Sample Type			Water(GW/SW)	Water(GW/SW)	Soil/Solid	Soil/Solid	Soil/Solid	Water(GW/SW)
Date Sampled			10/11/2016	10/11/2016	10/11/2016	10/11/2016	10/11/2016	09/11/2016
Sample Time			.	.	.	.	.	.
Date Received			17/11/2016	17/11/2016	17/11/2016	17/11/2016	17/11/2016	17/11/2016
SDG Ref			161117-88	161117-88	161117-88	161117-88	161117-88	161117-88
Lab Sample No.(s)			14548563	14548562	14548566	14548568	14548567	14548564
AGS Reference								
Tungsten (dis.filt)	<1 µg/l	TM152	<1	<1				<1
Zirconium (dis.filt)	<1 µg/l	TM152	<1	<1				<1
Silver (diss.filt)	<1 µg/l	TM152	<1	<1				<1
Mercury (diss.filt)	<0.01 µg/l	TM183	<0.01	<0.01				<0.01 @
Nitrite as NO2	<0.05 mg/l	TM184	0.054 #	0.067 #				<0.05 #
Sulphate	<2 mg/l	TM184	<2 #	<2 #				<2 #
Chloride	<2 mg/l	TM184	10.5 #	<2 #				<2 #
Phosphate (ortho) as PO4	<0.05 mg/l	TM184	<0.05 #	<0.05 #				<0.05 #
Nitrate as NO3	<0.3 mg/l	TM184	29.3 #	<0.3 #				<0.3 #
Calcium (diss.filt)	<0.012 mg/l	TM228	7.23 #	1.08 #				0.62 #
Sodium (diss.filt)	<0.076 mg/l	TM228	7.79 #	1.37 #				1.17 #
Magnesium (diss.filt)	<0.036 mg/l	TM228	1.75 #	0.475 #				0.348 #
Potassium (diss.filt)	<1 mg/l	TM228	3.06 #	<1 #				<1 #
Iron (diss.filt)	<0.019 mg/l	TM228	<0.019 #	0.323 #				0.186 #
pH	<1 pH Units	TM256	6.45 #	6.87 #				6.89 #
Phenol	<0.002 mg/l	TM259	<0.002 #	<0.002 #				<0.002 #
Tin(diss.filt)	<0.36 µg/l	TM283	<0.36	<0.36				<0.36
Moisture Content Ratio (% of as received sample)	%	PM024			17	21	15	
Exchangeable Ammonia as NH4	<15 mg/kg	TM024			<15 M	<15 M	<15 M	
Phenol	<0.01 mg/kg	TM062 (S)			<0.01 M	<0.01 M	<0.01 M	
Organic Carbon, Total	<0.2 %	TM132			0.454 M	0.497 M	0.401 M	
pH	1 pH Units	TM133			5.28 M	5.88 M	5.38 M	
Aluminium	<11 mg/kg	TM181			50300	72000	64200	
Antimony	<0.6 mg/kg	TM181			7.37 #	<6 #	<6 #	
Arsenic	<0.6 mg/kg	TM181			<6 M	<6 M	<6 M	
Barium	<0.6 mg/kg	TM181			<6 #	<6 #	<6 #	
Beryllium	<0.01 mg/kg	TM181			0.261 M	0.174 M	0.255 M	
Boron	<0.7 mg/kg	TM181			<7 #	<7 #	<7 #	
Cadmium	<0.02 mg/kg	TM181			<0.2 M	<0.2 M	<0.2 M	
Chromium	<0.9 mg/kg	TM181			545 M	219 M	323 M	
Cobalt	<0.1 mg/kg	TM181			4.22 M	4.18 M	1.15 M	
Copper	<1.4 mg/kg	TM181			16.2 M	<14 M	<14 M	

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CERTIFICATE OF ANALYSIS

SDG:	161117-88	**Location:**	Liberia	**Order Number:**	
Job:	H_EARTH_LIB-1	**Customer:**	Earthtime Inc.	**Report Number:**	388540
Client Reference:		**Attention:**	Basma Shamas	**Superseded Report:**	

Results Legend

- # ISO17025 accredited.
- M *m*CERTS accredited.
- aq Aqueous / settled sample.
- diss.filt Dissolved / filtered sample.
- tot.unfilt Total / unfiltered sample.
- * Subcontracted test.
- ** % recovery of the surrogate standard to check the efficiency of the method. The results of individual compounds within samples aren't corrected for the recovery
- (F) Trigger breach confirmed
- 1-5&+§@ Sample deviation (see appendix)

Customer Sample Ref.			BOLELAW1	DIMAH	MCC1	MCC4	MCCC CENTER	PO01
Depth (m)			.	.	0.50 - 0.80	0.50 - 0.80	0.50 - 0.80	.
Sample Type			Water(GW/SW)	Water(GW/SW)	Soil/Solid	Soil/Solid	Soil/Solid	Water(GW/SW)
Date Sampled			10/11/2016	10/11/2016	10/11/2016	10/11/2016	10/11/2016	09/11/2016
Sample Time			.	.	.	.	.	.
Date Received			17/11/2016	17/11/2016	17/11/2016	17/11/2016	17/11/2016	17/11/2016
SDG Ref			161117-88	161117-88	161117-88	161117-88	161117-88	161117-88
Lab Sample No.(s)			14548563	14548562	14548566	14548568	14548567	14548564
AGS Reference								
Component	**LOD/Units**	**Method**						
Iron	<1000 mg/kg	TM181			128000 #	98300 #	169000 #	
Lead	<0.7 mg/kg	TM181			10.1 M	13.6 M	10.6 M	
Manganese	<0.13 mg/kg	TM181			75.9 M	94.6 M	67.9 M	
Mercury	<0.14 mg/kg	TM181			<0.14 M	<1.4 M	<0.14 M	
Molybdenum	<0.1 mg/kg	TM181			<1 #	<1 #	<1 #	
Nickel	<0.2 mg/kg	TM181			16 M	12.9 M	10.9 M	
Phosphorus	<1 mg/kg	TM181			414	478	451	
Selenium	<1 mg/kg	TM181			<10 #	<10 #	<10 #	
Strontium	<0.4 mg/kg	TM181			2.49 #	2.92 #	2.95 #	
Tin	<0.24 mg/kg	TM181			<2.4 #	<2.4 #	<2.4 #	
Thallium	<0.7 mg/kg	TM181			<7 #	<7 #	<7 #	
Titanium	<0.1 mg/kg	TM181			1880	1830	1270	
Vanadium	<0.2 mg/kg	TM181			348 #	238 #	325 #	
Zinc	<1.9 mg/kg	TM181			<19 M	<19 M	29.5 M	
Bismuth	<1 mg/kg	TM181			41.4	29.5	56.6	
Lithium	<1 mg/kg	TM181			<10	<10	<10	
Tellurium	<1 mg/kg	TM181			26.2	25.9	28	
Sulphate, Total	<48 mg/kg	TM221			164 M	105 M	<48 M	
Total Sulphur (ASB)	<0.0016 %	TM221			0.00546	0.00349	<0.0016	
Calcium	<21 mg/kg	TM224			36.2	71.6	300	
Sodium	<7 mg/kg	TM224			47.2	46.2	50.3	
Magnesium	<8 mg/kg	TM224			104	155	24.3	
Potassium	<16 mg/kg	TM224			112	152	150	
Conductivity @ 20 deg.C	<0.014 mS/cm	TM234			1.6	1.68	1.75	
Phosphate (ortho) as PO4	<1 mg/kg	TM243			<1	<1	<1	
Nitrite as NO2, 2:1 water soluble	<0.1 mg/kg	TM243			1.91	1.58	0.95	
Water Soluble Sulphate as SO4 2:1 Extract	<0.004 g/l	TM243			<0.004 M	<0.004 M	0.0353 M	
Chloride (soluble)	<5 mg/kg	TM243			<5 M	<5 M	<5 M	
Nitrate as NO3, 2:1 water soluble	<1 mg/kg	TM243			5.94	2.85	3.34	
Silver	<10 mg/kg	TM250			<10	<10	<10	

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CERTIFICATE OF ANALYSIS

SDG:	161117-88	**Location:**	Liberia	**Order Number:**	
Job:	H_EARTH_LIB-1	**Customer:**	Earthtime Inc.	**Report Number:**	388540
Client Reference:		**Attention:**	Basma Shamas	**Superseded Report:**	

Results Legend

#	ISO17025 accredited.
M	*m*CERTS accredited.
aq	Aqueous / settled sample.
diss.filt	Dissolved / filtered sample.
tot.unfilt	Total / unfiltered sample.
*	Subcontracted test.
**	% recovery of the surrogate standard to check the efficiency of the method. The results of individual compounds within samples aren't corrected for the recovery
(F)	Trigger breach confirmed
1-5&+§@	Sample deviation (see appendix)

		Customer Sample Ref.	PO03	PO-DWST	SWAMP S	SWAMP W	VAR_HP	VT HP1
		Depth (m)	.	.	0.50 - 0.80	.	.	.
		Sample Type	Water(GW/SW)	Water(GW/SW)	Soil/Solid	Water(GW/SW)	Water(GW/SW)	Water(GW/SW)
		Date Sampled	09/11/2016	10/11/2016	10/11/2016	10/11/2016	09/11/2016	10/11/2016
		Sample Time	.	.	.	.	.	.
		Date Received	17/11/2016	17/11/2016	17/11/2016	17/11/2016	17/11/2016	17/11/2016
		SDG Ref	161117-88	161117-88	161117-88	161117-88	161117-88	161117-88
		Lab Sample No.(s)	14548558	14548557	14548565	14548560	14548559	14548561
		AGS Reference						
Component	**LOD/Units**	**Method**						
Sulphur, Total*	<10 mg/l	SUB	<10	<10		<10	<10	<10
Suspended solids, Total	<2 mg/l	TM022	10 #	5 #		<2 #	<2 #	<2 #
Oxygen, dissolved	<0.3 mg/l	TM046	11.5 @#	10.9 @#		10.8 @#	11.6 @#	11 @#
Organic Carbon, Total	<3 mg/l	TM090	4.17 @#	3.21 @#		<3 @#	<3 @#	<3 @#
Ammoniacal Nitrogen as NH4	<0.3 mg/l	TM099	<0.3 #	<0.3 #		<0.3 #	<0.3 #	<0.3 #
Conductivity @ 20 deg.C	<0.005 mS/cm	TM120	0.0126 #	0.0134 #		0.0151 #	0.0555 #	0.0563 #
Silicon (diss.filt)	<0.05 mg/l	TM129	2.69	3.21		2.38	1.36	2.16
Aluminium (diss.filt)	<2 µg/l	TM152	83.1 #	51.1 #		28.2 #	77.2 #	43.3 #
Antimony (diss.filt)	<0.16 µg/l	TM152	<0.16 #	<0.16 #		<0.16 #	<0.16 #	<0.16 #
Arsenic (diss.filt)	<0.51 µg/l	TM152	0.653 #	0.658 #		<0.51 #	<0.51 #	0.525 #
Barium (diss.filt)	<0.2 µg/l	TM152	13.3 #	14.6 #		7.41 #	10.3 #	9.12 #
Beryllium (diss.filt)	<0.1 µg/l	TM152	<0.1 #	<0.1 #		<0.1 #	<0.1 #	<0.1 #
Boron (diss.filt)	<5 µg/l	TM152	<5 #	<5 #		6.27 #	7.69 #	<5 #
Cadmium (diss.filt)	<0.08 µg/l	TM152	<0.08 #	<0.08 #		<0.08 #	<0.08 #	0.0966 #
Chromium (diss.filt)	<1.2 µg/l	TM152	<1.2 #	<1.2 #		<1.2 #	<1.2 #	<1.2 #
Cobalt (diss.filt)	<0.15 µg/l	TM152	<0.15 #	<0.15 #		0.286 #	0.345 #	0.182 #
Copper (diss.filt)	<0.85 µg/l	TM152	<0.85 #	<0.85 #		<0.85 #	13.2 #	12.3 #
Lead (diss.filt)	<0.1 µg/l	TM152	0.113 #	<0.1 #		<0.1 #	0.284 #	0.306 #
Lithium (diss.filt)	<1 µg/l	TM152	<1 #	<1 #		<1 #	<1 #	<1 #
Manganese (diss.filt)	<0.76 µg/l	TM152	4.28 #	4.61 #		10.2 #	13.4 #	16.7 #
Molybdenum (diss.filt)	<0.62 µg/l	TM152	<0.62 #	<0.62 #		<0.62 #	<0.62 #	<0.62 #
Nickel (diss.filt)	<0.44 µg/l	TM152	<0.44 #	<0.44 #		0.519 #	0.559 #	0.864 #
Phosphorus (diss.filt)	<15 µg/l	TM152	<15 #	<15 #		<15 #	<15 #	<15 #
Selenium (diss.filt)	<0.81 µg/l	TM152	0.819 #	<0.81 #		<0.81 #	<0.81 #	<0.81 #
Strontium (diss.filt)	<0.4 µg/l	TM152	6.83 #	7.17 #		6.05 #	35.9 #	34.3 #
Tellurium (diss.filt)	<7 µg/l	TM152	<7	<7		<7	<7	<7
Thallium (diss.filt)	<2 µg/l	TM152	<2	<2		<2	<2	<2
Titanium (diss.filt)	<1.5 µg/l	TM152	2.75 #	3.23 #		<1.5 #	<1.5 #	<1.5 #
Uranium (diss.filt)	<0.5 µg/l	TM152	<0.5	<0.5		<0.5	<0.5	<0.5
Vanadium (diss.filt)	<1.3 µg/l	TM152	<1.3 #	<1.3 #		<1.3 #	<1.3 #	<1.3 #
Zinc (diss.filt)	<1.3 µg/l	TM152	9.75 #	<1.3 #		2.67 #	29.8 #	134 #
Bismuth (dis.filt)	<0.1 µg/l	TM152	<0.1 #	<0.1 #		<0.1 #	<0.1 #	<0.1 #

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Validated

CERTIFICATE OF ANALYSIS

SDG:	161117-88	**Location:**	Liberia	**Order Number:**	
Job:	H_EARTH_LIB-1	**Customer:**	Earthtime Inc.	**Report Number:**	388540
Client Reference:		**Attention:**	Basma Shamas	**Superseded Report:**	

Results Legend
- # ISO17025 accredited.
- M *m*CERTS accredited.
- aq Aqueous / settled sample.
- diss.filt Dissolved / filtered sample.
- tot.unfilt Total / unfiltered sample.
- * Subcontracted test.
- ** % recovery of the surrogate standard to check the efficiency of the method. The results of individual compounds within samples aren't corrected for the recovery
- (F) Trigger breach confirmed
- 1-5&+§@ Sample deviation (see appendix)

Customer Sample Ref.			PO03	PO-DWST	SWAMP S	SWAMP W	VAR_HP	VT HP1
Depth (m)			.	.	0.50 - 0.80	.	.	.
Sample Type			Water(GW/SW)	Water(GW/SW)	Soil/Solid	Water(GW/SW)	Water(GW/SW)	Water(GW/SW)
Date Sampled			09/11/2016	10/11/2016	10/11/2016	10/11/2016	09/11/2016	10/11/2016
Sample Time			.	.	.	.	.	.
Date Received			17/11/2016	17/11/2016	17/11/2016	17/11/2016	17/11/2016	17/11/2016
SDG Ref			161117-88	161117-88	161117-88	161117-88	161117-88	161117-88
Lab Sample No.(s)			14548558	14548557	14548565	14548560	14548559	14548561
AGS Reference								
Component	**LOD/Units**	**Method**						
Tungsten (dis.filt)	<1 µg/l	TM152	<1	<1		<1	<1	<1
Zirconium (dis.filt)	<1 µg/l	TM152	<1	<1		<1	<1	<1
Silver (diss.filt)	<1 µg/l	TM152	<1	<1		<1	<1	<1
Mercury (diss.filt)	<0.01 µg/l	TM183	<0.01 @	<0.01		<0.01	<0.01 @	<0.01
Nitrite as NO2	<0.05 mg/l	TM184	<0.05 #	<0.05 #		0.053 #	0.103 #	<0.05 #
Sulphate	<2 mg/l	TM184	<2 #	<2 #		<2 #	<2 #	<2 #
Chloride	<2 mg/l	TM184	<2 #	<2 #		<2 #	3.2 #	3.7 #
Phosphate (ortho) as PO4	<0.05 mg/l	TM184	<0.05 #	<0.05 #		<0.05 #	<0.05 #	<0.05 #
Nitrate as NO3	<0.3 mg/l	TM184	15.6 #	<0.3 #		<0.3 #	16.3 #	8.03 #
Calcium (diss.filt)	<0.012 mg/l	TM228	0.939 #	0.65 #		0.51 #	3.96 #	6.18 #
Sodium (diss.filt)	<0.076 mg/l	TM228	1.18 #	1.31 #		1.05 #	5.04 #	3.34 #
Magnesium (diss.filt)	<0.036 mg/l	TM228	0.347 #	0.401 #		0.421 #	0.324 #	0.443 #
Potassium (diss.filt)	<1 mg/l	TM228	<1 #	<1 #		<1 #	1.24 #	<1 #
Iron (diss.filt)	<0.019 mg/l	TM228	0.199 #	0.177 #		<0.019 #	<0.019 #	0.0233 #
pH	<1 pH Units	TM256	6.85 #	7.04 #		5.88 #	6.09 #	6.51 #
Phenol	<0.002 mg/l	TM259	<0.002 #	<0.002 #		<0.002 #	<0.002 #	<0.002 #
Tin(diss.filt)	<0.36 µg/l	TM283	<0.36	<0.36		<0.36	<0.36	<0.36
Moisture Content Ratio (% of as received sample)	%	PM024			22			
Exchangeable Ammonia as NH4	<15 mg/kg	TM024			<15 M			
Phenol	<0.01 mg/kg	TM062 (S)			<0.01 M			
Organic Carbon, Total	<0.2 %	TM132			0.327 M			
pH	1 pH Units	TM133			5.66 M			
Aluminium	<11 mg/kg	TM181			57800			
Antimony	<0.6 mg/kg	TM181			<6 #			
Arsenic	<0.6 mg/kg	TM181			<6 M			
Barium	<0.6 mg/kg	TM181			13.8 #			
Beryllium	<0.01 mg/kg	TM181			<0.1 M			
Boron	<0.7 mg/kg	TM181			<7 #			
Cadmium	<0.02 mg/kg	TM181			<0.2 M			
Chromium	<0.9 mg/kg	TM181			146 M			
Cobalt	<0.1 mg/kg	TM181			1.76 M			
Copper	<1.4 mg/kg	TM181			<14 M			

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CERTIFICATE OF ANALYSIS

SDG:	161117-88	**Location:**	Liberia	**Order Number:**	
Job:	H_EARTH_LIB-1	**Customer:**	Earthtime Inc.	**Report Number:**	388540
Client Reference:		**Attention:**	Basma Shamas	**Superseded Report:**	

Results Legend

- # ISO17025 accredited.
- M mCERTS accredited.
- aq Aqueous / settled sample.
- diss.filt Dissolved / filtered sample.
- tot.unfilt Total / unfiltered sample.
- * Subcontracted test.
- ** % recovery of the surrogate standard to check the efficiency of the method. The results of individual compounds within samples aren't corrected for the recovery
- (F) Trigger breach confirmed
- 1-5&♦§@ Sample deviation (see appendix)

Customer Sample Ref.			PO03	PO-DWST	SWAMP S	SWAMP W	VAR_HP	VT HP1
Depth (m)			.	.	0.50 - 0.80	.	.	.
Sample Type			Water(GW/SW)	Water(GW/SW)	Soil/Solid	Water(GW/SW)	Water(GW/SW)	Water(GW/SW)
Date Sampled			09/11/2016	10/11/2016	10/11/2016	10/11/2016	09/11/2016	10/11/2016
Sample Time			.	.	.	.	.	.
Date Received			17/11/2016	17/11/2016	17/11/2016	17/11/2016	17/11/2016	17/11/2016
SDG Ref			161117-88	161117-88	161117-88	161117-88	161117-88	161117-88
Lab Sample No.(s)			14548558	14548557	14548565	14548560	14548559	14548561
AGS Reference								
Component	**LOD/Units**	**Method**						
Iron	<1000 mg/kg	TM181			64300 #			
Lead	<0.7 mg/kg	TM181			17.6 M			
Manganese	<0.13 mg/kg	TM181			24.1 M			
Mercury	<0.14 mg/kg	TM181			<0.14 M			
Molybdenum	<0.1 mg/kg	TM181			<1 #			
Nickel	<0.2 mg/kg	TM181			15.7 M			
Phosphorus	<1 mg/kg	TM181			323			
Selenium	<1 mg/kg	TM181			<10 #			
Strontium	<0.4 mg/kg	TM181			2.18 #			
Tin	<0.24 mg/kg	TM181			<2.4 #			
Thallium	<0.7 mg/kg	TM181			<7 #			
Titanium	<0.1 mg/kg	TM181			699			
Vanadium	<0.2 mg/kg	TM181			288 #			
Zinc	<1.9 mg/kg	TM181			<19 M			
Bismuth	<1 mg/kg	TM181			17.1			
Lithium	<1 mg/kg	TM181			<10			
Tellurium	<1 mg/kg	TM181			15.5			
Sulphate, Total	<48 mg/kg	TM221			101 M			
Total Sulphur (ASB)	<0.0016 %	TM221			0.00337			
Calcium	<21 mg/kg	TM224			57.9			
Sodium	<7 mg/kg	TM224			46.1			
Magnesium	<8 mg/kg	TM224			142			
Potassium	<16 mg/kg	TM224			305			
Conductivity @ 20 deg.C	<0.014 mS/cm	TM234			1.55			
Phosphate (ortho) as PO4	<1 mg/kg	TM243			<1			
Nitrite as NO2, 2:1 water soluble	<0.1 mg/kg	TM243			1.31			
Water Soluble Sulphate as SO4 2:1 Extract	<0.004 g/l	TM243			<0.004 M			
Chloride (soluble)	<5 mg/kg	TM243			<5 M			
Nitrate as NO3, 2:1 water soluble	<1 mg/kg	TM243			<1			
Silver	<10 mg/kg	TM250			<10			

