West African Power Pool

ESIA Report

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WEST AFRICAN POWER POOL (WAPP)
Benin

Mount Coffee HPP ESIA and RAP

Environmental and Social Impact Assessment and Resettlement Action Plan

for the Rehabilitation of the

64 MW Mount Coffee Hydropower Plant, Liberia

PÖYRY

The Technical Assistance operation is financed under the EU Africa Infrastructure Trust Fund

Access to transport and communication services, water and energy is at the heart of reducing poverty and achieving sustainable economic growth. Europe and Africa are working together to bridge Africa's infrastructure deficit. The EU-Africa Infrastructure Trust Fund, an instrument of the EU-African Partnership on Infrastructure, supports this objective. The fund is a financial mechanism blending grants from EU donors and financiers catalyzing investments in regional infrastructure to foster wider African development

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PÖYRY
Engineering balanced sustainability℠

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LIST OF ACRONYMS AND ABBREVIATIONS

$AlSO_4$	aluminium sulphate
ANC	Antenatal Clinic
ARV	Anti-Retrovirus
BCG	Bacillus Calmette and Guerin
CaOH	hydrated lime
CBD	Convention on Biodiversity
CEO	Chief Executive Officer
CH_4	Methane
CHT	County Health Teams
CIA	Cumulative Impact Assessment
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CR	Critically Endangered
CRAES	Chinese Research Academy of Environmental Sciences
d/s	downstream
DDT	Dichlorodiphenyltrichloroethane
DH	District Hospital
DPT	diphtheria, pertussis and tetanus
EHS/ EH&S	Environment Health and Safety
EIB	European Investment Bank
EMMP	Environmental Monitoring and Management Plan
EMP	Environmental Management Plan
EN	Endangered
EPA	Environmental Protection Agency
ESIA	Environmental and Social Impact Assessment

ESMP	Environment and Social Management Plan
EU	European Union
EWE	Electrowatt Engineering
EWI	Elekrtowatt Ingenieure
FDA	Forestry Development Authority
FSL	Full supply level
GCLM	Regional Fisheries Development Institution
GHG	Green House Gas
GO	Governmental Organisations
GOL	Government of Liberia
GSM	Global System for Mobile Communications
H_2S	Hydrogen sulphide
HBP	High Blood Pressure
HC	Health Centre
HEP	Hydroelectric Plant
HH	Household
HIV/AIDS	Human Immunodeficiency Virus/ Acquired Immune Deficiency Syndrome
HPP	Hydropower Project
ICCPR	International Covenant on Civil and Political Rights
ICESCR	International Covenant on Economic, Social and Cultural Rights
ICOLD	International Committee of Large Dams
IESS	Initial Environmental and Social Screening
IHA	International Hydropower Association
ILO	International Labour Organization
ITN	insecticide-treated net
IUCN	International Union for Conservation of Nature

JFK	John Fitzgerald Kennedy
KIS	Key Informant Survey
LAIR	Livelihood Augmentation and Income Restoration
LD	Liberian Dollar
LEC	Liberia Electricity Corporation
LESSP	Liberia Energy Sector Support Program
LHS	Liberia Hydrological Service
LWSC	Liberia Water and Sewage Corporation
M	Million
m asl	meters above sea level
MC	Mount Coffee
MCP	Malaria Control Program
MDG	Millennium Development Goal
MFA	Ministry of Foreign Affairs
MFIs	Multilateral Financial Institutions
MHSW	Ministry of Health and Social Welfare
MLM&E	Ministry of Lands, Mines and Energy
MOA	Ministry of Agriculture
MOC	Ministry of Commerce
MoHSW	Ministry of Health and Social Welfare
MOJ	Ministry of Justice
MOL	Minimum operation level
MPEA	Ministry of Planning and Economic Affairs
MPW	Ministry of Public Works
Mt.	Mount
MW	Mega Watt

Nb	Number
NBSAP	National Biodiversity Action Plan
NGO	Non-Governmental Organisation
NIP	National Implementation Plan
NPFL	National Patriotic Front of Liberia
NT	Near Threatened
NTFP	Non-Timber Forest Products
OHTC	Over Head Travelling Crane
OHTL	Over Head Transmission Line
O_2	Oxygen
OiC	Officer in Charge
PAP	Project affected person
PHC	Primary Health Care
PHCU	Primary Health Care unit
PMTCT	Prevention of Mother-to-Child Transmission
PoE	Panel of Experts
POP	Persistent Organic Pollutants
PRA	Participatory Rural Appraisal
Q	Discharge
RAP	Resettlement Action Plan
RCC	roller-compacted concrete dam
RIP	Resettlement Implementation Plan
ROR	Run-of-River
ROW	Right-of-Way
RPF	Resettlement Policy Framework
SAG	Social Assessment Guidelines

SEA	Strategic Environmental Assessment
SES	Socioeconomic Subgroup
STD/STI	Sexually Transmitted Diseases / Infections
TB	Tuberculosis
TOR	Terms of Reference
TV	Television
u/s	upstream
UDHR	Universal Declaration of Human Rights
UNDP	United Nations Development Programme
UNEP	United Nations Environmental Program
USGS	U.S. Geological Survey
v	volunteer
VU	Vulnerable
WAPP	West African Power Pool
WB Ops	World Bank Operational Policies
WCD	World Commission on Dams
WHO	World Health Organization

EXECUTIVE SUMMARY

The present document is the ESIA Report for the Mt. Coffee HPP. It is based on the Scoping Report, which was submitted to the Client and the authorities in charge of the ESIA process in February 2012, and accepted by EPA in its letter dated May 1, 2012.