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CERTIFICATE OF ANALYSIS

SDG:	161117-88	**Location:**	Liberia	**Order Number:**	
Job:	H_EARTH_LIB-1	**Customer:**	Earthtime Inc.	**Report Number:**	388540
Client Reference:		**Attention:**	Basma Shamas	**Superseded Report:**	

Table of Results - Appendix

Method No	Reference	Description	Wet/Dry Sample ¹	Surrogate Corrected
PM001		Preparation of Samples for Metals Analysis		
PM024	Modified BS 1377	Soil preparation including homogenisation, moisture screens of soils for Asbestos Containing Material		
SUB		Subcontracted Test		
TM022	Method 2540D, AWWA/APHA, 20th Ed., 1999 / BS 2690: Part120 1981;BS EN 872	Determination of total suspended solids in waters		
TM024	Method 4500A & B, AWWA/APHA, 20th Ed., 1999	Determination of Exchangeable Ammonium and Ammoniacal Nitrogen as N by titration on solids		
TM046	Method 4500G, AWWA/APHA, 20th Ed., 1999	Measurement of Dissolved Oxygen by Oxygen Meter		
TM062 (S)	National Grid Property Holdings Methods for the Collection & Analysis of Samples from National Grid Sites version 1 Sec 3.9	Determination of Phenols in Soils by HPLC		
TM090	Method 5310, AWWA/APHA, 20th Ed., 1999 / Modified: US EPA Method 415.1 & 9060	Determination of Total Organic Carbon/Total Inorganic Carbon in Water and Waste Water		
TM099	BS 2690: Part 7:1968 / BS 6068: Part2.11:1984	Determination of Ammonium in Water Samples using the Kone Analyser		
TM120	Method 2510B, AWWA/APHA, 20th Ed., 1999 / BS 2690: Part 9:1970	Determination of Electrical Conductivity using a Conductivity Meter		
TM129	Method 3120B, AWWA/APHA, 20th Ed., 1999 / Modified: US EPA Method 3050B	Determination of Metal Cations by IRIS Emission Spectrometer		
TM132	In - house Method	ELTRA CS800 Operators Guide		
TM133	BS 1377: Part 3 1990;BS 6068-2.5	Determination of pH in Soil and Water using the GLpH pH Meter		
TM152	Method 3125B, AWWA/APHA, 20th Ed., 1999	Analysis of Aqueous Samples by ICP-MS		
TM181	US EPA Method 6010B	Determination of Routine Metals in Soil by iCap 6500 Duo ICP-OES		
TM183	BS EN 23506:2002, (BS 6068-2.74:2002) ISBN 0 580 38924 3	Determination of Trace Level Mercury in Waters and Leachates by PSA Cold Vapour Atomic Fluorescence Spectrometry		
TM184	EPA Methods 325.1 & 325.2,	The Determination of Anions in Aqueous Matrices using the Kone Spectrophotometric Analysers		
TM221	Inductively Coupled Plasma - Atomic Emission Spectroscopy. An Atlas of Spectral Information: Winge, Fassel, Peterson and Floyd	Determination of Acid extractable Sulphate in Soils by IRIS Emission Spectrometer		
TM224	US EPA Method 6010B	Determination of Alkaline Metals by iCap 6500 Duo ICP-OES		
TM228	US EPA Method 6010B	Determination of Major Cations in Water by iCap 6500 Duo ICP-OES		
TM234	The measurement of Electrical Conductivity and the Laboratory Determination of the pH value of Natural, Treated and Waste Waters. HMSO, 1978. ISBN 011 751428 4.	Determination of Electrical Conductivity of Soils Extracted with Calcium Sulphate		
TM243		Mixed Anions In Soils By Kone		
TM250		Determination of Silver in Soil by ICP-OES		
TM256	The measurement of Electrical Conductivity and the Laboratory determination of pH Value of Natural, Treated and Wastewaters. HMSO, 1978. ISBN 011 751428 4.	Determination of pH in Water and Leachate using the GLpH pH Meter		
TM259	by HPLC	Determination of Phenols in Waters and Leachates by HPLC		
TM283		Determination of Dissolved Niobium, Tungsten, and Zirconium in Water Matrices by ICP-MS		

¹ Applies to Solid samples only. DRY indicates samples have been dried at 35°C. NA = not applicable.
Chemical testing (unless subcontracted) performed at ALcontrol Laboratories Hawarden (Method codes TM) or ALcontrol Laboratories Aberdeen (Method codes S).

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CERTIFICATE OF ANALYSIS

SDG:	161117-88	**Location:**	Liberia	**Order Number:**	
Job:	H_EARTH_LIB-1	**Customer:**	Earthtime Inc.	**Report Number:**	388540
Client Reference:		**Attention:**	Basma Shamas	**Superseded Report:**	

Test Completion Dates

Lab Sample No(s)	14548563	14548562	14548566	14548568	14548567	14548564	14548558	14548557	14548565	14548560
Customer Sample Ref.	BOLELAW1	DIMAH	MCC1	MCC4	MCCC CENTER	PO01	PO03	PO-DWST	SWAMP S	SWAMP W
AGS Ref.										
Depth			0.50 - 0.80	0.50 - 0.80	0.50 - 0.80				0.50 - 0.80	
Type	LIQUID	LIQUID	SOLID	SOLID	SOLID	LIQUID	LIQUID	LIQUID	SOLID	LIQUID
Alkali Metals by iCap-OES (Soil)			28-Nov-2016	28-Nov-2016	28-Nov-2016				28-Nov-2016	
Ammoniacal Nitrogen	25-Nov-2016	25-Nov-2016				25-Nov-2016	25-Nov-2016	25-Nov-2016		25-Nov-2016
Ammonium Soil by Titration			24-Nov-2016	25-Nov-2016	24-Nov-2016				24-Nov-2016	
Anions by Kone (soil)			25-Nov-2016	25-Nov-2016	25-Nov-2016				25-Nov-2016	
Anions by Kone (w)	25-Nov-2016	25-Nov-2016				25-Nov-2016	25-Nov-2016	25-Nov-2016		25-Nov-2016
Conductivity (at 20 deg.C)	23-Nov-2016	23-Nov-2016	25-Nov-2016	25-Nov-2016	25-Nov-2016	23-Nov-2016	23-Nov-2016	23-Nov-2016	25-Nov-2016	23-Nov-2016
Dissolved Metals by ICP-MS	24-Nov-2016	24-Nov-2016				24-Nov-2016	24-Nov-2016	24-Nov-2016		23-Nov-2016
Dissolved Oxygen by Probe	21-Nov-2016	21-Nov-2016				21-Nov-2016	21-Nov-2016	21-Nov-2016		21-Nov-2016
Dissolved Tin by ICPMS	22-Nov-2016	22-Nov-2016				22-Nov-2016	22-Nov-2016	22-Nov-2016		22-Nov-2016
Mercury Dissolved	24-Nov-2016	24-Nov-2016				24-Nov-2016	24-Nov-2016	24-Nov-2016		24-Nov-2016
Metals by iCap-OES Dissolved (W)	22-Nov-2016	24-Nov-2016				24-Nov-2016	24-Nov-2016	24-Nov-2016		24-Nov-2016
Metals in solid samples by OES			01-Dec-2016	01-Dec-2016	01-Dec-2016				01-Dec-2016	
Nitrite by Kone (w)	25-Nov-2016	25-Nov-2016				25-Nov-2016	25-Nov-2016	23-Nov-2016		25-Nov-2016
NO3, NO2 and TON by KONE (s)			25-Nov-2016	25-Nov-2016	25-Nov-2016				25-Nov-2016	
pH			23-Nov-2016	24-Nov-2016	23-Nov-2016				23-Nov-2016	
pH Value	22-Nov-2016	22-Nov-2016				22-Nov-2016	22-Nov-2016	22-Nov-2016		22-Nov-2016
Phenols by HPLC (S)			25-Nov-2016	25-Nov-2016	25-Nov-2016				25-Nov-2016	
Phenols by HPLC (W)	22-Nov-2016	22-Nov-2016				22-Nov-2016	23-Nov-2016	22-Nov-2016		23-Nov-2016
Phosphate (Ortho as PO4) (s)			25-Nov-2016	25-Nov-2016	25-Nov-2016				25-Nov-2016	
Sample description			22-Nov-2016	23-Nov-2016	22-Nov-2016				22-Nov-2016	
Silicon Dissolved by ICP-OES	25-Nov-2016	25-Nov-2016				25-Nov-2016	25-Nov-2016	25-Nov-2016		25-Nov-2016
Silver			25-Nov-2016	25-Nov-2016	25-Nov-2016				25-Nov-2016	
Sulphur Total*	28-Nov-2016	28-Nov-2016				28-Nov-2016	28-Nov-2016	28-Nov-2016		28-Nov-2016
Suspended Solids	25-Nov-2016	25-Nov-2016				25-Nov-2016	25-Nov-2016	25-Nov-2016		25-Nov-2016
Total Organic and Inorganic Carbon	22-Nov-2016	22-Nov-2016				22-Nov-2016	22-Nov-2016	22-Nov-2016		22-Nov-2016
Total Organic Carbon			25-Nov-2016	25-Nov-2016	25-Nov-2016				25-Nov-2016	
Total Sulphate			25-Nov-2016	25-Nov-2016	25-Nov-2016				25-Nov-2016	

Lab Sample No(s)	14548559	14548561
Customer Sample Ref.	VAR_HP	VT HP1
AGS Ref.		
Depth		
Type	LIQUID	LIQUID
Ammoniacal Nitrogen	25-Nov-2016	24-Nov-2016
Anions by Kone (w)	25-Nov-2016	25-Nov-2016
Conductivity (at 20 deg.C)	23-Nov-2016	23-Nov-2016
Dissolved Metals by ICP-MS	24-Nov-2016	24-Nov-2016
Dissolved Oxygen by Probe	21-Nov-2016	21-Nov-2016
Dissolved Tin by ICPMS	22-Nov-2016	22-Nov-2016
Mercury Dissolved	24-Nov-2016	24-Nov-2016
Metals by iCap-OES Dissolved (W)	22-Nov-2016	24-Nov-2016
Nitrite by Kone (w)	23-Nov-2016	25-Nov-2016
pH Value	22-Nov-2016	22-Nov-2016
Phenols by HPLC (W)	23-Nov-2016	23-Nov-2016
Silicon Dissolved by ICP-OES	25-Nov-2016	25-Nov-2016
Sulphur Total*	28-Nov-2016	28-Nov-2016
Suspended Solids	25-Nov-2016	25-Nov-2016
Total Organic and Inorganic Carbon	22-Nov-2016	22-Nov-2016

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Derwentside Environmental Testing Services

Certificate of Analysis

Certificate Number 16-84564

25-Nov-16

Client	Alcontrol Laboratories Units 7 & 8 Hawarden Business Park Manor Road Hawarden Deeside CH5 3US
Our Reference	16-84564
Client Reference	161117-88
Order No	(not supplied)
Contract Title	161117-88
Description	8 Water samples.
Date Received	21-Nov-16
Date Started	21-Nov-16
Date Completed	25-Nov-16
Test Procedures	Identified by prefix DETSn (details on request).
Notes	Opinions and interpretations are outside the scope of UKAS accreditation. This certificate is issued in accordance with the accreditation requirements of the United Kingdom Accreditation Service. The results reported herein relate only to the material supplied to the laboratory. Observations and interpretations are outside the scope of ISO 17025. This certificate shall not be reproduced except in full, without the prior written approval of the laboratory.

Approved By

Rob Brown
Business Manager

Derwentside Environmental Testing Services Limited
Unit 2, Park Road Industrial Estate South, Consett, Co Durham, DH8 5PY
Tel: 01207 582333 • email: info@dets.co.uk • www.dets.co.uk

Derwentside Environmental Testing Services

Summary of Chemical Analysis
Water Samples

Our Ref 16-84564
Client Ref 161117-88
Contract Title 161117-88

Test	Method	LOD	Units								
			Lab No	1087497	1087498	1087499	1087500	1087501	1087502	1087503	1087504
			Sample ID	14553895 BOLELAW1	1455388 6 DIMAH	14553938 PO-DWST	1455390 4 PO01	1455394 7 PO03	14553932 SWAMPW	14553926 VAR_HP	1455394 1 VT HP1
			Depth								
			Other ID								
			Sample Type	WATER	WATER	WATER	WATER	WATER	WATER	WATER	WATER
			Sampling Date	10/11/16	10/11/16	10/11/16	09/11/16	09/11/16	10/11/16	09/11/16	10/11/16
			Sampling Time	n/s	n/s	n/s	n/s	n/s	n/s	n/s	n/s
Inorganics											
Sulphur as S, Total	DETSC 2320*	10	mg/l	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10

Key: * -not accredited. n/s -not supplied.

Information in Support of the Analytical Results

Our Ref 16-84564
Client Ref 161117-88
Contract 161117-88

Containers Received & Deviating Samples

Lab No	Sample ID	Date Sampled	Containers Received	Holding time exceeded for tests	Inappropriate container for tests
1087497	14553895 BOLELAW1 WATER	10/11/16	PB to 250ml		
1087498	14553886 DIMAH WATER	10/11/16	PB to 250ml		
1087499	14553938 PO-DWST WATER	10/11/16	PB to 250ml		
1087500	14553904 PO01 WATER	09/11/16	PB to 250ml		
1087501	14553947 PO03 WATER	09/11/16	PB to 250ml		
1087502	14553932 SWAMP W WATER	10/11/16	PB to 250ml		
1087503	14553926 VAR_HP WATER	09/11/16	PB to 250ml		
1087504	14553941 VT HP1 WATER	10/11/16	PB to 250ml		

Key: P-Plastic B-Bottle

DETS cannot be held responsible for the integrity of samples received whereby the laboratory did not undertake the sampling. In this instance samples received may be deviating. Deviating Sample criteria are based on British and International standards and laboratory trials in conjunction with the UKAS note 'Guidance on Deviating Samples'. All samples received are listed above. However, those samples that have additional comments in relation to hold time, inappropriate containers etc are deviating due to the reasons stated. This means that the analysis is accredited where applicable, but results may be compromised due to sample deviations. If no sampled date (soils) or date+time (waters) has been supplied then samples are deviating. However, if you are able to supply a sampled date (and time for waters) this will prevent samples being reported as deviating where specific hold times are not exceeded and where the container supplied is suitable.

Disposal

From the issue date of this test certificate, samples will be held for the following times prior to disposal :-
Soils - 1 month, Liquids - 2 weeks, Asbestos (test portion) - 6 months

ALcontrol Laboratories

CERTIFICATE OF ANALYSIS

SDG:	161117-88	**Location:**	Liberia	**Order Number:**	
Job:	H_EARTH_LIB-1	**Customer:**	Earthtime Inc.	**Report Number:**	388540
Client Reference:		**Attention:**	Basma Shamas	**Superseded Report:**	

Appendix

General

1. Results are expressed on a dry weight basis (dried at 35°C) for all soil analyses except for the following: NRA and CEN Leach tests, flash point LOI, pH, ammonium as NH4 by the BRE method, VOC TICs and SVOC TICs.

2. Samples will be run in duplicate upon request, but an additional charge may be incurred.

3. If sufficient sample is received a sub sample will be retained free of charge for 30 days after analysis is completed (e-mailed) for all sample types unless the sample is destroyed on testing. The prepared soil sub sample that is analysed for asbestos will be retained for a period of 6 months after the analysis date. All bulk samples will be retained for a period of 6 months after the analysis date. All samples received and not scheduled will be disposed of one month after the date of receipt unless we are instructed to the contrary. Once the initial period has expired, a storage charge will be applied for each month or part thereof until the client cancels the request for sample storage. ALcontrol Laboratories reserve the right to charge for samples received and stored but not analysed.

4. With respect to turnaround, we will always endeavour to meet client requirements wherever possible, but turnaround times cannot be absolutely guaranteed due to so many variables beyond our control.

5. We take responsibility for any test performed by sub-contractors (marked with an asterisk). We endeavour to use UKAS/MCERTS Accredited Laboratories, who either complete a quality questionnaire or are audited by ourselves. For some determinands there are no UKAS/MCERTS Accredited Laboratories, in this instance a laboratory with a known track record will be utilised.

6. When requested, the individual sub sample scheduled will be analysed in house for the presence of asbestos fibres and asbestos containing material by our documented in house method TM048 based on HSG 248 (2005), which is accredited to ISO17025. If a specific asbestos fibre type is not found this will be reported as "Not detected". If no asbestos fibre types are found all will be reported as "Not detected" and the sub sample analysed deemed to be clear of asbestos. If an asbestos fibre type is found it will be reported as detected (for each fibre type found). Testing can be carried out on asbestos positive samples, but, due to Health and Safety considerations, may be replaced by alternative tests or reported as No Determination Possible (NDP). The quantity of asbestos present is not determined unless specifically requested.

7. If no separate volatile sample is supplied by the client, or if a headspace or sediment is present in the volatile sample, the integrity of the data may be compromised. This will be flagged up as an invalid VOC on the test schedule and the result marked as deviating on the test certificate.

8. If appropriate preserved bottles are not received preservation will take place on receipt. However, the integrity of the data may be compromised.

9. NDP - No determination possible due to insufficient/unsuitable sample.

10. Metals in water are performed on a filtered sample, and therefore represent dissolved metals - total metals must be requested separately.

11. Results relate only to the items tested.

12. LoDs (Limit of Detection) for wet tests reported on a dry weight basis are not corrected for moisture content.

13. **Surrogate recoveries** - Surrogates are added to your sample to monitor recovery of the test requested. A % recovery is reported, results are not corrected for the recovery measured. Typical recoveries for organics tests are 70-130%, they are generally wider for volatiles analysis, 50-150%. Recoveries in soils are affected by organic rich or clay rich matrices. Waters can be affected by remediation fluids or high amounts of sediment. Test results are only ever reported if all of the associated quality checks pass; it is assumed that all recoveries outside of the values above are due to matrix affect.

14. **Product analyses** - Organic analyses on products can only be semi-quantitative due to the matrix effects and high dilution factors employed.

15. Phenols monohydric by HPLC include phenol, cresols (2-Methylphenol, 3-Methylphenol and 4-Methylphenol) and Xylenols (2,3 Dimethylphenol, 2,4 Dimethylphenol, 2,5 Dimethylphenol, 2,6 Dimethylphenol, 3,4 Dimethyphenol, 3,5 Dimethylphenol).

16. Total of 5 speciated phenols by HPLC includes Phenol, 2,3,5-Trimethyl Phenol, 2-Isopropylphenol, Cresols and Xylenols (as detailed in 15).

17. Stones/debris are not routinely removed. We always endeavour to take a representative sub sample from the received sample.

18. In certain circumstances the method detection limit may be elevated due to the sample being outside the calibration range. Other factors that may contribute to this include possible interferences. In both cases the sample would be diluted which would cause the method detection limit to be raised.

19. Mercury results quoted on soils will not include volatile mercury as the analysis is performed on a dried and crushed sample.

20. For the BSEN 12457-3 two batch process to allow the cumulative release to be calculated, the volume of the leachate produced is measured and filtered for all tests. We therefore cannot carry out any unfiltered analysis. The tests affected include volatiles GCFID/GCMS and all subcontracted analysis.

21. For leachate preparations other than Zero Headspace Extraction (ZHE) volatile loss may occur.

22. We are accredited to MCERTS for sand, clay and loam/topsoil, or any of these materials - whether these are derived from naturally occurring soil profiles, or from fill/made ground, as long as these materials constitute the major part of the sample. Other coarse granular material such as concrete, gravel and brick are not accredited if they comprise the major part of the sample.

23. Analysis and identification of specific compounds using GCFID is by retention time only, and we routinely calibrate and quantify for benzene, toluene, ethylbenzenes and xylenes (BTEX). For total volatiles in the C5-C12 range, the total area of the chromatogram is integrated and expressed as ug/kg or ug/l. Although this analysis is commonly used for the quantification of gasoline range organics (GRO), the system will also detect other compounds such as chlorinated solvents, and this may lead to a falsely high result with respect to hydrocarbons only. It is not possible to specifically identify these non-hydrocarbons, as standards are not routinely run for any other compounds, and for more definitive identification, volatiles by GCMS should be utilised.

24. **Tentatively Identified Compounds (TICs)** are non-target peaks in VOC and SVOC analysis. All non-target peaks detected with a concentration above the LoD are subjected to a mass spectral library search. Non-target peaks with a library search confidence of >75% are reported based on the best mass spectral library match. When a non-target peak with a library search confidence of <75% is detected it is reported as "mixed hydrocarbons". Non-target compounds identified from the scan data are semi-quantified relative to one of the deuterated internal standards, under the same chromatographic conditions as the target compounds. This result is reported as a semi-quantitative value and reported as Tentatively Identified Compounds (TICs). TICs are outside the scope of UKAS accreditation and are not moisture corrected.

Sample Deviations

1	Container with Headspace provided for volatiles analysis
2	Incorrect container received
3	Deviation from method
4	Holding time exceeded before sample received
5	Samples exceeded holding time before presevation was performed
§	Sampled on date not provided
•	Sample holding time exceeded in laboratory
@	Sample holding time exceeded due to sampled on date
&	Sample Holding Time exceeded - Late arrival of instructions.

Asbestos

Identification of Asbestos in Bulk Materials & Soils

The results for identification of asbestos in bulk materials are obtained from supplied bulk materials which have been examined to determine the presence of asbestos fibres using ALcontrol Laboratories (Hawarden) in-house method of transmitted/polarised light microscopy and central stop dispersion staining, based on HSG 248 (2005).

The results for identification of asbestos in soils are obtained from a homogenised sub sample which has been examined to determine the presence of asbestos fibres using ALcontrol Laboratories (Hawarden) in-house method of transmitted/polarised light microscopy and central stop dispersion staining, based on HSG 248 (2005).

Asbestos Type	Common Name
Chrysotile	White Asbestos
Amosite	Brown Asbestos
Crocidolite	Blue Asbestos
Fibrous Actinolite	-
Fibrous Anthophyllite	-
Fibrous Tremolite	-

Visual Estimation Of Fibre Content

Estimation of fibre content is not permitted as part of our UKAS accredited test other than:
- Trace - Where only one or two asbestos fibres were identified.

Further guidance on typical asbestos fibre content of manufactured products can be found in HSG 264.

The identification of asbestos containing materials and soils falls within our schedule of tests for which we hold UKAS accreditation, however opinions, interpretations and all other information contained in the report are outside the scope of UKAS accreditation.

APPENDIX C PLANT SPECIES RECORDED IN THE STUDY AREA

Botanical name	Family	Growth form	Uses	Up stream	Down stream	Landfill site
Persea americana	Anacardiaceae	Tree	F/M	x	x	x
Pseudospondias microcarpa	Anacardiaceae	Tree				
Spondias mombin	Anacardiaceae	Tree	M			x
Spondias sp	Anacardiaceae	Tree	F	x	x	x
Trichoscypha arborea	Anacardiaceae	Tree		x	x	x
Trichoscypha mannii	Anacardiaceae	Tree		x	x	
Trichoscypha bijuga	Anacardiaceae	Tree		x		x
Lannea nigritanna	Anacardiaceae	Tree				x
Mangifera indica	Anacardiaceae	Tree	F/M	x	x	x
Spondias sp	Anacardiaceae	Tree	F	x	x	x
Annonia muricata	Annonaceae	Tree	F	x	x	x
Xylopia aethiopica	Annonaceae	Tree	M	x	x	x
Cleistopholis patens	Annonaceae	Tree	M		x	x
Xylopia villosa	Annonaceae	Liana		x	x	x
Uvaria afzelii	Annonaceae	Liana		x	x	x
Funtumia africana	Apocynaceae	Tree	M	x	x	x
Rauvolfia vomitoria	Apocynaceae	Shrub	M	x	x	x
Tabernaemontana glandulosa	Apocynaceae	Shrub				
Tabernaemontana crassa	Apocynaceae	Shrub				
Tabernaemontana pachysiphon	Apocynaceae	Shrub			x	
Tabernaemontana africana	Apocynaceae	Shrub			x	
Anubias afzelii	Araceae	Herb				
Cercestis afzelii	Araceae	Herb		x	x	
Cercestis angolensis	Araceae	Herb		x	x	
Cercestis styriolata	Araceae	Herb				
Newbouldia laevis	Bignoniaceae	Shrub	M	x		x
Ceiba pentandra	Bombacaceae	Tree	M/T	x	x	
Bombax buonopozense	Bombacaceae	Tree		x		
Canarium schweinfurthii	Burseraceae	Tree	T			
Santiria trimera	Burseraceae	Tree	F			
Amphimas pterocarpoides	Caesalpiniaceae	Tree	T	x	x	x
Berlinia confusa	Caesalpiniaceae	Tree		x		x
Copaifera salikounda	Caesalpiniaceae	Tree	T	x	x	x
Dialum dinklagei	Caesalpiniaceae	Tree				
Dialum sp	Caesalpiniaceae	Tree	M			x
Distemonanthus benthamianus	Caesalpiniaceae	Tree				
Daniella ogea	Caesalpiniaceae	Tree			x	
Cassia sieberiana	Caesalpiniaceae	Shrub				
Anthonota macrophylla	Caesalpiniaceae	Tree		x	x	x
Anthonota fragrans	Caesalpiniaceae	Tree		x	x	x
Bussea occidentalis	Caesalpiniaceae	Tree				
Apodostigma pallens	Celastraceae	Liana		x	x	x
Salacia owabiensis	Celastraceae	Liana		x	x	x
Salacia elegans	Celastraceae	Liana		x	x	x
Salacia staudtiana	Celastraceae	Liana		x	x	x

Botanical name	Family	Growth form	Uses	Up stream	Down stream	Landfill site
Cenestis ferruginea	Connaraceae	Shrub	M	x	x	x
Agelaea pentagyna	Connaraceae	Shrub		x	x	x
Manotes expansa	Connaraceae	Shrub		x	x	x
Parinari excelsa	Chrysobelanaceae	Tree	M/T			x
Parinari macrophylla	Chrysobelanaceae	Shrub	M/T		x	
Terminalia ivorensis (VU)	Combretaceae	Tree				
Terminalia catapa	Combretaceae	Tree	T			
Combretum grandiflorum	Combretaceae	Liana	M	x	x	x
Palisota hirsuta	Commelinaceae	Herb	M	x	x	x
Chromolaena odarata	Compositae	Herb		x	x	x
Rhynchospora corymbosa	Cyperaceae	Grass				
Scleria barteri	Cyperaceae	Grass		x	x	x
Cyperus sp	Cyperaceae	Grass				
Dichapetlum oblongum	Dichapetalaceae	Liana			x	
Dichapetalum toxicarium	Dichapetalaceae	Liana	M	X	x	x
Tapura ivorensis	Dichapetalaceae	Liana			x	
Tetracera alnifolia	Dilleniaceae	Liana	M	x	x	x
Tetracera potatoria	Dilleniaceae	Liana				x
Dracaena cerasifera	Dracaenaceae	Herb				
Dracaena cristula	Dracaenaceae	Herb				
Dracaena surculosa	Dracaenaceae	Shrub				
Dracaenea arborea	Dracaenaceae	Tree		x		
Dichapetalum toxicarium	Dichapetalaceae	Liana	M	x	x	x
Diospyros gabonensis	Ebenaceae	Shrub	M	x	x	x
Diospyros thomasii	Ebenaceae	Shrub				
Diospyros sp	Ebenaceae	Shrub				
Alchonea cordifolia	Euphorbiaceae	Shrub	M	x	x	x
Alchonea hirtella	Euphorbiaceae	Shrub		x	x	x
Amanoa bracteosa (VU)	Euphorbiaceae	Tree		x		
Hymenocardia lyrata	Euphorbiaceae	Tree	M	x	x	x
Macaranga bateri	Euphorbiaceae	Tree	M	x	x	x
Macaranga heudelotii	Euphorbiaceae	Tree		x	x	x
Macaranga sp	Euphorbiaceae	Tree				x
Mareya micrantha	Euphorbiaceae	Shrub	M	x	x	x
Phyllanthus discoideus	Euphorbiaceae	Tree	M	x	x	x
Uapaca guineensis	Euphorbiaceae	Tree	T	x	x	x
Uapaca heudelotii	Euphorbiaceae	Tree		x		
Tetrarchidium didymostemon	Euphorbiaceae	Tree			x	
Microdesmis puberula	Euphorbiaceae	Shrub	M	x	x	x
Maniophytum fulvum	Euphorbiaceae	Liana	M	x	x	x
Drypetes chevalieri	Euphorbiaceae	Tree	T	x	x	
Bridelia micrantha	Euphorbiaceae	Shrub	M			
Anthostema senegalense	Euphorbiaceae	Shrub	M/T	x		x
Pphyllanthus discoides	Euphorbiaceae	Tree	M	x	x	x
Olyra latifolia	Gramineae	Grass				
Bambusa vulgaris	Gramineae	Grass	M/T	x	x	x
Harungana madagascariensis	Guttiferae	Shrub	M	x	x	x
Pentadesma butyracea	Guttiferae	Tree	T	x	x	x
Vismia guineensis	Guttiferae	Shrub	M	x	x	x
Garcinia afzelii (VU)	Guttiferae	Tree				

Botanical name	Family	Growth form	Uses	Up stream	Down stream	Landfill site
Garcinia sp.	Guttiferae	Tree				
Anthocleista nobilis	Gentianaceae	Tree	M	x	x	x
Anthocleista vogelii	Gentianaceae	Tree	M	x	x	x
Klainedoxa gabonensis	Irvingiaceae	Tree				x
Phyllacosmus africanus	Ixonanthaceae	Tree	T			
Napoleona heudelotii	Lecythidaceae	Shrub		x		
Strychnos afzelii	Loganiaceae	Liana		x	x	x
Strychnos densiflora	Loganiaceae	Liana		x	x	x
Hibisus sterculilfolius	Malvaceae	Herb		x		x
Urena lobata	Malvaceae	Herb		x	x	x
Sarcophrynlum brachystachys	Marantaceae	Herb		x	x	x
Carapa procera	Meliaceae	Tree	M	x	x	x
Trichilia ornithothera (VU)	Meliaceae	Tree				
Turraenthus africanum (VU)	Meliaceae	Tree	T	x	x	x
Lovoa trichylioides	Meliaceae	Tree				
Acacia pennata	Mimosaceae	Liana				
Albizia adianthifolia	Mimosaceae	Tree	M	x	x	x
Albizia zygia	Mimosaceae	Tree	M	x	x	x
Cathornium altissimum	Mimosaceae	Tree		x	x	x
Cathornium rhombifolium	Mimosaceae	Tree		x	x	x
Entada gigas	Mimosaceae	Liana		x		
Parkia bicolor	Mimosaceae	Tree	F/T			x
Pentarclethra macrophylla	Mimosaceae	Tree		x	x	x
Piptadeniastrum africanum	Mimosaceae	Tree	T			
Samanea dinklagei	Mimosaceae	Tree	M	x	x	x
Dichrostachys glomerata	Mimosaceae	Shrub	M	x	x	x
Calpocalyx aubrevillei	Mimosaceae	Tree				
Acacia mangium	Mimosaceae	Tree	T	x	x	x
Tiliacora leonensis	Menispermaceae	Liana		x	x	x
Ficus exasperate	Moraceae	Tree	M			
Ficus capensis	Moraceae	Shrub	F/M	x	x	x
Ficus mucuso	Moraceae	Tree				
Ficus sp.	Moraceae	Tree		x		
Milicia regia (VU)	Moraceae	Tree	M/T	x		x
Musanga cecropoideds	Moraceae	Tree	T	x	x	x
Myrianthus libericus	Moraceae	Tree		x	x	x
Myrianthus serratus	Moraceae	Tree		x	x	x
Myrianthus arboreus	Moraceae	Tree		x	x	x
Antiaris africana	Moraceae	Tree				
Artocarpus communis	Moraceae	Tree	F/M	x	x	x
Artocarpus hecterophylla	Moraceae	Tree	F	x	x	x
Pycnanthus angolensis	Myristicaceae	Tree		x	x	
Psidium guajava	Myrtaceae	Shrub	F/M	x	x	x
Oratea flava	Ochnaceae	Shrub				
Elaeis gaineensis	Palmae	P	F/M	x	x	x
Eremospatha macroparpa	Palmae	P	T	x	x	
Raffia palma-pinus	Palmae	P	T			
Cocos nucifera	Palmae	P	F		x	x
Millettia thonningii	Papilionaceae	Tree		x	x	
Millettia warneckei	Papilionaceae	Liana				x
Millettia sp	Papilionaceae	Shrub		x		x
Pterocarpus santalinoides	Papilionaceae	Tree		x	x	x

Botanical name	Family	Growth form	Uses	Up stream	Down stream	Landfill site
Baphia nitida	Papilionaceae	Tree		x	x	x
Leptodarris miegei	Papilionaceae	Liana	T	x	x	x
Leptodarris sp	Papilionaceae	Liana		x	x	x
Dalbergia saxatilis	Papilionaceae	Liana	M	x	x	x
Smeathmannia pubescens	Passifloraceae	Shrub		x	x	x
Smeathmannia laevigata	Passifloraceae	Shrub				
Carpolobia lutea	Polygalaceae	Shrub			x	x
Coffea arabica	Rubiaceae	Shrub				
Hallea stipulosa (VU)	Rubiaceae	Tree	M/T			x
Nauclea diderrichii (VU)	Rubiaceae	Tree	M/T	x		
Nauclea latifolia	Rubiaceae	Shrub	M	x	x	x
Oxyanthus spinoceus	Rubiaceae	Shrub				
Craterispermum laurinum	Rubiaceae	Shrub	M	x	x	x
Bertiara spicata	Rubiaceae	Shrub	M	x	x	x
Psychotria cornuta	Rubiaceae	Herb		x		x
Psychotria liberica	Rubiaceae	Herb			x	x
Psychotria sp	Rubiaceae	Herb				x
Heinsia pulchelia	Rubiaceae	Shrub				
Morinda geminata	Rubiaceae	Tree	M	x	x	x
Morinda longiflora	Rubiaceae	Tree		x	x	x
Ixora sp	Rubiaceae	Shrub		x	x	x
Vangueriella discolor	Rubiaceae	Shrub		x	x	x
Vangueriella sp	Rubiaceae	Shrub		x		
Gaertnea paniculata	Rubiaceae	Shrub				
Mussaenda lingeri	Rubiaceae	Liana		x	x	x
Mussaenda elegans	Rubiaceae	Liana	F			
Diodiaq scandens	Rubiaceae	Herb	M	x	x	x
Uncaria africana	Rubiaceae	Liana	M		x	x
Citrus auritifolia	Rutaceae	Tree	F	x	x	x
Citrus sinensis	Rutaceae	Tree	F	x	x	x
Citrus sp	Rutaceae	Tree	F	x	x	x
Zanthoxylum atchoum (VU)	Rutaceae	Tree	T			
Placodiscus sp	Sapindaceae	Shrub				
Lecaniodiscus cupaniodes	Sapindaceae	Tree	M	x		
Allophylus africanus	Sapindaceae	Tree	M	x	x	x
Blighia sapida	Sapindaceae	Tree				x
Chrysophyllum pruniforme	Sapotaceae	Tree	T			
Synsepalum afzelii	Sapotaceae	Tree		x	x	x
Synsepalum brevipes	Sapotaceae	Tree		x	x	x
Synsepalum ntimii	Sapotaceae	Tree		x	x	
Synsepalum sp	Sapotaceae	Tree		x	x	x
Smilax kraussiana	Smilacaceae	Herb	M	x	x	x
Homalium africana	Salicaceae	Tree	M/T			x
Cola lateritia	Sterculiaceae	Tree	M	x		
Cola nitida	Sterculiaceae	Tree	F/M	x	x	x
Sterculia tragacantha	Sterculiaceae	Tree	M		x	x
Sterculia oblonga (VU)	Sterculiaceae	Tree	M			
Theobroma cacao	Sterculiaceae	Shrub	F	x	x	x
Cyclosorus afer	Thelypteridaceae	Herb	M		x	x
Triumfeta tomentosa	Tiliaceae	Herb	M	x	x	x
Glypaea brevis	Tiliaceae	Shrub				x
Cclappertonia ficifolia	Tiliaceae	Herb		x	x	x

Botanical name	Family	Growth form	Uses	Up stream	Down stream	Landfill site
Vitex grandifolia	Verbenaceae	Tree	T	x	x	x
Vitex micrantha	Verbenaceae	Tree	T	x	x	x
Clerodendrum splendens	Verbenaceae	Liana	M	x	x	x
Rinorea microdon	Violaceae	Herb				x
Rinorea oblanceolata	Violaceae	Herb				x
Rinorea coccinea	Violaceae	Herb		x	x	x
Rinorea sp	Violaceae	Herb				x
Aframomum melegueta	Zingiberaceae	Herb	M			x
Costus afer	Zingiberaceae	Herb	M			x

APPENDIX D BIRD SPECIES RECORDED IN THE STUDY AREA

Family/species	English names	Up stream	Down Stream	Land fill	IUCN	EBA	Biome
ACCIPITRIDAE							
Milvus migrans	Black Kite	x	x		AM		
Gypohierax angolensis	Palm-nut Vulture		x		R		
Polyboroides typus	African Harrier Hawk	x	x	x	R		
PHASIANIDAE							
Francolinus ahantensis	Ahanta Francolin	x			R		GC
Francolinus bicalcaratus	Double-spurred Francolin	x		x	R		
CHARADRIIDAE							
Vanellus spinosus	Spur-winged Lapwing	x			AM		
COLUMBIDAE							
Treron calvus	African Green Pigeon		x		R		
Turtur tympanistria	Tambourine Dove	x	x	x	R		
Turtur afer	Blue-spotted Wood Dove	x	x	x	R		
Streptopelia semitorquata	Red-eyed Dove	x	x		R		
Streptopelia vinacea	Vinaceous Dove	x		x	R		
MUSOPHAGIDAE							
Corythaeola cristata	Great Blue Turaco	x		x	R		
Tauraco persa	Green Turaco	x	x		R		GC
Crinifer piscator	Western Grey Plantain-eater			x	R		
CUCULIDAE							
Chrysococcyx klaas	Klaas's Cuckoo	x		x	AM		
Chrysococcyx klaas	Emerald Cuckoo		x				
Ceuthmochares aereus	Yellowbill		x		R		
Centropus senegalensis	Senegal Coucal	x	x	x	R		
STRIGIDAE							
Strix woodfordii	African Wood Owl		x		R		
CAPRIMULGIDAE							
Caprimulgus nigriscapularis	Black-shouldered Nightjar	x		x	R		GC
Caprimulgus inornatus	Plain Nightjar	x			R		
APODIDAE							
Rhaphidura sabini	Sabine's Spinetail	x	x		R		GC
Cypsiurus parvus	African Palm Swift		x	x	R		
Apus apus	Common Swift		x	x	PM		
Apus affinis	Little Swift	x	x	x	R		
Tachymarptis aequatorialis	Mottled Swift	x			R		
ALCEDINIDAE							
Halcyon malimbica	Blue-breasted Kingfisher	x		x	R		
Halcyon senegalensis	Woodland Kingfisher			x	R		
Ceyx pictus	African Pygmy Kingfisher	x		x	AM		
Alcedo cristata	Malachite Kingfisher		x	x	R		
Alcedo quadribrachys	Shining-blue Kingfisher	x			R		
Megaceryle maxima	Giant Kingfisher		x		R		

Family/species	English names	Up stream	Down Stream	Land fill	IUCN	EBA	Biome
MEROPIDAE							
Merops albicollis	White-throated Bee-eater	x	x	x	AM		
Merops pusillus	Little Bee-eater	x		x	R		
BUCEROTIDAE							
Tockus fasciatus	African Pied Hornbill	x		x	R		GC
Bycanistes fistulator	Piping Hornbill		x		R		GC
CAPITONIDAE							
Gymnobucco calvus	Naked-faced Barbet	x			R		GC
Pogoniulus scolopaceus	Speckled Tinkerbird	x	x	x	R		GC
Pogoniulus subsulphureus	Yellow-throated Tinkerbird		x	x	R		GC
Pogoniulus atroflavus	Red-rumped Tinkerbird	x		x	R		
Tricholaema hirsuta	Hairy-breasted Barbet	x			R		
INDICATORIDAE							
Indicator conirostris	Thick-billed Honeyguide	x			R		
PICIDAE							
Dendropicos gabonensis	Gabon Woodpecker		x	x	R		GC
Dendropicos goertae	Grey Woodpecker	x		x	R		
HIRUNDINIDAE							
Psalidoprocne nitens	Square-tailed Saw-wing	x	x	x	R		GC
Hirundo daurica	Red-rumped Swallow			x	AM		
Hirundo preussi	Preuss's Cliff Swallow	x	x	x	R		
Hirundo abyssinica	Lesser-striped Swallow	x					
Hirundo nigrita	White-throated Blue Swallow		x				
MOTACILLIDAE							
Anthus leucophrys	Plain-backed Pipit			x	R		
Motacilla flava	Yellow Wagtail			x	R		
PYCNONOTIDAE							
Andropadus virens	Little Greenbul	x	x	x	R		
Andropadus gracilis	Little Grey Greenbul	x	x		R		GC
Andropadus ansorgei	Ansorge's Greenbul		x		R		GC
Andropadus gracilirostris	Slender-billed Greenbul	x	x	x	R		
Andropadus latirostris	Yellow-whiskered Greenbul	x		x	R		
Baeopogon indicator	Honeyguide Greenbul		x	x	R		GC
Chlorocichla simplex	Simple Leaflove	x	x	x	R		GC
Thescelocichla leucopleura	Swamp Palm Bulbul	x		x	R		GC
Phyllastrephus icterinus	Icterine Greenbul		x	x	R		GC
Bleda canicapillus	Grey-headed Bristlebill	x	x		R		GC
Criniger barbatus	Western Bearded Greenbul		x	x	R		GC
Criniger calurus	Red-tailed Greenbul	x			R		GC
Pycnonotus barbatus	Common Bulbul	x	x	x	R		
Nicator chloris	Western Nicator	x	x	x	R		GC
TURDIDAE							
Alethe diademata	White-tailed Alethe	x	x		R		GC

Family/species	English names	Up stream	Down Stream	Land fill	IUCN	EBA	Biome
Neocossyphus poensis	White-tailed Ant Thrush	x			R		GC
Stizorhina finschi	Finsch's Flycatcher Thrush		x		R		GC
SYLVIIDAE							
Hippolais polyglotta	Melodious Warbler		x		PM		
Cisticola lateralis	Whistling Cisticola	x		x	R		
Cisticola brachypterus	Short-winged Cisticola		x	x	R		
Cisticola cantans	Singing Cisticola		x	x	R		
Prinia subflava	Tawny-flanked Prinia	x	x	x	R		
Apalis nigriceps	Black-capped Apalis		x		R		GC
Apalis sharpii	Sharpe's Apalis	x			R	UGF	GC
Camaroptera brachyura	Grey-backed Camaroptera	x		x	R		
Camaroptera superciliaris	Yellow-browed Camaroptera	x		x	R		GC
Camaroptera chloronota	Olive-green Camaroptera			x	R		GC
Macrosphenus concolor	Grey Longbill	x		x	R		GC
Macrosphenus kempi	Kemp's Longbill	x	x		R		
Eremomela badiceps	Rufous-crowned Erememela		x	x	R		GC
Sylvietta virens	Green Crombec	x	x	x	R		GC
Sylvietta denti	Lemon-bellied Crombec	x	x		R		GC
Hylia prasina	Green Hylia	x	x	x	R		GC
MUSCICAPIDAE							
Muscicapa cassini	Cassin's Flycatcher		x		R		GC
Muscicapa epulata	Little Grey Flycatcher	x			R		GC
Fraseria cineracens	White-browed Forest Flycatcher	x			R		
Trochocercus nitens	Blue-headed Crested Flycatcher			x	R		GC
Terpsiphone viridis	African Paradise Flycatcher			x	R		
Terpsiphone rufiventer	Red-bellied Paradise Flycatcher	x	x	x	R		GC
PLATYSTEIRIDAE							
Bias musicus	Black-and-white Flycatcher	x	x		R		
Dyaphorophyia castanea	Chestnut Wattle-eye		x		R		GC
Platysteira cyanea	Common Wattle-eye	x			R		
TIMALIIDAE							
Illadopsis rufipennis	Pale-breasted Illadopsis	x			R		
Illadopsis fulvescens	Brown Illadopsis	x			R		GC
Phyllanthus atripennis	Capuchin Babbler			x	R		GC
NECTARINIIDAE							
Anthreptis gabonicus	Brown Sunbird		x				
Cyanomitra olivacea	Olive Sunbird	x	x	x	R		
Hedydipna collaris	Collared Sunbird	x	x	x	R		
Cinnyris chloropygius	Olive-bellied Sunbird	x	x	x	R		
Cinnyris venustus	Variable Sunbird	x		x	R		

Family/species	English names	Up stream	Down Stream	Land fill	IUCN	EBA	Biome
Cinnyris johannae	Johanna's Sunbird	x			R		GC
Cinnyris superbus	Superb Sunbird			x	R		GC
ZOSTEROPIDAE							
Zosterops senegalensis	Yellow White-eye	x	x	x	R		
MALACONOTIDAE							
Lanius collaris	Common Fiscal	x		x	R		
Laniarius leucorhynchus	Sooty Boubou			x	R		GC
Laniarius turatis	Turatis Boubou	x		x	R		
Tchagra senegalus	Black-crowned Tchagra		x	x	R		
DICRURIDAE							
Dicrurus modestus	Velvet-mantled Drongo	x			R		
CORVIDAE							
Corvus albus	Pied Crow	x	x	x	R		
PASSERIDAE							
Passer griseus	Norther Grey-headed Sparrow	x	x		R		
PLOCEIDAE							
Malimbus scutatus	Red-vented Malimbe	x	x	x	R		GC
Ploceus nigerrimus	Vieillot's Black Weaver	x	x		R		GC
Ploceus cucullatus	Village Weaver	x	x	x	R		
Ploceus nigricollis	Black-necked weaver		x		R		
ESTRILDIDAE							
Nigrita canicapillus	Grey-headed Negrofinch	x	x	x	R		
Nigrita bicolor	Chestnut-breasted Negrofinch	x	x	x	R		GC
Estrilda melpoda	Orange-cheeked Waxbill			x	R		
Spermophaga haematina	Western Bluebill		x		R		GC
Lagonosticta rubricata	Blue-billed Firefinch		x		R		
Spermestes cucullatus	Bronze Mannikin	x	x		R		
Spermestes bicolor	Black-and-Whtite Mannikin	x			R		

APPENDIX E CHANCE FIND PROCEDURE

CHANCE FIND PROCEDURE

Chance finds are defined as physical cultural resources encountered unexpectedly during project implementation. Chance find Procedures includes provisions for managing aforementioned encountered chance finds. These include the following:

- In the case of chance find of any sites or artifacts of historical, cultural, archeological or religious significance all construction activity in the vicinity of the find/feature/site will cease immediately.
- The discovery will be clearly delineated and secured, and all found remains will be left in situ.
- An MCC assigned archaeological consultant will assess, record, and photograph the find/feature/ site.
- In consultation with the Ministry of Information, Culture and Tourism, the assigned Archaeologist will complete a report on the findings and determine the appropriate course of action to take.
- An on-site finds storage area will be provided, allowing storage of any artifacts or other archaeological material recovered during the process.
- A conservator will be made available to the project, if required, and will decide on the disposition of any found samples or relics.

APPENDIX F GUIDELINES FOR COMPOST QUALITY

ORDINANCE ON THE QUALITY ASSURANCE AND UTILIZATION OF COMPOST IN AGRICULTURE, HORTICULTURE, AND LANDSCAPING

OBJECTIVES

The main objective of this ordinance is to create a legal framework for the production and utilization of compost and to improve at long term the recycling quota of organic material from waste. Therefore, the Compost Ordinance regulates the application of treated and untreated bio-wastes and mixtures on land, which is used in agriculture, horticulture, viticulture, or forestry, and it treats as well the use of compost, having a low quality, in landscaping and in landfill operation. It also covers suitable raw materials, quality and hygiene requirements, and treatment and investigations of such bio-wastes and mixtures. The Compost Ordinance regulates – from a precautionary perspective – the waste side (e.g. heavy metals) of the application.

Areas of application

All treated and untreated biodegradable wastes from animals or plants, and all mixtures under the collective name of 'biowastes' applied to soils through agriculture, forestry or horticulture, landscaping and landfill operations are subject to the requirements of the compost ordinance.

Definitions

Additives: Materials to improve structure and to form clay-humus-complexes of compost (e.g. basalt meal, calcium bentonite, clay granulate, bone meal, horn meal, lime etc.), are added to raw compost materials for their nutrient or bulk qualities.

Biowaste: Term used to describe the composting of separately collected organic domestic waste. It is collected separately from households in so-called 'bio bins', which are sometimes also known as compost bins or 'green' bins. Biowaste normally contains a certain amount of garden or green waste (up to 40%).

Bulk density: Density of loosely heaped material per volume unit in t/m^3.

C/N-ratio: Ratio of carbon to nitrogen (total content); used to describe nutrient or decomposing ability of organic waste.

Compost: Product of decomposition process resulting from the aerobic treatment of organic material.

Compost windrows: Stacking of organic matter intended for composting in regular piles of triangular or trapezoid cross-section.

Contaminants / pollutants: Organic and inorganic materials in concentrations harmful to health and environment.

Degree of maturation: Identification of the status of the decomposition process to characterize the progress of maturation. Scale ranges from I (compost raw material) to V (mature compost).

DEWAR Self-Heating Test: used to determine maturation stage of compost by investigating temperature rise of compost under standardized conditions;

Dry substance: Amount of substance after removal of water; measurement after drying at 105°C until constant weight is reached.

Impurities: Unwanted substances which are disturbance factor either technically or optically and which lower the quality of compost (e.g. stones, glass, metal, plastics).

Fertilizers: Substances intended to be added directly or indirectly to plants to promote growth, increase harvests, or increase quality of crops.

Food waste: Waste from restaurants and large kitchens (larger than a normal household) which is normally collected in addition to the regular bio-bin system, in special containers. (Those wastes have to undergo extra treatment (70 °C for one hour) to guarantee sanitation, which has to be done before they are treated in composting or digestion plants.)

Green waste: Pure organic residues from gardens and parks.

Heavy metals: Lead, Chromium, Nickel, Zinc, Cadmium, Copper and Mercury.

Horticulture: Capital and/or labor intensive form of agricultural cultivation often carried out in relatively small areas; often close to houses.

Household waste: Waste from households and similar waste from small businesses, which are regularly collected, transported, treated, and disposed.

Humus: The product of aerobic biological decomposition processes such as composting.

Immature Compost: Compost in an early stage of decomposition which is characterized by maturation stages I and II

Mature Compost: Compost in an advanced stage of decomposition, which is characterized, by maturation stages IV and V (i.e. temperature rise smaller than 10°C at DEWAR-self-heating test.)

Native organic waste: Organic waste consisting of materials in their natural state.

Pathogen: Causing diseases.

Quality criteria: Description of certain quality characteristics and contents for compost.

Sanitizing: Process stage with the aim to disinfect material.

Organic fraction of household waste: Fraction of household waste containing predominantly organic matter as result of previous sieving and sorting process.

Semi-mature Compost: Compost in an incomplete stage of decomposition which is characterized by maturation stages III (i.e. temperature rise between 10°C and 20°C at DEWAR-self-heating test.)

SUITABLE RAW COMPOST MATERIAL

Suitable raw material is listed in the enclosed Annex of this Ordinance and includes the following groups of organic waste materials:

- Source separated organic municipal waste
- Organic fraction of household waste
- Green waste
- Residues from the food and animal feed industry
- Mineral composting additives.

A detailed list of waste types suitable for composting either as organic matter or as additive is given in the enclosed annex. If the operator of the composting plant intends the composting of wastes not listed in annex than he requires a specific authorization by the Ministry of Environment.

Types and quality standards for compost

Four different types of compost are defined by quality criteria presented in table 1 (overview) to table 5 are valid. The range goes from Grade "A" compost, being a high quality compost and most appropriate for any agricultural utilization, to Grade D compost which must only be used on controlled landfills as intermediate cover or as landscaping material. The product of a composting process, which does not correspond to the specifications of Grade D compost, cannot be considered as an organic recycling-product and must be categorized as waste.

Table F-1 Definition of compost types (overview)

Type of compost	Characteristics	Main Fields of Utilization
Grade A	Main characteristics are: • Native organic raw material, generated by source-separation; • Mature compost (maturation degree V); hygienised, biologically stable; • Corresponds to European Eco-label for composts	Food production in • Agriculture • Horticulture • Viticulture
Grade B	Main characteristics are: • Organic raw material, generated by mechanical treatment of household waste; • Mature compost (maturation grade IV or V); • hygienised, biologically stable; • Corresponds to European Eco-label for composts;	Food production in • Agriculture • Horticulture • Viticulture
Grade C	Main characteristics are: • Organic raw material, generated by mechanical treatment of household waste or appropriate waste from industrial sources (e.g. residues from the food and animal feed industry • Semi-mature compost (maturation grade III); hygienised material, • Limits given for heavy metals correspond to doubled values of European Eco-label for composts;	Utilized only if any risks to humans and any contamination of food or agricultural soil can be excluded; e.g. in • Landscaping • Recultivation of abandoned quarries • Soil for green space along traffic roads
Grade D	Main characteristics are: • Organic raw material, generated by mechanical treatment of household waste or appropriate waste from industrial sources (e.g. residues from the food and animal feed industry) after appropriate treatment • Immature compost (maturation grade II); hygienised material, • Limits given for heavy metals correspond to fivefold values of European Eco-label for composts;	Only to be used as recultivation material on controlled landfills and as intermediate layer of deposited waste. No to be utilized as top layer of recultivated landfill sites in order to prevent contamination of humans, fauna and flora as well as spreading of pollutants.

Table F-2 Quality standard for compost, Grade A

<table>
<tr><th>Quality characteristics</th><th colspan="4">Quality requirements</th></tr>
<tr><td>Origin of raw material</td><td colspan="4">Source-separated organic material from households or agriculture;
Mechanical sorting of impurities prior to composting process</td></tr>
<tr><td>Hygiene</td><td colspan="4">Exposure of entire material to temperatures > 65°C for at least 7 days during thermophilic decomposition phase (sanitizing phase).
Extensive exclusion of germinable seeds and sprouting plant parts
(less than 1 germinable weed-seed in 2 liters of compost).
Exclusion of Salmonellae
Feceal coliforms must be < 1,000 MPN[1]/g of total solids calculated on a dry weight basis</td></tr>
<tr><td>Man-made impurities[2]</td><td colspan="4">Maximum of 0.5 weight-% in dm; plastic less than 0.1 weight-% in dm
(selection of impurities in compost fraction > 2 mm)</td></tr>
<tr><td>Stones</td><td colspan="4">Maximum of 5.0 weight-% in dm
(selection of stones in compost fraction > 5 mm)</td></tr>
<tr><td>Plant compatibility</td><td colspan="4">50% compost with 50 % standard soil media;
germination rate of barley seeds must pass > 90 % after 5 days</td></tr>
<tr><td>Decomposition degree</td><td colspan="4">Maturation degree V</td></tr>
<tr><td>Water content</td><td colspan="4">Loose material: maximum 45% weight
Bagged material: maximum 35 % weight
Higher contents of water are admissible for composts with more than 40% organic matter</td></tr>
<tr><td>Organic matter</td><td colspan="4">at least 15 % weight-% in dm, measured as volatile solids</td></tr>
<tr><td>Plant nutrients and salt content</td><td colspan="4">Salt content max. 2.5 g/l
Minimum nitrogen (sum NO_3/NH_4-N) <300 mg/l
Soluble phosphate P_2O_5 <1.200 mg/l
Soluble potassium K_2O <2.000 mg/l
Soluble chloride <500 mg/l
Soluble sodium <250 mg/l</td></tr>
<tr><td rowspan="5">Contents of heavy metals</td><td colspan="4">Guide values[3] (mg/kg dm)</td></tr>
<tr><td>Lead</td><td>< 150</td><td>Cadmium</td><td>< 1.5</td></tr>
<tr><td>Chromium</td><td>< 100</td><td>Copper</td><td>< 100</td></tr>
<tr><td>Nickel</td><td>< 50</td><td>Mercury</td><td>< 1.0</td></tr>
<tr><td>Zinc</td><td>< 400</td><td></td><td></td></tr>
<tr><td>Parameter for declaration to user</td><td colspan="4">Mature compost from source – separated organic waste
Producer
Grain size and bulk density (volume weight)
C/N-ratio
pH value
Salt content
Plant nutrients total (N, P_2O_5, K_2O, MgO, CaO)
Plant nutrients soluble (N, P_2O_5, K_2O)
Organic matter
Net weight or volume
Information for a suitable application (method and application rate)</td></tr>
<tr><td colspan="5">[1]MPN: Most probable number
[2] Glass, metal, plastics
[3]Guide values: The heavy meal limit values are adhered to if the mean value of the last four analyses lies under the limit value and no analysis surpasses the limit value by >25%. This guide excludes the cadmium test.
dm = dry matter; fm= fresh matter; om = organic matter;</td></tr>
</table>

Table F-3 Quality standard for compost, Grade B

<table>
<tr><th>Quality characteristics</th><th colspan="4">Quality requirements</th></tr>
<tr><td>Origin of raw material</td><td colspan="4">Organic raw material, generated by mechanical treatment of mixed household waste; minimum standard of treatment: sieving, hand-sorting, magnetic separation of impurities by drum-magnets or equivalent equipment</td></tr>
<tr><td>Hygiene</td><td colspan="4">Exposure of entire material to temperatures > 65°C for at least 7 days during thermophilic decomposition phase (sanitizing phase).
Extensive exclusion of germinable seeds and sprouting plant parts (less than 1 germinable weed-seed in 2 liters of compost).
Exclusion of Salmonellae
Feceal coliforms must be < 1,000 MPN[1]/g of total solids calculated on a dry weight basis</td></tr>
<tr><td>Man-made impurities[2]</td><td colspan="4">Maximum of 0.5 weight-% in dm; plastic less than 0.1 weight-% in dm
(selection of impurities in compost fraction > 2 mm)</td></tr>
<tr><td>Stones</td><td colspan="4">Maximum of 5.0 weight-% in dm
(selection of stones in compost fraction > 5 mm)</td></tr>
<tr><td>Plant compatibility</td><td colspan="4">25% compost with 75 % standard soil media;
germination rate of barley seeds must pass > 90 % after 5 days</td></tr>
<tr><td>Decomposition degree</td><td colspan="4">Maturation degree IV or V</td></tr>
<tr><td>Water content</td><td colspan="4">Loose material: maximum 45% weight
Bagged material: maximum 35 % weight
Higher contents of water are admissible for composts with more than 30% organic matter</td></tr>
<tr><td>Organic matter</td><td colspan="4">at least 15 % weight-% in dm, measured as volatile solids</td></tr>
<tr><td>Plant nutrients and salt content (only required if compost is used as substrate for production of potting soil)</td><td colspan="4">Salt content max. 2.5 g/l
Minimum nitrogen (sum NO_3/NH_4-N) <300 mg/l
Soluble phosphate P_2O_5 <1.200 mg/l
Soluble potassium K_2O <2.000 mg/l
Soluble chloride <500 mg/l
Soluble sodium <250 mg/l</td></tr>
<tr><td rowspan="5">Contents of heavy metals</td><td colspan="4">Guide values[3] (mg/kg dm)</td></tr>
<tr><td>Lead</td><td>< 150</td><td>Cadmium</td><td>< 1.5</td></tr>
<tr><td>Chromium</td><td>< 100</td><td>Copper</td><td>< 100</td></tr>
<tr><td>Nickel</td><td>< 50</td><td>Mercury</td><td>< 1.0</td></tr>
<tr><td>Zinc</td><td>< 400</td><td></td><td></td></tr>
<tr><td>Parameter for declaration to user</td><td colspan="4">Mature compost from mixed waste
Producer
Grain size and bulk density (volume weight)
C/N-ratio
pH value
Salt content
Plant nutrients total (N, P_2O_5, K_2O, MgO, CaO)
Plant nutrients soluble (N, P_2O_5, K_2O)
Organic matter
Net weight or volume
Information for a suitable application (method and application rate)</td></tr>
<tr><td colspan="5">[1]MPN: Most probable number
[2] Glass, metal, plastics
[3]Guide values: The heavy meal limit values are adhered to if the mean value of the last four analyses lies under the limit value and no analysis surpasses the limit value by >25%. This guide excludes the cadmium test.
dm = dry matter; fm= fresh matter; om = organic matter;</td></tr>
</table>

Table F-4 Quality standard for compost, Grade C

<table>
<tr><th>Quality characteristics</th><th colspan="4">Quality requirements</th></tr>
<tr><td>Origin of raw material</td><td colspan="4">Organic raw material, generated by mechanical treatment of household waste; minimum standard of mechanical treatment: sieving, hand-sorting, magnetic separation of impurities by drum-magnets or equivalent equipment;
Appropriate organic waste from industrial sources (e.g. residues from the food and animal feed industry) after proper treatment</td></tr>
<tr><td>Hygiene</td><td colspan="4">Exposure of entire material to temperatures > 60°C for at least 7 days during thermophilic decomposition phase (sanitizing phase).
Exclusion of germinable seeds and sprouting plant parts to a large extend (less than 5 germinable weed-seeds in 2 liters of compost).
Exclusion of Salmonellae
Feceal coliforms must be < 2,000 MPN[1]/g of total solids calculated on a dry weight basis</td></tr>
<tr><td>Man-made impurities[2]</td><td colspan="4">Maximum of 1.0 weight-% in dm; plastic less than 0.5 weight-% in dm
(selection of impurities in compost fraction > 2 mm)</td></tr>
<tr><td>Stones</td><td colspan="4">Maximum of 10.0 weight-% in dm
(selection of stones in compost fraction > 5 mm)</td></tr>
<tr><td>Plant compatibility</td><td colspan="4">25% compost with 75 % standard soil media;
germination rate of barley seeds must pass > 75 % after 5 days</td></tr>
<tr><td>Decomposition degree</td><td colspan="4">Minimum maturation degree III</td></tr>
<tr><td>Water content</td><td colspan="4">Loose material: maximum 40% weight
Bagged material: maximum 30% weight
Higher contents of water are admissible for loose composts with more than 30% organic matter</td></tr>
<tr><td>Organic matter</td><td colspan="4">at least 20% weight-% in dm, measured as volatile solids</td></tr>
<tr><td rowspan="5">Contents of heavy metals</td><td colspan="4">Guide values[3] (mg/kg dm)</td></tr>
<tr><td>Lead</td><td>< 300</td><td>Cadmium</td><td>< 3</td></tr>
<tr><td>Chromium</td><td>< 200</td><td>Copper</td><td>< 200</td></tr>
<tr><td>Nickel</td><td>< 100</td><td>Mercury</td><td>< 2.0</td></tr>
<tr><td>Zinc</td><td>< 1000</td><td></td><td></td></tr>
<tr><td>Parameter for declaration to user</td><td colspan="4">Semi-mature compost; only to be used for landscaping, rehabilitation of abandoned quarries and green space along traffic roads
Producer
Grain size and bulk density (volume weight)
C/N-ratio
pH value
Salt content
Plant nutrients total (N, P_2O_5, K_2O, MgO, CaO)
Organic matter
Net weight or volume
Information for a suitable application (method and application rate)</td></tr>
<tr><td colspan="5">[1]MPN: Most probable number
[2] Glass, metal, plastics
[3]Guide values: The heavy meal limit values are adhered to if the mean value of the last four analyses lies under the limit value and no analysis surpasses the limit value by >25%. This guide excludes the cadmium test.
dm = dry matter; fm= fresh matter; om = organic matter;</td></tr>
</table>

Table F-5 Quality standard for compost, Grade D

<table>
<tr><th>Quality characteristics</th><th colspan="4">Quality requirements</th></tr>
<tr><td>Origin of raw material</td><td colspan="4">Organic raw material, generated by mechanical treatment of household waste; minimum standard of mechanical treatment: sieving, hand-sorting, magnetic separation of impurities by drum-magnets
Appropriate organic waste from industrial sources (e.g. residues from the food and animal feed industry)
Food waste after sanitation at 70°C for 1 hour or more</td></tr>
<tr><td>Hygiene</td><td colspan="4">Exclusion of Salmonellae
Feceal coliforms must be < 2,000 MPN[1]/g of total solids calculated on a dry weight basis</td></tr>
<tr><td>Man-made impurities[2]</td><td colspan="4">No specific requirements</td></tr>
<tr><td>Stones</td><td colspan="4">No specific requirements</td></tr>
<tr><td>Plant compatibility</td><td colspan="4">No specific requirements</td></tr>
<tr><td>Decomposition degree</td><td colspan="4">Minimum maturation degree II</td></tr>
<tr><td>Water content</td><td colspan="4">Loose material: maximum 40% weight
Not to be bagged</td></tr>
<tr><td>Organic matter</td><td colspan="4">No specific requirements</td></tr>
<tr><td rowspan="5">Contents of heavy metals</td><td colspan="4">Guide values[3] (mg/kg dm)</td></tr>
<tr><td>Lead</td><td>< 750</td><td>Cadmium</td><td>< 7.5</td></tr>
<tr><td>Chromium</td><td>< 500</td><td>Copper</td><td>< 500</td></tr>
<tr><td>Nickel</td><td>< 250</td><td>Mercury</td><td>< 5.0</td></tr>
<tr><td>Zinc</td><td>< 2000</td><td></td><td></td></tr>
<tr><td>Parameter for declaration to user (here: landfill)</td><td colspan="4">Immature compost; only to be used on landfills as intermediate cover and as rehabilitation material; not to be used as top layer
Producer
Grain size and bulk density (volume weight)
Net weight or volume
Information for a suitable application (method and application rate)</td></tr>
<tr><td colspan="5">[1]MPN: Most probable number
[2] Glass, metal, plastics
[3]Guide values: The heavy meal limit values are adhered to if the mean value of the last four analyses lies under the limit value and no analysis surpasses the limit value by >25%. This guide excludes the cadmium test.
dm = dry matter; fm= fresh matter; om = organic matter;</td></tr>
</table>

UTILIZATION OF COMPOST GRADE A AND GRADE B

Nutrients

Application rates, given for one year, shall specify that the amount of compost spread per year should not exceed the following limits:

- $17 g/m^2$ total nitrogen
- $6 g/m^2$ phosphate
- $12 g/m^2$ potassium oxide

In addition to those limits, the following figures and comments presented in table 5 and 6 should be used as an orientation for the specific use of compost from organic waste. Table 5 refers to tropical climate, while the values presented in table 6 are to be applied for agricultural land in irrigated arid zones with a high rate of mineralization.

Table F-6 Recommended use for compost from organic waste (coastal zones)

Area of use	Vegetation	Purpose	Amount[1] kg FS/m[2]	Frequency	Method
Horticulture	Vegetable beds	Supply of humus	3 – 5	Annual	Work in superficially
	Vegetables with high nutrient needs	Fertilizing, soil improvement, supply of humus	4 – 6	Annual	Work in superficially
	Vegetables with medium nutrient needs	Fertilizing, soil improvement, supply of humus	2 – 4	Annual	Work in superficially
	Vegetables with low nutrient needs	Fertilizing, soil improvement, supply of humus	1 – 2	Annual	Work in superficially
	Trees/bushes	New planting	2 – 8	Once	Mix 3 parts soil and 1 part compost and add to hole for plant
	Sandy, heavy, shallow and contaminated sites	Soil improvement	10 – 15	Every 2 years	Work into loose topsoil
Fruit growing	Stone and soft fruit	Supply of humus, fertilizing	3 – 5	Annual	Spread on surface
Viticulture	Fertilizing of existing vineyard	Supply of humus	3 – 6	Every 2 years	Spread superficially
	New planting	Supply of humus	5 – 10	Once	Work into loose topsoil
Tree nursery	Nutrient poor soil	Soil improvement	8 – 10	Once	Work into loose topsoil
	Open land cultivation	Supply of humus, fertilizing	3 – 4	Every 2 years	Spread or work in superficially
	Container cultivation	Container substrate	25 – 50 vol. %	Once	As component for mixing with soil
Agriculture	Crop growing, generally	Soil improvement	Up to 15	Once	Work into loose topsoil
	Crop growing, generally	Supply of humus	4 – 8	Every 3 years	Work into loose topsoil
	Root crops, field vegetables	Supply of humus	3 – 5	Every 2 years	Work in superficially
	Root crops, field vegetables	Fertilizing, supply of humus, soil improvement	3 – 6	Annually	Work in superficially
	Cereals	Fertilizing, supply of humus, soil improvement	2 – 4	Every 2 years	Work in superficially
	Pasture	Fertilizing, supply of humus, soil improvement	3 – 6	Every 2 years	Work in superficially

[1]The amounts refer to fresh compost, with a dry substance content of 60 %. The formula for t/ha is achieved by multiplying by the factor 10 (e.g.: 4 kg/m² = 40 t/ha). The formula for with a volume weight of e.g. 700 kg/m³ is achieved with the reciprocal value (e.g. 1/0.7= around 1.42). Example: 4 kg/m² = 5.7 l/m² = 57 m³/ha.
[2]FS = fresh substance

Table F-7 Recommended use for compost from organic waste (Interior parts)

Plant culture	Amount[1] (kg FS/m²)
Root and tuberous vegetables	6 – 25
Cereals	10
Fodder plant	20
Pasture	3 – 5
Viticulture	8 – 30
Fruit growing	20 – 100
Vegetable growing	20 – 50
Tree nursery	Up to 30
[1]See Table F-5	

MONITORING PROCEDURE

Bill of Delivery

In order to document a properly executed process, the compost plant has to give a bill of delivery to the person responsible for application to the soil and to send every 3 months a report on the utilization of compost to the concerned authorities:

The report should outline the absolute amounts of utilized compost, the specific type of agricultural or other utilization and the specific amount of utilized compost per costumer.

Frequency of investigations

The frequency of the investigations during the first year of a composting plant and the subsequent on-going monitoring procedure depends on the plant input capacity (see Table 8). At least four inspections should be carried out during the first year of operation – one for every season – to assess the essential quality characteristics over the course of the year. At least one sample should be taken every three months.

Table F-8 Frequency of investigations within the monitoring procedure (per year)

Plant input (tons/year)	Number of analysis during first year	Number of analysis after first year
Up to 2,000	4	4 analyses/year
2,001 to 5,000	5	4 analyses/year
5,001 to 10,000	10	8 analyses/year
More than 10,001	12	12 analyses/year

External monitoring

Within the framework of the quality monitoring procedure, sample-taking and analyses must be carried out by external monitoring laboratories that should be licensed by the Ministry of Environment. Licensing of the independent outside monitors is subject to verifying certain preconditions of the recognized laboratories (for example taking part in an inter-laboratory ring test).

In-house analysis

The compost producer also does its own analyses. He is obliged to verify the safe hygiene status of the decomposition or the digestion process by documenting accurately the temperatures achieved during the first intense decomposition phase. Within the framework of the monitoring procedures carried out by external laboratories the correct measuring and documentation of those temperature protocols is examined in irregular intervals but at least once a month. The laboratory should produce a quarterly report on the results of their examinations. This report should be presented to the Ministry of Environment at the latest in the third week of the following month.

Further in-house analyses can be carried out on a voluntary basis. The determination of characteristics important for the application of compost and digestion residues which can be ascertained using simple techniques, such as water content, weight by volume, salt content, pH value, plant compatibility and extraneous matter in the end product, is recommended.

TEST METHODS

In the following, the procedures to be applied can only be outlined in a few sentences.

Sampling procedure

In order to produce a representative sample 12 single samples (5 – 10L per sample) should be taken at 12 different spots of the compost heap to be examined. After thorough mixing of those samples the material is then reduced by dividing it repeatedly into quarters until the remaining representative sample has a volume of around 4 liters. This sample, it is then again divided into 4 separate samples. One sample is used for the determination of the water content. The other samples are dried in an oven at a temperature of 105°C until no further loss of water is detectable. They are then filled into airtight plastic bottles and conserved at a temperature level of a few degrees Celsius.

Determination of water content

The water content is determined according to the international standard ISO 11465 by drying 2 samples each having a quantity of around 100 g under an infrared-light and measuring permanently the weight. As soon as there is, no further loss in weight the drying-process is stopped. The weight determined before and after the drying procedure is then used for the determination of the water content.

Determination of man-made impurities

The content of man-made impurities is determined by sieving a dried sample of around 200 g at a screen size of 2 mm. Then man-made impurities such as glass, metal an plastic are separately sorted by using tweezers. The plastic fraction is then weighed apart from the other fractions.

Determination of stones

The content of stones is determined by sieving the dried sample of around 200 g at screen size of 5 mm. Stones are then sorted by using tweezers.

Determination of maturity grade

The maturity of compost is determined by carrying out the DEWAR self-heating test. This test uses a standardized steel container that holds approximately 1 litre of compost. As with any test, the compost sample moisture content may need to be adjusted prior to incubation. A maximum-minimum thermometer is then inserted to about 5 cm of the bottom of the container, which is left to stand at room temperature (20 °C) for a period of at least 5 days and no more than 10. The highest temperature of the compost sample is recorded daily. The results are calculated as maximum temperature rise during the test period. The maturity is then expressed as number ranging between I (fresh compost) and V (mature compost).

Determination of plant compatibility

In order to determine the plant compatibility of compost the germination of barley seeds in a mixture of compost and standard soil must be greater than the germination rate of barley in a control sample (standardized soil) and the growth rate of plants grown in a mixture of compost and soil must not differ more than 50 percent in comparison with the control sample.

Determination of organic matter

In order to determine the content in organic matter three samples of dried compost with 10 g /each are filled into temperature resistant ceramic vessels. The vessels are then set into a laboratory oven and exposed to a temperature of 750°C. After 3 hours, all the organic material is burnt up and the amount of organic matter can be then calculated by weighing the totally mineralized residue in the vessels.

Determination of heavy metals

The determination of the heavy metal content is determined according to the international standard ISO 11047.

Determination of nutrients, pH, and salt content

The determination of nutrient content is carried out according to test methods 86/278/EEC.

Table F-9 Suitable organic waste and mineral additives

Name of waste type	Key according to EWC[1]	Examples
I Waste with a high percentage of organic material		
Waste from plant tissue	02 01 03	• Wheat dust • Fodder waste
Animal feces, urine and dung (including spoilt straw)	02 01 06	• Chicken droppings • Liquid manure from cows • Dung • Used straw
Forestry waste	02 01 07	• Bark • Wood, wood chippings
Waste unsuitable for consumption or processing (Food processing)	02 03 04	• Spoilt foodstuff • Residues from preserving factories • Residue from oil seeds
Undefined waste	02 03 99	• Sludge from consumable oil production • Residues from spices • Residue from potatoe, corn or other starch production
Materials unsuitable for consumption	02 05 01	• Spoilt foodstuff
Undefined waste	02 05 99	• Whey
Materials unsuitable for consumption or processing	02 06 01	• Spoilt foodstuff • Dough remains

[1] EWC: European Waste Catalogue

Name of waste type	Key according to EWC[1]	Examples
Waste from washing, cleaning of mechanical grinding of raw material	02 07 01	• Used filters and adsorption masses, active and siliceous earth
Waste from distilling spirits	02 07 02	• Fruit, wheat and potato pulp • Sludge from distillery
Undefined waste	02 07 99	• Malt • Hops • Liquid residue and sludge from breweries • Sludge from wine making • Wine remains • Yeast and similar residues
Bark and cork waste	03 01 01 03 03 01	• Bark
Sawdust	03 01 02	• Sawdust and wood shavings

APPENDIX G WORLD BANK GRIEVANCE REDRESS SERVICE

What is the GRS?

The World Bank's **Grievance Redress Service (GRS)** provides an additional, accessible way for individuals and communities to complain directly to the World Bank if they believe that a World Bank-financed project had or is likely to have adverse effects on them or their community. The GRS enhances the World Bank's responsiveness and accountability by ensuring that grievances are promptly reviewed and responded to, and problems and solutions are identified by working together.

THE WORLD BANK
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The World Bank is committed to ensuring that Bank-financed projects do not harm people or the environment. The objective of the Grievance Redress Service is to make the Bank more accessible for project-affected communities and to help ensure faster and better resolution of project-related complaints.

For more information: http://www.worldbank.org/grs
email: grievances@worldbank.org

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GRIEVANCE REDRESS SERVICE

Helping individuals and communities get faster and better resolution of their complaints

Which complaints can the GRS handle?

The GRS accepts complaints that are:

- related to an active World Bank-supported project (IBRD or IDA)
- filed by a person or community who believes they have been adversely affected by a World Bank-financed project
- filed by a bidder or potential bidder about the procurement process on a World Bank-financed contract

What information is needed?

Complaints must:

- identify the project subject of the complaint
- clearly state the project's adverse impact(s)
- identify the individual(s) submitting the complaint and whether confidentiality is requested
- specify if the complaint is submitted by a representative of the person(s) or community affected by the project
- if the complaint is submitted by a representative, include the name, signature, contact details, and written proof of authority of the representative

Supporting evidence is not necessary but may be helpful in reviewing and resolving the complaint. The complaint may also include suggestions on how the individuals believe the complaint could be resolved.

The identity of complainants will be kept confidential upon request.

How is a complaint handled?

GRS receives complaint
- Notifies receipt
- Determines eligibility

Within 10 days
- Notifies eligibility, or ineligibility, if applicable
- Requests additional information, if necessary

Proposed solution
- Solution is proposed to complainants within 30 days
- If complainants agree, Project team implements and GRS monitors
- Complainants are referred to other complaint mechanisms, if not resolved

How can I submit a complaint?

The GRS accepts complaints in English or the official language of the country of the person submitting the complaint. Submissions to the GRS may be sent by:

Email: grievances@worldbank.org
Fax: +1-202-614-7313

Letter: The World Bank
Grievance Redress Service (GRS)
MSN MC 10-1018
1818 H St NW
Washington, DC 20433, USA

What about other grievance mechanisms?

Affected citizens and communities should use existing project-level grievance mechanisms where possible.

The GRS does not replace other existing accountability mechanisms of the World Bank. Requests can be submitted to the Inspection Panel to determine compliance with World Bank policies (www.inspectionpanel.org).

If a project is funded by the World Bank as well as the International Finance Corporation (IFC) or the Multilateral Investment Guarantee Agency (MIGA), the GRS will refer complaints related to the IFC/MIGA portions of the project to the Office of the Compliance Advisor (CAO) (www.cao-ombudsman.org).

Complaints involving issues related to fraud or corruption in World Bank-financed projects should be reported to the Office of Institutional Integrity (INT) (www.worldbank.org/integrity).

Frequently Asked Questions

Why use the GRS?

The process established by the GRS helps affected individuals and communities engage with the World Bank and the project executing agency to address issues as they happen, for faster and better resolution of complaints.

Does filing a complaint stop a project?

Submitting a complaint does not in itself stop a project.

Is there a statute of limitations for making a complaint?

The GRS will attempt to help resolve every eligible concern in active projects. The GRS cannot review issues related to closed projects.

What is the relation of the GRS to project-level grievance mechanisms?

Project-level grievance mechanisms remain the primary tool to raise and address project-related grievances. The GRS seeks to help resolve issues that cannot be resolved at the project level or where there is no project-level grievance mechanism.

What outcomes can we expect from using the GRS?

Resolution of each complaint depends on the issues at hand. The World Bank will make every effort to resolve all issues in a timely manner, working with the project and affected individuals/communities.

What is the relationship to the Inspection Panel?

There is no sequential relationship between the GRS and the Inspection Panel. The GRS is an additional mechanism for individuals and communities to use. The use of the GRS does not restrict access to the Inspection Panel.

APPENDIX H SAMPLE CHECKLIST FOR REGURAL CONTROL AT COMPOSTING FACILITIES

I- General Information			
1.	Company name		
2.	Facility/MRF name		
3.	Address		
4.	Operation start (day/month/year)		
5.	General Manager name		
6.	Hotline		
7.	Number of administrative staff		
8.	Number of workers		
9.	Business hours: – Hours per day – Days per week – Days per year		
10.	Site plan (main access roads; buildings and installations; property lines)	Attach in separate sheet	
11.	Contractors and subcontractors		
II- Input/ Output			
12.	Planned capacity (tons/year)		
13.	Actual yearly capacity (last year)		
14.	Actual daily capacity (tons/day)		
15.	Average number of truck loads per day		
16.	Average daily quantity of each waste type received		
17.	Average daily quantity of each waste type outgoing to landfill		
18.	Name of landfill to which the remaining waste stream is transported		
19.	Complaints of national or local authorities against the operation of plant (since the inspection)	Attach in separate sheet	
III- Entrance Control			
20.	Quality of access roads (paving, dust, litter, wastes)		
21.	Weight measured at the entrance control	YES	NO
22.	Quantity/quality-documentation of input material	YES	NO
23.	Has the MRF accepted wastes coming from areas not covered by the contact (if yes record type, source, and EPA approval)	YES	NO
24.	Balance sheets containing information about waste origin, waste producers and delivered quantities are kept	YES	NO
25.	Daily operational records being made and maintained (i.e. waste received, problems, violations, rejected loads, radioactive materials, overweight trucks)	YES	NO
26.	Average time required to direct collection trucks to unloading area and time needed to unload	YES	NO
27.	Site perimeter clearly delineated	YES	NO
28.	A wheelwash has been installed at the exit from the site	YES	NO
IV- Materials Recovery Facility			
29.	Regular use of checklists for the regular control of the technical components of the MRF	YES	NO
30.	Unauthorized wastes: Source, type, quantity, management option adopted after consultation with EPA		
31.	Types/composition of recovered recyclable wastes		
32.	Average daily percentage and quantity of each type of recovered recyclable waste		
33.	Each type of recyclable waste is stored separately	YES	NO
34.	Storage area for recyclable wastes is paved and roofed	YES	NO
35.	Average daily percentage of organic wastes recovered for further composting		
36.	Storage area for recovered organic wastes is paved, roofed, and has a drainage collection system linked to a leachate collection tank	YES	NO
37.	Sampling of waste (i.e. pH, Arsenic, Pb, Cd, Cr, Cu, Ni, Hg, Zn, phenols, mineral oils, Mg, Fe, Mg, Ca, K, Na, total organic carbon, Cl) is conducted	YES	NO

38.	Types of wastes sampled		
39.	Parameters sampled		
40.	Frequency of waste sampling		
41.	Results of waste sampling		
42.	Functioning condition of the conveyor belts		
43.	Functioning condition of the magnetic separators		
44.	Functioning condition of the drum sieves		
45.	Functioning condition of the sorting belts		
46.	Functioning condition of the shredders		
47.	Functioning condition of the bale compactors		
48.	Wrapping condition of the bales		
49.	Functioning condition of the electrical system		
50.	Regular maintenance of equipment/machinery	YES	NO
51.	Frequency of maintenance of equipment/machinery		
52.	Measures adopted by the operator for ensuring low fuel consumption of equipment/machinery		
V- Water and Leachate management			
53.	Measures adopted to reduce water consumption		
54.	Daily consumption of water		
55.	Source(s) of freshwater		
56.	Frequency of cleaning of floor surface and machinery		
57.	Floor surface is inclined	YES	NO
58.	Ponding of leachate on floor surface is a recurring problem	YES	NO
59.	Functioning condition of the leachate drainage and collection systems		
60.	Moisture content of incoming wastes (average and maximum)		
61.	Methods applied for treating the leachate		
62.	Regular operation and maintenance of the leachate treatment system is conducted	YES	NO
63.	Daily flow measurement at leachate treatment unit (average and maximum)		
64.	Amount of leachate treated and discharged per month		
65.	Discharge conforms to EPA set standards for discharge into the environment	YES	NO
66.	Specify where the leachate is discharged after treatment		
67.	Location of leachate monitoring		
68.	Monitoring frequency for leachate		
69	Monitoring parameters for leachate		
70.	Results of leachate monitoring	Attach in separate sheet	
71.	Frequency of inspecting the leachate collection system		
72.	Groundwater monitoring wells are tapped up- downstream of the site	YES	NO
73.	Number of groundwater monitoring wells		
74.	Location of groundwater monitoring wells	Attach in separate sheet	
75.	Monitoring frequency for the groundwater monitoring wells		
76.	Monitoring parameters for the groundwater monitoring wells		
77.	Results of groundwater monitoring	Attach in separate sheet	
78.	Problems encounter with adopted leachate drainage/collection system and corrective actions adopted		
79.	Describe adopted leachate holding tanks (type of material used for holding tanks, volume, above ground/underground, type of infiltration prevention liner if present)		
80.	Wastewater collected from the storage tanks of the vehicles transporting waste, cleaning water, drainage water and vehicle washing facilities are treated with the collected leachate	YES	NO

81.	Receiving area has provisions for a leachate collection system and a protective layer		
82.	Receiving area is roofed and has an impermeable paving, a proper drainage and ventilation system and the capacity to hold at least one nominal day throughput	YES	NO
83.	Oil-waster separators and sand precipitators are present at all workshops on-site	YES	NO
84.	Presence of sand/silt/debris removal facilities	YES	NO
VI- Stack emissions and odors			
85.	Sources of exhaust emissions		
86.	Chimney/stack properties (height, diameter, exit speed/flow rate, exit temperature)		
87.	Monitoring frequency of stack gases		
88.	Monitoring parameters of stack gases		
89.	Monitoring results of stack gases	Attach in separate sheet	
90.	Distance to nearby receptors		
91.	Frequency of odor complaints		
92.	Adopted mitigation measures		
93.	Location of complaining receptors		
VII- Work safety and environmental Protection			
94.	Number of work-related accident (since last inspection)		
95.	Kinds of accidents		
96.	Measures introduced for accident prevention		
97.	Indications for the occurrence of work-related diseases (e.g. hepatitis, deafness, skin diseases, orthopedic defects or others)		
98.	List of personal protective equipment and clothes for individual workers		
99.	Functioning conditions of the personal protective equipment and clothes		
100.	Provision of health care to workers		
101.	Name and distance to nearest hospital or medical emergency unit	YES	NO
102.	Separate storing places for both private clothes and working clothes	YES	NO
103.	Working conditions (noise/dust/odours/humidity/rodents/flies) within the facility		
104.	Sufficiency and conditions of actual sanitary installations		
105.	Drinking water supply available on-site	YES	NO
106.	Smoking allowed	YES	NO
107.	Safety signs are installed and maintained	YES	NO
108.	Disease vector control plan is adopted	YES	NO
109.	Fences and gates are maintained for access control	YES	NO
110.	Signs installed at the outer perimeter are maintained and provide clear indication of he presence of a MRF	YES	NO
VIII- Fire fighting/prevention			
111.	Prohibition of fires on the MRF site (if no provide reason for approval)	YES	NO
112.	Type of fire protection equipment		
113.	Location of fire protection equipment	Attach in separate sheet	
114.	Implementation of fire fighting training drills	YES	NO
115.	Frequency of fire fighting training drills		
116.	Maintenance of fire protection equipment	YES	NO
117.	Frequency of maintenance of fire protection equipment		
IX- Other aspects to be examined			
118.	Functioning conditions and regular maintenance of all trucks and other vehicles of the MRF		
119.	Functioning conditions of the other mobile machinery of the MRF		
120.	Power generator installation in a closed chamber	YES	NO

121.	Number, type, manufacturer, model type, and location of filters (air quality)		
122.	Number, type, manufacturer, model type, and location of mufflers (noise)		
123.	Sufficiency and functioning conductions of fire extinguishers		
124.	Proper collection of hazardous liquids and solid wastes (such as used oil, grease, paint and sprays)		
125.	Safe storage of poisons used for rodents		
126.	Adequate stand-by equipment are present on-site	YES	NO
127.	Type, capacity, and location of stand-by equipment present on-site		
128.	The MRF has a buffer area separating the site from nearby property	YES	NO
129.	All records concerning the planning, construction, and operation phases of the MRF are maintained until closure	YES	NO
130.	Regular maintenance and rehabilitation of buildings and landscaped areas are conducted	YES	NO
131.	Landscaping program compatible with landform and surrounding areas	YES	NO
132.	The MRF has established a formal complaints system which responds in a timely fashion to complaints	YES	NO
133.	The MRF has adequate off-street parking spaces	YES	NO

APPENDIX I SAMPLE CHECKLIST FOR REGURAL CONTROL AT COMPOSTING FACILITIES

I- General Information			
1.	Company name		
2.	Facility/MRF name		
3.	Address		
4.	Operation start (day/month/yearly)		
5.	General manager name		
6.	Hotline		
7.	Number of administrative staff		
8.	Number of workers		
9.	Business hours: – Hours per day – Days per week – Days per year		
10.	Site plan (main access roads; buildings and installations; property lines)	Attach in separate sheet	
11.	Contractors and subcontractors		
II- Input			
12.	Planned capacity (tons/year)		
13.	Actual yearly capacity (last year)		
14.	Actual daily capacity (tons/day)		
15.	Average number of truck loads per day		
16.	Incoming wastes have been separated at a material recovery facility	YES	NO
17.	All incoming wastes are processed within 24 hours	YES	NO
III- Entrance Control			
18.	Quality of access roads (paving, dust, litter, wastes)		
19.	Weight measured at the entrance control	YES	NO
20.	Quantity/quality-documentation of input material	YES	NO
21.	Have the compost facility accepted wastes coming from areas not covered by the contact? (If yes record type, source, and EPA approval)	YES	NO
22.	Balance sheets containing information about waste origin, waste producers and delivered quantities are kept	YES	NO
23.	Average time required to direct collection trucks to unloading area and time needed to unload		
24.	Site perimeter clearly delineated	YES	NO
25.	A wheelwash has been installed at the exit from the site	YES	NO
IV- Compost Hangar			
26.	Regular use of checklists for the regular control of the technical components of the plant	YES	NO
27.	Unauthorized wastes: Source, type, quantity, management option adopted after consultation with EPA		
28.	Visible impurities in the organic matter	YES	NO
29.	Quality of the received wastes		
30.	Report decaying or unsorted incoming wastes	Attach in separate sheet	
31.	Time required to complete composting		
32.	If anaerobic composting is adopted, what is the frequency of windrow turning?		
33.	Optimal temperature required for the process		
34.	Range of temperatures recorded within windrows/in-vessel (average, minimum, maximum)		
35.	Frequency of windrow temperature measurement		
36.	Average and range of temperatures measured in windrows		
37.	Height and volume of windrows		
38.	Number of windrows adopted		
39.	Type of aeration scheme adopted		

40.	Adopted aeration rate		
41.	Time allocated for curing phase		
42.	Composting activities complies with WHO guidelines set for the destruction of common pathogens and parasites		
43.	Functioning condition of equipment used for turning the compost		
44.	Functioning condition of equipment used for the mechanical treatment of mature compost		
V- Output			
45.	Actual output of compost with respect to each of the selected compost types defined by the EPA *(Average and maximum quantities per year and per day)*		
46.	Amount and type of compost being diverted to landfill *(Average and maximum quantities per year)*		
47.	Region(s) where compost is used		
48.	Quantity of remaining residues *(Average and maximum quantities per year and per day)*		
49.	Final disposal of residues *(name of landfill)*		
50.	Complaints from national or local authorities against the operation of plant *(since the last inspection)*		
51.	Monitoring frequency of heavy metal concentration		
52.	Types of heavy metals monitored		
53.	Assistance and training programs for compost end-users is provided	YES	NO
54.	Proposed Compost Ordinance is complied with	YES	NO
55.	Compost application rates are clearly displayed	YES	NO
56.	Bills of delivery to each end-user are issued	YES	NO
57.	Reports are kept identifying the amounts of compost used, specific types of agricultural or other uses, and specific amounts of compost used per customer		
VI- Water and Leachate Management			
58.	Measures adopted to reduce water consumption		
59.	Daily consumption of water		
60.	Source(s) of freshwater		
61.	Functioning conditions of the leachate collection systems		
62.	Moisture content of incoming wastes (Average maximum)		
63.	Methods applied for treating the leachate		
64.	Regular operation and maintenance of the leachate treatment system is conducted	YES	NO
65.	Daily flow measurement at leachate treatment unit (average and maximum)		
66.	Amount of leachate and wastewater treated and discharged per month		
67.	Compliance of the treated leachate at the point of discharge with national standards	YES	NO
68.	Discharge conforms to EPA set standards for discharge into the environment	YES	NO
69.	Specify where the leachate is discharged after treatment		
70.	Location of leachate monitoring		
71.	Monitoring frequency for leachate		
72.	Monitoring parameters for leachate		
73.	Results of leachate monitoring	Attach in separate sheet	
74	Frequency of inspecting the leachate collection syetem		
75.	Number of groundwater monitoring wells		
76.	Location of groundwater monitoring wells	Attach in separate sheet	
77.	Monitoring frequency for the groundwater monitoring wells		
78.	Monitoring parameters for the groundwater monitoring wells		
79.	Results of groundwater monitoring	Attach in separate sheet	

80.	Groundwater monitoring wells have been fitted with seals to prevent tampering or contamination	YES	NO
81.	Problems encountered with adopted leachate collection system and corrective actions adopted		
82.	Describe adopted leachate holding tanks (type of material used for holding tanks, volume, above ground/underground, type of infiltration prevention liner if present)		
83.	Wastewater collected from the storage tanks of the vehicles transporting waste, cleaning water and drainage water collected from the compost plant and vehicle washing facilities are treated with the collected leachate	YES	NO
84.	Receiving and holding areas has provisions for a leachate collection system and a protective layer		
85.	Oil-water separators and sand precipitators are present at all workshops on-site	YES	NO
86.	Stormwater collection system has been capable of preventing flow into active portions of the facility (If no specify time of failure, location, and corrective measures(s))		
87.	Storage area, composting area, and curing area are roofed and have an impermeable paving, a proper drainage and ventilation system and the capacity to hold at least one nominal day throughput	YES	NO
88.	Location, capacity, and connectivity to stormwater collection system		
89.	Natural drainage channels have been appropriately diverted		
90.	Culverts or other approved diversion schemes have been adequate (If no describe problems encountered, location, and corrective measures adopted)		
VII- Stack Emission Odors			
A. Stacks emissions			
91.	Sources of exhaust emissions		
92.	Chimney/stack properties (height, diameter, exit speed/flow rate, exit temperature)		
93.	Monitoring frequency of stack gases		
94.	Monitoring parameters of stack gases		
95.	Monitoring results of stack gases	Attach in separate sheet	
96.	Distance to nearby receptors		
B. Odors			
97.	Frequency of odor complaints		
98.	Adopted mitigation measures		
99.	Location of complaining receptors		
100.	Manufacturer(s) and model number of biofilter or other odor mitigation devices		
101.	Rating of biofilter or other odor mitigation devices		
102.	Location of biofilter or other odor mitigation devices		
103.	Life expectancy of biofilter or other odor mitigation devices		
VIII- Work Safety and Environmental Protection			
104.	Number of work-related accident (since last inspection)		
105.	Kinds of accidents		
106.	Measures introduced for accident prevention		
107.	Indications for the occurrence of work-related diseases (e.g. hepatitis, deafness, skin diseases, orthopedic defects or others)		
108.	List of personal protective equipment and clothes for individual workers		
109.	Functioning conditions of the personal protective equipment and clothes		
110.	Provision of health care to workers	YES	NO
111.	Name and distance to nearest hospital or medical emergency unit		
112.	Separate storing places for both private clothes and working clothes	YES	NO

113.	Working conditions (noise / dust / odors / humidity / rodents / flies) compost facility		
114.	Sufficiency and conditions of actual sanitary installations		
115.	Safety signs are installed and maintained	YES	NO
116.	Combustible gas concentration levels have not exceeded critical levels (If yes report location, frequency, and corrective measure adopted)	YES	NO
117.	Disease vector control plan is adopted	YES	NO
118.	Fences and gates are maintained for access control	YES	NO
119.	Signs installed at the outer perimeter are maintained and provide clear indication of the presence of a landfill	YES	NO
120.	Litter fences have been erected to prevent litter blowing	YES	NO
121.	The entire site is cleaned at least once per week	YES	NO
122.	Adopted ventilation rate		
IX- Other Aspects To Be Examined			
123.	Functioning conditions and regular maintenance of all trucks and other vehicles		
124.	Functioning conditions of the other mobile machinery of the plant		
125.	Power generator installation in a closed chamber	YES	NO
126.	Number, type, manufacturer, model type, and location of filters (air quality)		
127.	Number, type, manufacturer, model type, and location of mufflers (noise)		
128.	Sufficiency and functioning conductions of fire extinguishers		
129.	Proper collection of hazardous liquids and solid wastes (such as used oil, grease, paint and sprays)		
130.	Safe storage of poisons used for rodents		
131.	Adequate stand-by equipment are present on-site	YES	NO
132.	Type, capacity, and location of stand-by equipment present on-site		
133.	The compost plant has a buffer waste-free area separating the site from nearby property	YES	NO
134.	All records concerning the planning, construction, and operation phases of the compost facility are maintained until closure	YES	NO
135.	Regular maintenance and rehabilitation of buildings and landscaped areas are conducted	YES	NO
136.	Landscaping program compatible with landform and surrounding areas	YES	NO
137.	The facility has established a formal complaints system which responds in a timely fashion to complaints	YES	NO
138.	The facility has adequate off-street parking spaces	YES	NO

APPENDIX J NOTICE OF INTENT

DAILY OBSERVER
Wednesday, November 16, 2016
Page 6

REPUBLIC OF LIBERIA)
MONTSERRADO COUNTY)

IN THE SIXTH JUDICIAL CIRCUIT, CIVIL LAW COURT, MONTSERRADO COUNTY

ACTION OF EJECTMENT

PLAINTIFF'S COMPLAINT

WHEREFORE AND IN VIEW OF THE FOREGOING

Respectfully submitted
PLAINTIFF
By and thru his Legal Counsel
GARLAWOLU AND ASSOCIATES LAW OFFICES
Congo Town Back Road
Monrovia, Liberia

ATTORNEY-AT-LAW

ATTORNEY-AT-LAW

REPUBLIC OF LIBERIA)
MONTSERRADO COUNTY)

IN THE OFFICE OF THE JUSTICE OF PEACE FOR MONTSERRADO COUNTY, R.L.

ACTION OF EJECTMENT

PLAINTIFF'S AFFIDAVIT

SWORN AND SUBSCRIBED TO BEFORE ME THIS ... DAY OF MAY, A.D. 2016

JUSTICE OF THE PEACE FOR MONTSERRADO COUNTY, R.L.

ATTORNEY-AT-LAW/DEPONENT

UNDP 50 YEARS
Empowered lives. Resilient nations.

14th November 2016

PROCUREMENT NOTICE

Reference No: CALL FOR PROPOSAL – SUPPORT FOR VOTER REGISTRATION PUBLIC OUTREACH CIVIL SOCIETY GRANTS PROGRAMME

The United Nations Development Programme (UNDP) hereby invites qualified Civil Society Organisations which includes non-governmental organizations/community-based organizations/ faith based institutions/academic institutions (except public entities), including journalist organizations to submit proposal to this Call for Proposal (CFP) for Voter Registration Public Outreach (Civil Society Grants Programme) as per details provided in this CFP.

The bid documents for the requirements can be obtained as follows:
http://www.lr.undp.org/content/liberia/en/home/operations/procurement/
http://procurement-notices.undp.org/

Deadline for submission of this CFP is 28th November, 2016 at 12.00 Noon (GMT). All bids must be delivered at the UNDP Registry or by email to bids.lr@undp.org as indicated in the CFP. Any offer received after this deadline will not be considered.

UNDP-Liberia would like to encourage interested suppliers to UNDP to register online at http://evendor.lr.undp.org/vendor for prequalification purposes. Your participation is highly anticipated.

Notice of Intent

Environmental & Social Impact Assessment for Cheesemanburg Urban Sanitation Project Monrovia City Corporation

The general public and all concerned or interested parties are hereby informed that the Monrovia City Corporation (MCC) "Applicant", has hired Earthtime "Consultant" to prepare an Environmental and Social Impact Assessment (ESIA) for the proposed Cheesemanburg Urban Sanitation Landfill.

MCC intends to construct and operate a new landfill site in the Township of Cheesemanburg on a 100 acres land.

The overall objective of the project is to increase access to solid waste management services in Monrovia and five other participating cities in recipient's territory. The Cheesemanburg landfill is planned to be used by Cities of Monrovia, Paynesville, Browerville, Tubmanburg and Cheesemanburg Township as a regional facility. Beneficiary secondary cities including Kakata, Buchanan, Gbarnga and Ganta will receive technical assistance to provide solid waste services to citizens particularly in disadvantaged communities within these participating cities.
In keeping with Section 11 of the Environmental Protection and Management Law of the Republic of Liberia (2003), Applicant's consultants are preparing an ESIA. The ESIA process will help the Applicant manage any associated environmental and socioeconomic issues in accordance with company policies, the laws of Liberia and international expectations.

In the process of identifying potential environmental and social impacts that may result from activities of the process, the Applicant's consultant (Earthtime Inc.) and Applicant will request and receive inputs from the public, including interested and affected parties. All persons having views, comments or concerns regarding the proposed project are encouraged to contact the Applicant's consultants as follows:

Applicant's email: tkerkulah@yahoo.com
Applicant's Consultant email: whamdan@earthtimegroup.com
Contact number: +231-886325677, +231-888-300744

Your participation or input in this assessment will be highly appreciated in order to guide decision making relevant to the proposed project.

PUBLIC RELATIONS DEPARTMENT
FREEPORT OF MONROVIA
BUSHROD ISLAND
P.O. BOX 1849
MONROVIA, LIBERIA

OFFICE OF THE MANAGER

Public Service Announcement

The Management of the National Port Authority (NPA) in collaboration with (APM) Terminals and the Liberia Revenue Authority LRA) is pleased to inform the general public that it has extended the clearing time for containers under the Presidential Storage waver proclamation which was once extended to and expired on August 20, 2016.

This new extension is for three (3) months period commencing August 22, 2016 to November 22, 2016. This is intended to further allow legitimate owners/consignees to clear their containers in fulfillment of the President's gesture.

PROCEDURES FOR CLEARING OF ALL OVERSTAYED CONTAINERS AS PRONOUNCED BY THE GOVERNMENT

1. All consignees must display title of ownership, i.e.: Bill of Lading, Delivery Order, IPD.
2. All validated consignees will bring their documents to the LPMC Warehouse for validation before proceeding for payment.
3. Consignees who do not have NPA Access Pass are required to show shipping documents at the main entrance gate to enable you to have Access to the Port.
4. All consignees must proceed to the One-Stop-Shop (Customs) to make settlement of Customs duties.
5. All consignees whose containers are still in the APMT yard shall pay only Terminal handling charges at the APMT windows at the One-Stop-Shop.
6. All consignees whose containers are in the NPA yard will make payment only for Terminal handling charges at the NPA Finance department.
7. When all documents are validated and payments of handling and Customs charges are completed, each consignee will receive loading slip/gate pass from NPA Staff at LPMC Warehouse, to pick up their cargo.
8. Each consignee will be responsible for their own trucking.
9. Consignees are required to present full documents at the gate and depart the Port on the same date of loading.
10. Consignees are required to take delivery of their cargo by November 22, 2016. Failure on the part of any consignee to do so, said cargo will be auctioned.

NOTE:

There is a 100% waiver of all storage charges ONLY.

You are encouraged to read the NPA website to review the full list of containers that fall in this category.

Signed:

The Management

The INQUIRER, Wednesday, November 16, 2016, Page 9

earthtime

Notice of Intent

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Applicant's email: tkerkulah@yahoo.com
Applicant's Consultant email: whamdan@earthtimegroup.com
Contact number: +231-886325677, +231-888-300744

Your participation or input in this assessment will be highly appreciated in order to guide decision making relevant to the proposed project.

unite for children unicef

Request for Proposals - Consultancy for Environment Impact Assessment (EIA)

PURPOSE: Request for proposal from qualified consultants (firms) to enter into contract to undertake Environmental Impact Assessment (EIA) study in 120 targeted schools and their immediate surrounding communities in five (5) counties in Liberia.

Interested firms meeting the criteria as specified are requested to submit along with their bid response the following documents which will be used in the evaluation process:

Reference No.: LRFP/2016/9128739

The Expression of interest shall contain the following documents for our evaluation:

- Completed UNICEF Supplier/Company Profile Form
- Copy of Company/applicant's registration in country of origin
- Copy of company/applicant's registration in Liberia
- Company Profile which should include:
- Company structure
- Company line of business
- Number and type of employees
- Trade License- (English Version)
- Certificate of incorporation (if applicable)
- TAX Registration Certificate
- Any other licenses or authorizations issued by the appropriate government authority to operate a business in Liberia
- At least three references of major customers/clients
- Suppliers must not have prior record of inappropriate conduct in ethical, social or environmental issues (corporate responsibility).

The entire LRFP package can be picked up from UNICEF Office, Supply Unit, Mamba Point, Monrovia, between 12 p.m. to 3 p.m., Monday 14th November – Thursday 24th November, 2016. A pre-bidders meeting is schedule for 21 November 2016 11 am at UNICEF Office, Mamba Point, Monrovia

Please Note that failure to provide compliant documentations may result in invalidation of submission.

UNICEF
Bright's Apartment
Mamba Point, Monrovia
Attention: Supply Officer

The sealed RFP will be placed in the BID BOX on the ground floor, Building 01. (Ask the security at UNICEF for bid box). The deadline for submission of the Bid is Monday, 28 November, **2016 at 12:00 noon prompt.**

For clarifications, please contact Mrs. Ruth N.W. Kwabo, rkwabo@unicef.org or Mr. Henson King hking@unicef.org; telephone number 0770267301 or 0770267308 respectively.

LIBERIA OPPORTUNITIES INDUSTRIALIZATION CENTER, INC.
NEW MATADI ESTATE-SINKOR
MONROVIA, LIBERIA

PUBLIC SERVICE ANNOUNCEMENT

The Management of the Liberia Opportunities Industrialization Center, Inc. hereby solicits sealed bids for the provision of training materials in the following categories:

1. Auto Mechanics, Small Engine
2. Carpentry
3. Electricity
4. Plumbing
5. Masonry
6. Computer Science
7. Tailoring
8. & Cosmetology

Detailed information concerning the sealed bids can be picked up at LOIC Main Office in New Matadi Estate, Sinkor Monrovia, Liberia, on Tuesday November 22, 2016 from 8:00 A.M to 3:00 P.M daily and ends on 25th November 2016.

Thereafter, The Liberia Opportunities Industrialization Centers (LOIC) will inform bidders through letters regarding the opening, reviewing and determining bids winner (winners).

This invitation for bids and awarding of contracts is in accordance with Procurement procedures applicable under the Republic of Liberia Amended and Restated Public Procurement and Concession Act published and approved September 18, 2010.

Contact us on Cell # 0886515999
Email : sdking0@gmail.com

Signed:
The Management LOIC

DAILY OBSERVER Thursday, November 17, 2016 Page 6a

UNDP
Empowered lives. Resilient nations.
50 YEARS

14th November 2016

PROCUREMENT NOTICE

Reference No.: CALL FOR PROPOSAL – SUPPORT FOR VOTER REGISTRATION PUBLIC OUTREACH CIVIL SOCIETY GRANTS PROGRAMME

The United Nations Development Programme (UNDP) hereby invites qualified Civil Society Organizations which includes non-governmental organizations/community-based organizations/ faith based institutions/academic institutions (except public entities), including journalist organizations to submit proposal to this Call for Proposal (CFP) for Voter Registration Public Outreach (Civil Society Grants Programme) as per details provided in this CFP.

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Deadline for submission of this CFP is 28th November, 2016 at 12.00 Noon (GMT). All bids must be delivered at the UNDP Registry or by email to bids.lr@undp.org as indicated in the CFP. Any offer received after this deadline will not be considered.

UNDP-Liberia would like to encourage interested suppliers to UNDP to register online at http://evendor.lr.undp.org/vendor for prequalification purposes. Your participation is highly anticipated.

NOTICE OF WINDING UP ORDER

In the matter of Anglo American Kumba Exploration Liberia Limited.

Winding up order made 8th September 2016.
Name and address of Liquidator:
New Pier Business Management
21st Street / Coleman Avenue
alyoscha@newpier.com

(a) All creditors of the above named company should file their proof of debt with the liquidator who will be administering all affairs of the company.

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Applicant's Consultant email: **whamdan@earthtimegroup.com**
Contact number: **+231-886325677, +231-888-300744**

Your participation or input in this assessment will be highly appreciated in order to guide decision making relevant to the proposed project.

REPUBLIC OF LIBERIA
LIBERIA NATIONAL COMMISSION ON SMALL ARMS (LiNCSA)
Executive Mansion Grounds
Capitol Hill
Monrovia, Liberia
Mobile: +231-886-498-816 / +231-776-363-346

LiNCSA

Invitation for Bids (IFB)
National Competitive Bidding

1. The Liberia National Commission on Small Arms has received funding from the United Kingdom and intends to use portion of it to fund eligible payment under the contract for the procurement of the below packages.
2. The LiNCSA now invites sealed bids from eligible and qualified bidders for the Procurement of the following packages:

#	Contract Package	IFB No	Bid opening Dates/Times
1	Advertising	LINCSA/NCB/UKG/003/16/17	November 23, 2016 @ 10:00 am
2	Catering Service	LINCSA/NCB/UKG/004/16/17	November 23, 2016 @ 11:00 am
3	Vehicle Rental	LINCSA/NCB/UKG/001/16/17	November 23, 2016 @ 12:00 noon
4	Printing, Binding & Publication	LINCSA/NCB/UKG/002/16/17	November 23, 2016 @ 1:00 pm

3. Bidding will be conducted through the National Competitive Bidding (NCB) procedures as specified in the PPC Act and is opened to all eligible bidders.
4. Interested eligible bidders may obtain further information from the
Liberia National Commission on Small Arms
Executive Mansion Grounds
Capitol Hill
Monrovia, Liberia
Tel: 231 – (0886)-561-399
5. Qualification requirements: All bids must be accompanied by
a. Current tax clearance
b. Current Business registration
c. Proof of similar goods been supplied
6. Bids must be delivered to the address below on or before the specified dates in the above matrix. All bids must be valid for a period of forty- five (45) days after the deadline of bid submission.
7. Bids will be opened as specified in the matrix above in the presence of bidders' representative who choose to attend at the address below:

LiNCSA Conference Room,
Executive Mansion Grounds
Capitol Hill, Monrovia, Liberia

8. A complete set of Bidding Document for each package in English may be purchased by interested bidders upon payment of a non-refundable fee of USD50.00 to the Commission's Finance & Administration Department and obtain a complete set of Bidding Document.
9. All bids must be clearly marked with the address indicated below.
10. **Electronic bids will not be accepted.** Late bids will be rejected and returned unopened.
11. **The address is:**
Liberia National Commission on Small Arms
Executive Mansion Grounds
Capital Hill
Monrovia, Liberia.

Approved: [illegible]
Head of Administration

Signed: PP. [illegible]
Head of Procurement

The INQUIRER, Thursday, November 17, 2016, Page 9

earthtime

Notice of Intent

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UN DP
Empowered lives. Resilient nations.

14th November 2016

PROCUREMENT NOTICE

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The bid documents for the requirements can be obtained as follows:
http://www.lr.undp.org/content/liberia/en/home/operations/procurement/
http://procurement-notices.undp.org/

Deadline for submission of this CFP is 28th November, 2016 at 12.00 Noon (GMT). All bids must be delivered at the UNDP Registry or by email to bids.lr@undp.org as indicated in the CFP. Any offer received after this deadline will not be considered.

UNDP-Liberia would like to encourage interested suppliers to UNDP to register online at http://evendor.lr.undp.org/vendor for prequalification purposes. Your participation is highly anticipated.

Central Agricultural Research Institute

[illegible]
Monrovia, Liberia

Invitation for Bid
CENTRAL AGRICULTURAL RESEARCH INSTITUTE (CARI)
National Competitive Bidding (NCB)
For The
Agriculture Supplies & Tools

[illegible]

1. The Government of Liberia through the Central Agriculture Research Institute (CARI) has received budgetary allotment and intends to apply part of the proceed toward the cost of AGRICULTURE SUPPLIES & TOOLS for which this invitation for Bids is issued. The Central Agriculture Research Institute (CARI) now invites sealed bids from eligible and qualified bidders for AGRICULTURE SUPPLIES & TOOLS with the below descriptions and quantities:

Items / Description	Quantities	Lots
Agriculture Supplies	Assorted	1
Agriculture Tools	Assorted	2

- Bidding will be conducted through the National Competitive Bidding (NCB) procedures specified in the PPCA and approved by the PPCC, and are open to all Eligible bidders.
- As of Monday, 18th November 2016, eligible bidders may obtain further information from the Procurement Unit, Central Agricultural Research Institute, C/o Ministry of Agriculture, 1st Floor Room 007 and pick up the bidding documents at the address given below from 09:00 A.M – 4:00 P.M. Monday to Friday.
4. A complete set of Tender documents [illegible] may be purchased by interested Bidders upon a payment of a nonrefundable fee of fifty United States dollars (US$50.00) for each set. [illegible]

Tender shall be delivered to the address below at or before 1:00 PM, Tuesday, December 20, 2016. Tenders shall be valid for a period of 60 days after the deadline of Tender submission. All Tenders must be accompanied by a Bid Declaration. Late Tenders will be rejected and returned to the bidder unopened. Tenders will be opened in the presence of the Bidders or their representative who choose to attend at 1:30 PM, Tuesday, December 20, 2016 in the **Conference Room of the Ministry of Agriculture.**

5. Qualification requirements include:
   1. Articles of Incorporation,
   2. Valid Tax Clearance,
   3. Valid Business Registration
   4. Bidders must had complied fully with the vendor registration process with the Public Procurement and Concessions Commission (PPCC)
   5. Past performance records including the names and contact number of at least three clients.
   6. Availability of goods upon request
   7. Line of Credit (30days)

Bids must be in English and fees much be quoted in United States dollars

6. Prospective bidders must submit one original and three copies. Original bid must be enclosed in a separate envelope and marked "ORIGINAL". The three copies and the original copy must then be enclosed in one larger envelope and labeled "AGRICULTURE SUPPLIES & TOOLS; IFB NO: CARI/NCB/CB/001/16/17" and must be submitted to the office of the Procurement Unit. Additional details are provided in the Bidding Documents.

Attention: The Procurement Unit
Central Agricultural Research Institute
C/o Ministry of Agriculture Room 007
Old Lincoln Compound
Old LPRC Road, Gardnersville
1000 Monrovia, 10 Liberia

Cell No: +231886542797/+231886509910

Signed: ____________
Procurement Officer

Approved: ____________
Director General

LIBERIA OPPORTUNITIES INDUSTRIALIZATION CENTER, INC.
NEW MATADI ESTATE-SINKOR
MONROVIA, LIBERIA

PUBLIC SERVICE ANNOUNCEMENT

The Management of the Liberia Opportunities Industrialization Center, Inc. hereby solicits sealed bids for the provision of training materials in the following categories:

1. Auto Mechanics, Small Engine
2. Carpentry
3. Electricity
4. Plumbing
5. Masonry
6. Computer Science
7. Tailoring
8. & Cosmetology

Detailed information concerning the sealed bids can be picked up at LOIC Main Office in New Matadi Estate, Sinkor Monrovia, Liberia, on Tuesday November 22, 2016 from 8:00 A.M to 3:00 P.M daily and ends on 25th November 2016.

Thereafter, The Liberia Opportunities Industrialization Centers (LOIC) will inform bidders through letters regarding the opening, reviewing and determining bids winner (winners).

This invitation for bids and awarding of contracts is in accordance with Procurement procedures applicable under the Republic of Liberia Amended and Restated Public Procurement and Concession Act published and approved September 18, 2010.

Contact us on Cell # 0886515999
Email : sdking0@gmail.com

Signed: ____________
The Management LOIC

DAILY OBSERVER Friday, November 18, 2016 Page 7

United Nations Development Programme

UNDP 50 YEARS

Empowered lives. Resilient nations.

PROCUREMENT NOTICE

Reference No.: RE-ADVERTISED! REQUEST FOR PROPOSAL – GRAPHIC DESIGN COMPANY

The United Nations Development Programme (UNDP) hereby invites qualified Graphic Design Companies to submit proposal to this Request for Proposal (RFP) Graphic Design Company as per details provided in this RFP.

The bid documents for the requirements can be obtained as follows:
http://www.lr.undp.org/content/liberia/en/home/operations/procurement/
http://procurement-notices.undp.org/

Deadline for submission of this RFP is 2nd December, 2016 at 12.00 Noon (UTC) Liberian Time. All bids must be delivered at the UNDP Registry or by email to bids.lr@undp.org as indicated in the CFP. Any offer received after this deadline will not be considered.

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Simpson Building, Sekou Toure Avenue, Mamba Point - P. O. Box 10 - 0274 - Monrovia V-sat 0031-20-5407-121 Fax 0031-20-5407-127

LRA
LIBERIA REVENUE AUTHORITY

November 14, 2016
PSA/LRA-025

Important Government Notice

Attention: Time Extension For Filing Monthly Withholding Taxes

Due to frequent power and system failures experienced at the Liberia Revenue Authority (LRA) Headquarters during the peak payment period for the Personal Income Tax (PIT), the Commissioner General herewith extends the due date for the filing and payment of the Monthly Personal Income Tax Withholding for the month of October 2016 from Thursday November 10, to Saturday November 19, 2016.

This extension, as sanctioned under Section 50 (C) and (D) of the Liberia Revenue Code, takes automatic effect.

No penalty for failure to file and, or failure to pay shall be applicable within the specified extension period granted herein by the Commissioner General for the monthly payment and filing of the PIT for the month of October.

All taxpayers which include both businesses and individuals including high wealth individuals are hereby advised to take advantage of the period of extension herein granted by the Commissioner General to fully comply with their tax obligations as required by law and avoid Interest and Penalty.

Signed: ____________
Elfrieda Stewart Tamba
Commissioner General/CEO

Notice of Intent

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Your participation or input in this assessment will be highly appreciated in order to guide decision making relevant to the proposed project.

LRA
LIBERIA REVENUE AUTHORITY

VACANCIES

November 16, 2016

The Liberia Revenue Authority (LRA) was established by an Act of Legislature in September 2013 for the purposes of assessing and collecting national revenues as specified in the Revenue Code of Liberia and other related laws; administering, accounting, auditing, enforcing revenue collection laws and regulations; and educating taxpayers to facilitate tax and customs compliance.

The Liberia Revenue Authority now seeks to recruit competent, hardworking, and committed Liberians with integrity for the below positions:
1. Manager, Customs Reform& Modernization
2. Customs Data Reconciliation Officer
3. Customer Services Officer
4. Officer, Warehouse/Stores

Applicants will be selected through a highly competitive evaluation process.
Detail of the requirements can be obtained at:
- **www.lra.gov.lr**
- **Liberia Revenue Authority Facebook Page**

Interested individuals are advised that all applicants should submit their resume Online (**www.lra.gov.lr**) via LRA job recruiting link (job portal).

Note: Every ToR downloaded has an opposite corresponding link to submit related application/resume for said job.

The deadline for application is on or before Thursday, December 1, 2016 at 5:00 pm

The LRA strongly encourages qualified females to apply.

Note: This announcement and other LRA related information are also available at **www.lra.gov.lr** and Liberia Revenue Authority Facebook page.

Signed:
D. Kaihenneh Sengbeh
Communications, Media & Public Affairs /LRA

WOMEN VOICES, Friday, November 18, 2016 Page 9

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Vacancy Announcement
United States Peace Corps in Liberia

Personal Service Contractor Position Title: Driver
Location: Monrovia
Work Hours: Full Time; 44 hours per week; Typically Monday through Friday from 7:30 am to 5:00 pm
Basic Salary: Based on U. S. Mission Local Compensation Plan – Grade 3 Equivalent

Under the direct supervision of the Motor Pool Coordinator, and oversight from General Services Manager, the incumbent is responsible for driving Peace Corps vehicles and providing general maintenance and cleanliness for those vehicles; performing office errands assigned by supervisors, including picking up and delivering supplies, and transporting programmatic staff on overnight site visits. Extensive travel throughout Liberia is required.

Basic Duties:
The incumbent is required to provide safe, professional and courteous transport for staff, Volunteers and other personnel conducting official Peace Corps business.
Serves as Duty Driver, both at the office and up-country during training activities,
Provides vehicle support during emergency situations
Assures that vehicles are operated in accordance with PC, Embassy and other USG guidelines, and manufacturer specifications.
Maintains the daily vehicle logs and reports all vehicle malfunctions or problems to the Motor Pool Coordinator.
Records repair and maintenance operations of assigned PC vehicle as outlined in the Vehicle Maintenance Log.
Wash vehicles daily and ensures that vehicles are kept clean inside and outside.

QUALIFICATIONS REQUIRED FOR EFFECTIVE PERFORMANCE
- EDUCATION: Completion of Secondary School is required.
- PRIOR WORK EXPERIENCE: At least three years of professional safe driving experience with International Government Missions, or NGOs is required.
- LANGUAGE PROFICIENCY: Proficient in both written and spoken English.
- KNOWLEDGE:

Knowledge of all aspect of Liberia
Knowledge of road conditions throughout Liberia

ABILITIES AND SKILLS:
- Must possess a valid Liberian driver's license.
- Demonstrated ability to drive under difficult situations in rural Liberia and adhere to driving laws.
- Ability to maintain vehicles in good working condition.
- Any additional skill to the work will be preferred.
- Ability to courier cash to Peace Corps Training site or Volunteers safely
- Ability to assist property manager and do some lifting
- Ability to spend weeks at a time at Peace Corps Sub office in Zwedru or training center in Kakata
- Ability to respond to emergencies even at night
- ability to plan vehicle maintenance and to fill a vehicle movement log

To apply:
Submit a Cover Letter addressing all the requirements stated in this advertisement, a resume or curriculum vitae, copy of driver's license, diplomas, certificates and the names and contact information for 3 references via email to: **pcjobs@lr.peacecorps.gov**

Please note: Only individuals selected for an interview will be contacted. No phone calls will be accepted. Contract is contingent on a security background and medical check.

FEMALE CANDIDATES ARE STRONGLY ENCOURAGED TO APPLY.

The deadline for applications is December 2, 2016. Applications received after this date may be considered at the discretion of the Contracting Officer.

Date: November 14 2016
Ref.: **RFP/17/019**
Subject: Solicitation for Radio Production and Broadcast Services

The International Foundation for Electoral Systems (IFES), invites your firm to participate in this competitive solicitation for pricing, delivery, and terms of potential sale of the following services for the IFES office in Monrovia, Liberia. IFES reserves the right to reject any and all offers, to add, delete, or modify any element of the solicitation at any time without prior notification and without any liability or obligation of any kind. This RFP does not obligate IFES to enter into a contract nor does it obligate IFES to pay any costs incurred in the preparation of submission of any Response.

Description of Services

In order to promote voter education and peaceful elections, IFES seeks the service s of a Media Production Company to produce and broadcast radio jingles, public service announcements (PSAs), short radio dramas, and the weekly "Elections and You" radio talk show prior to and after the Republic of Liberia's Presidential and General Elections scheduled for October 10, 2017.

The vendor will also be responsible to select, in coordination with IFES, at least two main Liberian Radio Channels with maximum, nation-wide coverage and purchase from hem airtime, at peak broadcast hours for the airing of all the radio content according to the frequency specified under the Broadcast section of the RFP.

Those interested in receiving the full Request for Proposals (RFP) are asked to contact Ms. Salima Wiggins, at swiggins@ifes.org and Ms. Jenny Xu, at jxu@ifes.org. The deadline for submitting quotations is November 28, 2016, by 5:00PM local Monrovia time.

APPENDIX K MINUTES OF MEETINGS

Public Meeting – Environmental and Social Impact Assessment (ESIA) for Cheesmanburg Urban Sanitation Project

Meeting: (ESIA) for Cheesmanburg Urban Sanitation Project

Date: 09 November 2016

Venue: Quendee Town – Kle District – Bomi County

Summary:

A meeting was held between the community members of Quendee, Gbonjema, Korsor Town and Varnja Town, a representative of MCC and the consultation team in the presence of the Commissioner of Kle district to present and discuss the construction and operation of the Cheesemanburg Urban Sanitation Project. The discussion included a brief presentation of the project location and components as well as the probable environmental and social impacts that might arise from the project and the concerns and opinions that the communities might have regarding the project.

Presentation:

The consultation Team (Beageorge M. Cooper and Prince Barnes) introduced the project and provided a brief description of the project component and location and probable environmental and social impacts arising from project activities.

Attendants:

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Stakeholder Consultation Meeting

Environmental and Social Impact Assessment (ESIA) for Cheesmanburg Urban Sanitation Project

Meeting Venue: Quenyondee Town

Date: 11/09/16

Attendance Sheet

No	Name	Town	Position	Phone No./Email	Signature
1.	Thomas S. Cassel	QUenyondee	Commissioner	0775592651	[signature]
2.	Joseph S. Weah, Jr.	Brewerville		0886753182	[signature]
3.	Sunnah T. Weah	Brewerville		0886578286	Sucah
4.	Richard B. Cassell	QuenyONDEE		0776815960	RCassell
5.	Sando Jallah	Quenyondee			[signature]
6.	Prince Conneh	Vansiah			[signature]
7.	Goito massaie	Vanjah			G.Massie
8.	MiaTTa Jones	Vanjah Town			[signature]
9.	Charme R.T. Sando Jr	Vanjah		0777279582	[signature]
10.	Saffa Jalleh	Quenyondee			[signature]

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№	Name	Town	Position	Phone No./Email	Signature
11.	Christopher Poindoe	VanJah Town		0777290684	[illegible]
12.	Musu Carter	Quenyondee			M.Carter
13.	Junior Singbeh	Quenyondee		0770698539	[illegible]
14.	Willie G. Cole	Vanjah town		0775541936	[illegible]
15.	Zolu Hills	Korsor town		0773988 95	Zaulhills
16.	Toney G. Beimah	Karsor		0775279468	T.G.B
17.	Fahn G. Jallah	Vanjah Town		0770390373	F.G.J
18.	Tomah Jallah	Vanjah Town		0770390373	T.J
19.	Zinnah Farmah	Vanjah Town		0770271148	[illegible]
20.	Steven Gisen	Quenyondee			S. Gisen
21.	Emmanuel Brown	Korsor Town		077008507	
22.	BENDU KAMARA	VANJAH TOWN		077679285	B.K
23.	CeCelie Gotolo	Vanjah town			C.G
24.	Konah Flomo	Qunyondee		0770648778	

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№	Name	Town	Position	Phone No./Email	Signature
11.	Blamah Willie	Senjay		0776874461	B.W
12.	Momo Willie	Senjay			M.W
13.	Zinnah Willie	Senjay			
14.	Maime Blamah	Senjay			
15.	tata Vaney	Vanijah			T.V
16.	Jaru Burphy	Vanijah			
17.	Alex Farmah	Senijah			
18.	Thomas M. Quie	Vanijah			T.M.Q
19.	Jessie Farmah				
20.	Dabbah Qui	Vanjah			D.Qui
21.	Massa Qui	Queyondee			
22.	Massa Sambala	Queyondee			
23.	Zammah Cassell	Queyondee			Z.Cassell
24.	Watta Kamara	Quenyondee			

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№	Name	Town	Position	Phone No./Email	Signature
11.	Hawa Dorley	Queagondee		NO	H.Dorley
12.	Toneah Jallah	Quenyondee			
13.	Massa Jallah	Quenyondee			
14.	Konah Bench	Quenyondee			
15.	Fatu Kamara	Queyondee			
16.	Zinnah Calless	Quenyondee			
17.	Dabbah Rogess	Quenyondee			D.R
18.	Dabbah Dorley	Quenyondee			
19.	Zoe Willtion	Quenyondee			Z.W
20.	James L Paye	Quenyondee			J.Paye
21.	ZOE K. COOPER	Queayondee			Z.K.C
22.	Sando Passaway	Quenyondee			
23.	Varney Holf	Quenyondee			V.H
24.	Samuel Jallah	Vanjah			

2

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№	Name	Town	Position	Phone No./Email	Signature
11.	Sanda Kabah	Gbojimah			
12.	Andrew Fleman	Ballah Village			
13.	Reginald Karmon	Vanjah Town			R.Karmon
14.	Nanie Grant	Quenyondee		0775986508	N.G
15.	Jartu Dorley	Korsor		0775816 9230	
16.	Gbessay Johnson	Wuluwein			G.J.
17.	Blama Quaye	Quenyondee			Blama Quaye
18.	Jah Gohn	Gbojimah			J.G
19.	Jerry Moore	Vanjah Toon			[illegible]
20.	Momo Farmah	Korsor			
21.	Sekou Boimah	Gbojimah			
22.	Fahn Kamara	Gbojimah			S.B. Sekou
23.	Charles Momo	Quenyondee		0776157754	
24.	Alex Z. Cooper	Vanjah		0770-767887	[illegible]

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Questions and Concerns Session:

The purpose of this section is to focus on the questions, concerns and comments on the different aspects of the project that were discussed in the meeting.

The following questions were raised and discussed during the meeting:

Name	Question	Response	Respondent
Blama Quaye (Town Chief of Quenyondee)	This feels like a dream come through and we are all happy to have your team here today. Using Duala market as an example and knowing how much dirt is piled up, we have been worried that the site here is going to be a similar situation. We are at ease now that you have explained to us all measures that will be put in place to ensure the safety of our water, fish, soil, animal and people will not be affected. All we can do now is observe the site. Thanks for the brilliant ideas. I pause now and if anything, later, I will come back.	Thanks very much for your contribution and we are confident that the Project will be implemented in accordance to both national and international best practices.	Beageorge M. Cooper

Name	Question	Response	Respondent
Sando Jallah	How are the health hazard of the mosquitoes going to be controlled?	Measures will be put in place to reduce the mosquitos, insects, flies and other rodents. To manage those, some measure to be put in place includes (i) proper containment and treatment of the water collected from the bottom of the pit of cell, known as leachate. Knowing such water could serve as a nesting place for mosquitos, the water will be treated routinely or kept in an enclosed environment to avoid exposure and being used as a breeding place for insects. (ii)The daily covering of garbage layers in a cell with the recommended inches of dirt/soil will help minimize the exposure of the trash to insects	Beageorge M. Cooper
Sunnah P. Weah (Resident of Brewerville)	Will the pit containing the dirty water drained from the bottom of the cell be protected?	Yes, it is going to be protected. The pit could be designed in the form of a reservoir with minimum porosity to avoid seepage into the soil. The leachate will be treated routinely and either recycled or dispose of efficiently. Leachate gathered could also be store in an enclosed space.	Beageorge M. Cooper

Name	Question	Response	Respondent
Joseph S. Weah Jr. (Resident of Brewerville)	My concern has to do with the social aspect. You talked about recruitment of workers where the land fill be concentrated. Will there be provision for the training of workers in order to observe the safety measure that is expected? Secondly: in the diagram displayed, you talked about the waste producing some form gas like methane that could sometime be used to generate electricity. Will the Project be implementing such projects to electrify the impacted communities?	Health and safety is amongst the key best practice standard of the World Bank and as recommended in the Project documents, during both construction and implementation stages, all health and safety measures will be enforced. It can also be expected that workers will be trained in accordance with the operational guidelines of the Project. Before you bring people to work for you, you must train them to your methods and way to ensure desired output. Generation of electricity from Methane gas: The image was meant to show the different components or design of the site and how the impacts can be managed. I cannot say if the Project is considering the generation of electricity from methane gas, or that the amount released is enough to undertake such projects. It is an expensive Project of its own.	Beageorge M. cooper

Name	Question	Response	Respondent
Richard B. Cassell	You talked about job opportunities for our people. When UNDP came here, they promised jobs to our people. Later, we discovered information relative to recruitment was only given to people in Monrovia and we were left out. In the end, we saw strange people from Monrovia doing work that was promised to be given to us. We would like to know if information on recruitment or vacancies be shared with our communities?	We know employment is one of the most important concerns of the communities. In creating job opportunities, the safety of the people is seriously taken into consideration. The Project will try to avoid giving jobs that you are capable of doing to people coming from Monrovia. So, in as much we continue to work together, we can assure you that what you deserve will be given to you if the opportunity exists. But it is important for us to understand that there are jobs that require specific technical skills and know-how that cannot be offered by your communities. Therefore; these jobs will have to be given to people outside your communities and sometime outside of Liberia.	Tolbert A. Kerkulah and
	You did say the Project is expected to last for 50 years and there will be a mixture of different types of garbage, how will our future generation be protected against the impact of the waste?	Ensuring the protection and safety of the future generation: Like discussed during the presentation, the waste will be separating both manually and with the use of machines. The mixture of these processes will potentially reduce the impact to the environment by allowing some of the waste to be recycled, reuse and turn into compost. The construction design and operational plan, that meets international best practices, will ensure the safe management of the Project, thus avoiding or minimizing any adverse impact and enhancing those that are positive.	Beageorge M. Cooper

Name	Question	Response	Respondent
Thomas M. Quie	Thanks to MCC for the hard work being carried in the city and now they are in the interior. I have been monitoring stock pile of dirt in some corners of Monrovia and there is no proper supervision. An example: month ago, I passed at the intersection of Clay & Benson street and I saw a dead baby in the waste bucket and that polluted the entire place. Will this landfill site be monitored on a daily basis to avoid people dumping dead bodies instead of dirt?	Your concern is appreciated. This place will be different from that place you spoke about because we are focusing on final disposal site. The location identified is a collection point where people from the community come to dump dirt unlike this project where the dirt will be properly handled. The Cheesemanburg site will not be accessed by individuals, it will be restricted and only MCCs authorized personals will have access. It is unfortunate that you had to see an unpleasant act of corpse disposal, but some things are beyond the control of others. The Landfill site will be fenced to minimize exposure of the community to direct view of the waste.	Tolbert A. Kerkulah And Beageorge M. Cooper
Konah Flomo (Quenyondee)	I want to thank you all for coming because there were rumors going around that MCC is bringing garbage in our community to make us sick. But the way you explained the Process to us made me better understand the project. My only question to you is that, if the whole site is filled with waste, will you not relocate us from our towns?	Well, the feasibility studies carried out for this Project does not recommend the need for resettlement. The site did meet the EPA & World Bank standard on minimum proximity to structure, towns, water bodies and other key indicators. The design has also been done to avoid or minimize adverse impacts to the environment and community. With our team collecting baselines samples, routine collection and testing of samples will advise the Project of its impact to the environment and if the measure put in place are effective and efficient.	Tolbert A. Kerkulah and Beageorge M. Cooper

Name	Question	Response	Respondent
Zoe Willtion	I want to know whether our water at the creek will be safe because MCC is bringing dirt to our community.	The project design is developed to avoid seepage of harmful contaminants, leachate and disposal of the Project's output into the environment. The construction, implementation and closure stages will ensure the safety and protection of the water bodies, water tables, soil, air, environment, animals, and health of the communities.	Beageorge M. Cooper
Willie G. Cole (Quenyondee)	We understand and appreciate all that has been said, but we want to know what we can do if our community experiences any pollution?	As much as the Project will work towards mitigating an adverse impact, if the community is being impacted negatively, we would like to encourage you to actively engage the MCC on these issues	Beageorge M. Cooper

Public Meeting – Environmental and Social Impact Assessment (ESIA) for Cheesmanburg Urban Sanitation Project

Meeting: (ESIA) for Cheesmanburg Urban Sanitation Project

Date: 09 November 2016

Venue: Dolela Town – Kle District – Bomi County

Summary:

A meeting was held between the community members of Dolela and Dimei, a representative of MCC and the consultation team in to present and discuss the construction and operation of the Cheesemanburg Urban Sanitation Project. The discussion included a brief presentation of the project location and components as well as the probable environmental and social impacts that might arise from the project and the concerns and opinions that the communities might have regarding the project.

Presentation:

The consultation Team (Beageorge M. Cooper and Prince Barnes) introduced the project and provided a brief description of the project component and location and probable environmental and social impacts arising from project activities.

Attendants:

earthtime

Stakeholder Consultation Meeting

Environmental and Social Impact Assessment (ESIA) for Cheesmanburg Urban Sanitation Project

Meeting Venue: Dorlelah Town

Date: 11/09/16

Attendance Sheet

№	Name	Town	Position	Phone No./Email	Signature
1.	Francis M. Guemou	Dorley-lah Town		0777056 9478	FMGuemou
2.	SeneFu V. DoRley	Dorley-lah Town		0776293756	S.Dorley
3.	Patrick P. Kollie	Dorley-lah		0770547263	P.P. Kollie
4.	Peter Flomo	Dorley-lah			[illegible]
5.	Zinnah Wilson	"		0775203524	
6.	K. Larmine Swaray	"		0777450955	
7.	Musu B. Dorley	"			
8.	K. Amadu Sanor	"		0775972-550	
9.	Varmuyan M. Siryon	"		0776-705183	
10.	Gormah G. Lamah	"			

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№	Name	Town	Position	Phone No./Email	Signature
11.	Annie Flomo	Dorley-lah			
12.	Nowah Mountain	〃			
13.	Nowah Kollie	〃			
14.	Maima Jalibah	Dorley-lah			[illegible]
15.	Tonyon Kollie	Dorley-lah			[illegible]
16.	Hawa Kanneh	Dorley-lah			H.K
17.	Bandu Moore	Dorley-lah			[illegible]
18.	Edith Soclo	〃			E.S
19.	AMOS Soclo	〃			A.S
20.	Racheal Lamah	Dorley-lah			[illegible]
21.	VARNEY JAH	DORLEY-LAH			V.J
22.	David N. Kollie	Folley Town			[illegible]
23.	Saymah Kanneh	Dorley-lah			S.K
24.	NyahQuioh Lamah	Demeh			N.L

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№	Name	Town	Position	Phone No./Email	Signature
11.	Joseph Parson	Dorley-lah			J.P
12.	Tangay Jellbah	"			T.J
13.	Careful Toe	"			C.T
14.	Arhamula Lamah	Dorley-lah			A.L
15.	StePhen Flomo	Dorley-lah			S.F
16.	Fatumata Swaray	"			F.S
17.	christine Skaine	"			C.S
18.	Alice Dukuly	Dorley-lah			A.D
19.	Tonneh Walson	"			T.W
20.	Famatea Dorley	Dorley-lah			F.D
21.	Massah kollie	Dorley-lah			M.K
22.	Massa Wilson	"			M.W
23.	Jerryline Manee	"			JM
24.	Sadie Kaidii	"			S.Kaidii

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№	Name	Town	Position	Phone No./Email	Signature
11.	Roseline Mosleg	Dorley-lah			RM
12.	Marie Flomo	"			M.F
13.	Hannah Flomo	"			H.F
14.	Madison G. Kollie	Dorley-lah		0775973081	[illegible]
15.	Mary Flomo	"			M.F
16.	Zinnah Ballah	"			Ballah
17.	Ballah N. David	Dorley-lah	Administrator	0777208864	[illegible]
18.	ALFRED SEH	DEMEH		0880421612	A. SEH
19.	Sundifu Z. Dorley	Demeh		0886629475	S.Z.D
20.	Mohammed Jalobah	Dorley-lah		0770383813	M.J
21.	Siafa Dorley	Demeh			S.D
22.	Musu Karr	Demeh			M.K
23.	Gbassay Kamara	Demeh			G.K
24.	Kanfe Varney	Demeh			K.V

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Stakeholder Consultation Meeting

Environmental and Social Impact Assessment (ESIA) for Cheesmanburg Urban Sanitation Project

Date: ______________________

Attendance Sheet

№	Name	Town	Position	Phone No./Email	Signature
1.	Miatta W. Tokpah	Quenyundee	MEMEBER		
2.	Momodee Gotolo	Vanjah Town	Member		M.G
3.	Seh Dolo	Momo Jallah Town	Member	0777412952	
4.					
5.					
6.					
7.					
8.					
9.					
10.					

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Questions and Concerns Session:

The purpose of this section is to focus on the questions, concerns and comments on the different aspects of the project that were discussed in the meeting.

The following questions were raised and discussed during the meeting:

Name	Question	Response	Respondent
Senefu M. Dorley (Administrator of Dorley-lah)	You are talking about establishing waste site near our town. I want to know what will be the aftermath when our people are experiencing pollution.	Firstly, let me say that we will put measures in place to reduce the pollution. There will be a channel through which the pollution will be controlled. One of the ways of controlling pollution is that, when the dirt comes, it will be covered on daily a basis. If the community is eventually impacted by air or water pollution, we urge that you engage MCC Management.	Beageorge M. Cooper
K. Larmie Swaray	Is the Project working with EPA assigned personnel to the County?	The Project has been engaging the EPA since its inception. During the presentation, you were informed that the EPA the agency responsible to grant environmental permit or clearance for such a Project. Working with EPA means that the Project is working indirectly with its agents in each County. But it is within the purview of the EPA to determine the how the Project engages with it.	Beageorge M. Cooper
Varmuyan M. Siryon	According to the presenter, we have some people testing the soil & water, what happens if in the next three to four years the water quality deteriorates.	If it is discovered that the water quality is deteriorating. The team will have to get back to the drawing board to thoroughly study its current design and management processes, develop and deploy corrective measure. For now, the study, construction design and mitigation measures seem to be effective and efficient.	Beageorge M. Cooper
Patrick P. Kollie (Dorley-lah)	I want to know how guaranteed material lining at the bottom of each cell is.	The material lining to be placed at the bottom of the each cell to manage leachate will have to meeting the highest grades and standards.	Beageorge M. Cooper

Name	Question	Response	Respondent
K. Amadu Sarnor (Folley Town)	The water that will be treated at the site, I want to know what it will be used for. Will it be safe for consumption or for other designs? What will be the Socio Corporate responsibility of MCC to the community?	In our continuous engagement with the communities, we have stated our desire to work and collaborate with the surrounding communities. But notwithstanding, management of expectation is also key. The project will not be able to hire everyone, just a few if the skillset available in the community commensurate with the requirement of the position. The project will work to ensure that if someone within the community has the necessary skillset, that person will receive the first priority. The leachate collection pit will be treated routinely and the water could either be recycled to be used for the cleaning of the garbage sorting room, used for flushing of toilets or properly treat and dispose of.	Tolbert A. Kerkulah And Beageorge M. Cooper
Tangay Jalibah	I recommend that MCC build clinic for our people just in case if there is pollution, our people can be treated right here!	Thanks very much for the recommendation. It will be captured in our report	Beageorge M. Cooper
Mohammed Jalibah (Town Chief – Dorley-lah)	You talked about plastic that you put at the pit to prevent water from passing through. There could be sharp objects in the waste that could pierce the plastic leading to contaminated water entering the soil.	It is important to clarify the material lining to be used at the bottom of the cell could be made of any material and is not a regular plastic. It will meet the required best standard and be made of pressure resistant and durable material specifically engineered to serve such As shown in the presentation, the bases of the pit or cell will be layered with different materials before garbage is dumped there. The leachate control material lining will be covered with a geotextile mat, followed by a layer of small pebbles or stone before adding a thick layer of soil. These different layering are meant to trap impurities and avoid the kind of situation you are concerned of.	Tolbert A. Kerkulah And Beageorge M. Cooper

Name	Question	Response	Respondent
Mamie Jalibah	From the presentation you stated that the life of the site is 50 years but what we see around Monrovia, we understand that large quantities of dirt will be coming in. How is it possible for garbage not to fill that space within 3 to 5 years?	As explained, the large quantities of dirt that will be coming on a daily basis will be sorted out, separated. This will allow some of the waste to be marketed for reuse and organic waste turned into compost for fertilizer leaving the rest to be deposited into the cell. The composition of the types of waste shows that 43% of all waste generated across the Project areas is made up of vegetable and putrescible. The separation, processing and recovery of materials from the solid waste stream constitute an important part of an integrated solid waste management plan and will significantly reduce the amount of unusable waste the goes into the pit.	Beageorge M. Cooper
Jerryline Manee	I've heard all you have to say to us and how the all of the hazards will be managed. But with my experience from living in and around Project areas like Weala & Firestone Rubber Companies, it is difficult to manage or control air pollution. In the event that the Project cannot control or mitigate air pollution, will provisions be made to relocate the surrounding town?	Thank you very much! The point you made relating to rubber factories like Weala & Firestone is completely different from what we about to do here. We are talking about treatment plant that will deal with waste management in order to avoid harm to the general population. Unlike the rubber factories with a priority of processing their rubber, this priority of this Project to mitigate air pollution across Monrovia and its environs. This Project seeks to ensure better sanitation. Based on the preliminary studies and design, it seems unlikely that adverse impacts will escalate to heights that negatively affect the environment and the community. In adherence to both the EPA and World Bank best practices, the first response to address any negative impact is avoidance, in the case where avoidance is not an option, mitigation of the impact is next. Relocation is always the last option. The Project will have to ensure measures are in place to address avoid relocation as an option. Thank you!	Tolbert A. Kerkulah And Beageorge M. cooper

Name	Question	Response	Respondent
David N. Kollie	You talked about a special pipe that will absorb the water to control pollution. When we go Monrovia, we see all kinds of feces water running from pipes. My concern is how guaranteed is this pipe you are talking about?	For starters, all material to be used at site will have to meet international standards. So it has be made of long lasting materials. The pipes are different, in function and material, from the ones used in the public sewage systems.	Beageorge M. Cooper

Public Meeting – Environmental and Social Impact Assessment (ESIA) for Cheesmanburg Urban Sanitation Project

Meeting: (ESIA) for Cheesmanburg Urban Sanitation Project

Date: 10 November 2016

Venue: Vincent Town – Kle District – Bomi County

Summary:

A meeting was held between the community members of Vincent Town and the consultation team in to present and discuss the construction and operation of the Cheesemanburg Urban Sanitation Project. The discussion included a brief presentation of the project location and components as well as the probable environmental and social impacts that might arise from the project and the concerns and opinions that the communities might have regarding the project.

Presentation:

The consultation Team (Beageorge M. Cooper) introduced the project and provided a brief description of the project component and location and probable environmental and social impacts arising from project activities.

Attendants:

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Stakeholder Consultation Meeting

Environmental and Social Impact Assessment (ESIA) for Cheesmanburg Urban Sanitation Project

Meeting Venue: Vincent Town **Date:** 11/10/16

Attendance Sheet

№	Name	Town	Position	Phone No./Email	Signature
1.	S. Simeon Dukuly	Vincent Town	Town Chief	0770902026	[signature]
2.	P. Dennis KAI	Vincent Town	Youth Leader	0770589665	[signature]
3.	J. ANDREW DORLEY	VINCENT TOWN	CHC Chairman	0776881562	[signature]
4.	Boakai Sambullah	Vincent Town	Development Chairman	0770754512	[signature]
5.	Abraham Kroah	Vincent Town	IMAM	0775115025	[signature]
6.	Nathaniel G. Sumo	Vincent Town	Resident	0888413629	[signature]
7.	ADDU ESAU	Vincent Town	—	—	A. E
8.	Tete Cooper	Vincent Town	—	—	T. C
9.	Ben de Kai	Vincent Town	—	0886769672	BK
10.	Clarence Cooper	Vincent Town	Principal	0770775074	[signature]

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earthtime

№	Name	Town	Position	Phone No./Email	Signature
11.	Musco Vincent	Vincent Town	member	0770358058	M.V.
12.	Weah Koomah	Vincent Town	"	0 ——	KK
13.	Elizebeth Flomo	Vincent Town	"	——	E.F
14.	Fatu parker	Vincent Town	Teacher	——	L.T.
15.	Fatu Jabalo	Vincent Town	School cook	——	F.J.
16.	Mamie Smith	Vincent Town	member	0880226343	M.S.
17.	Rebeca Philip	Vincent Town	member	——	R.P
18.	Teta Boimah	Vincent Town	member	——	T. Boimah
19.	Bendu Quaye	Vincent Town	member	——	B Quaye
20.	Kamah Vincent	Vincent Town	Elder	——	K.V.
21.	Joseph Dolo	Vincent Town	Member	0770632158	[illegible]
22.	Boysah Deno	Vincent Town	youth	0775000916	[illegible]
23.	musa moris	Vincent Town	Youth	——	M-M
24.	Ruth Dukuly	Vincent Town	Student	0770147723	R.D

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No	Name	Town	Position	Phone No./Email	Signature
11.	Jumah Johnson	Vincent Town	Elder	—	J.J
12.	Musu Kai	Vincent Town	youth	—	M.Kai
13.	Sando Wolobah	Vincent Town	Elder	—	S.Wolobah
14.	Kona McGee	Vincent Town	Youth	—	K.A.F.
15.	Zoe Donley	Vincent Town	youth	—	Z.Donley
16.	Noah Vincent	Vincent Town	member	—	N.Vincent
17.	Konah B. morris	Vincent Town	youth	—	Konah
18.	Paye Grey	Vincent Town	Student	—	P.G
19.	Miatta Shaman	Vincent Town	Student	0770513988	M.S
20.	Massa Dukuly	Vincent Town	Student	077041009	M.D
21.	Annie Sambullah	Vincent Town	member	—	A.S
22.	Beatrice Kollie	Vincent Town	youth	—	BK
23.	Senebue Samay	Vincent Town	Youth	0770794433	SS
24.	Omar Barry	Vincent Town	Student	—	[illegible]

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earthtime

№	Name	Town	Position	Phone No./Email	Signature
11.	Massa Dagoseh	Vincent Town	youth	—	[illegible]
12.	Kula Musa	Vincent	Member	—	KM
13.	Samuel Toe	Vincent Town	Elder	—	Saafa
14.	Sunnah Duo	Vincent Town	Member	~~0776622~~085	
15.	Esther Duo	Vincent Town	Member	0776622085	
16.					
17.					
18.					
19.					
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24.					

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Questions and Concerns Session:

The purpose of this section is to focus on the questions, concerns and comments on the different aspects of the project that were discussed in the meeting.

The following questions were raised and discussed during the meeting:

Name	Question	Response	Respondent
Abraham Kromah (Imam-Vincent Town)	You did speak about the water or leachate that is drained to the bottom of cell and how it will be drained into a pit. How will it be kept to avoid more health problems?	The leachate collection pit will be treated routinely and the water could either be recycled to be used for the cleaning of the garbage sorting room, used for flushing of toilets or properly treat and dispose of.	Beageorge M. Cooper
Clarence Cooper (Principal – Vincent Public School)	We understand that this process is all about informing us on all the details about the project and how you all of the impacts will be eliminated. We welcome you and hope the Project is a benefit to us.	Thanks for welcoming the Project to your community.	Beageorge M. Cooper
Sayon M. Dukuly (Town Chief – Vincent Town)	When it comes to this dirt business, it has lot of contaminations. It creates lot of germs and health hazard. Will there be safety measures put in place for workers? Will the facility be built after or before the dumping of waste begins?	It is my understanding that this project is committed to the community and safety is at the forefront of its operations. There will be training conducted for workers and adherence to operational mandates will be enforced. We will make sure that all measures are put in place for workers to adhere to the safety rules. The facility will have to be build and commissioned before the transfer of garbage begins.	Beageorge M. Cooper
Nathaniel J. Sumo	I want to know whether Vincent Town is one of the dumping sites.	No! The Town is far from the site. It's just part of our work to inform you about this project.	Beageorge M. Cooper

Name	Question	Response	Respondent
E. Dennis Kai (Youth Chairman – Vincent Town)	In the past few years, we had a bad experience with Beer factory. The company was openly dumping its waste close to the communities and this led to a pollution eventually resulting in health hazards. Eventually the EPA worked with other the company and relocated their waste sites. So, I would like to know if the chemicals used at the site will not lead to health hazards and affect our people, source of food, water and the environment.	Given that this project has to be approved by the World Bank & EPA, it is safe to confidently say that all chemical, inputs and materials used will meet international standards that are likely to generate minimum or no impact to the environment and communities.	Beageorge M. Cooper