Based on the preliminary evaluation and assessment in the Scoping Report, extensive field work was carried out in the meantime on all subjects identified as relevant, i.e. as subject to certain or probable environmental impacts caused by the Project. As required for any environmental and social impact assessment, the following main steps were carried out for all these topics:

- Description of the present situation, i.e. the situation without project.
- Identification of project impacts, classified according to their importance and probability of manifestation; obviously, positive as well as negative effects had to be identified. In specific cases, a rather extensive analysis was also required in order to demonstrate that the Project will cause no or only a very marginal impact.
- Identification of mitigation measures, where the anticipated impacts require such measures. In the case of negative impacts, the aim here was, as always, to avoid the impact, to minimise it to an acceptable level or to provide compensation where avoidance and minimisation was not possible.

The Report follows the structure which was proposed in the Inception Report and which was then also used for the Scoping Report. There is an Annex to each main Chapter, which provides supporting material to the topic treated in the respective chapter, if any. This structure was chosen for ease of reference. The Executive Summary follows the structure of the Report.

The legal and administrative framework is described in Chapter 2. Relevant legal texts and applicable standards can be grouped in three categories as follows:

- Laws on environmental protection and, mainly, procedure for preparation of an EIA.
- Laws on resettlement; there is no resettlement law in Liberia, but the constitution and other Liberian laws provide a basis for resettlement and compensation.
- Applicable international guidelines and standards. World Bank Operational Policies are the most important ones, and their relevance is analysed shortly; other relevant guidelines and standards, like those of the African Development Bank, are addressed as well.

The chapter also mentions the institutional setup for the ESIA process, which is guided by the EPA (Environmental Protection Agency).

Chapter 3 describes the Project and its relevant parts. Basis for the description of the project is the daft feasibility study submitted by Stanley Consultants in February 2012. Some additional detail information on the project was derived from this study, while the main parameters have not changed in comparison to the earlier studies.

The Mount Coffee Hydropower Project (MC HPP) is located on the St Paul River about 25 km upstream of Monrovia and 3 to 4 km west of Arthington town. The St Paul River has a length of about 500 km and originates as Diani River in south-eastern Guinea. It flows in a south-westerly direction through Liberia and empties into the Atlantic Ocean.

The Mt. Coffee HPP is the lowermost Hydropower Plant of the planned development on the St Paul River Cascade. It is will include four units (Francis turbines), with a nominal installed capacity of 66 MW in the existing Mt Coffee Powerhouse. The main dam has a height of 22.9 m; the spillway is 18.3 m high and will be equipped with 10 tainter gates. Furthermore, three zoned, earthen forebay dams are located near the powerhouse and serve to retain water in these low areas. These forebay dams have a top elevation of 31.1 m. The reservoir which will form behind the dams will have a surface area of 8.1 km^2 at a full supply level of 29.08 m asl.

The substation will be constructed on the foundation of the previous one and will be energized at 66 kV with a clearance established for 115 kV (all equipment will be sized for 115 kV). The transmission line from Mt. Coffee HPP to Bushrod, with a length of approximately 24.8 km, will be completely reconstructed. The current 30.5 m right-of-way can accommodate either a single circuit 230 kV line or a double circuit 115 kV line. In addition to the reconstruction of the old transmission line a new one is planned for the future additional generation at Mt. Coffee, for added capacity and enhanced reliability of the tie to Monrovia. The new line will operate at 69 kV initially and be constructed to allow it to be energized at 115 kV.

The 25 km long access roads (access is possible on both banks of St. Paul river) from Monrovia to Mt Coffee HPP will have to be partly refurbished.

Since the study also includes an evaluation of impacts of the entire St. Paul River cascade, a short description of this cascade is also given in this chapter.

Chapter 4 describes the study area. The most important parts are:

- The reservoir area, i.e. the area which will be submerged during the filling phase of the reservoir; it should be noted that in the case of Mt. Coffee HPP, this will be a re-impoundment, since the reservoir already existed before the breaching of the dam 20 years ago.
- The construction site, i.e. the site where most of the work related activities take place; this area needs to be considered specifically for impacts related to construction activities; however, at this point in time there is a yet no detailed layout of the construction site available.
- The downstream area, whereby this will have to be considered as far as effects of the project on river discharge may reach, for certain aspects right down to the estuary.

Chapter 5 provides a short overview of impacts which are usually associated with or caused by a hydropower project. This serves as a basis for understanding the topics dealt with in the following sections of the Report. First comments on impacts to be expected specifically from Mt. Coffee HPP rehabilitation are also provided here.

Chapter 6 deals with the geology of the project area and with project effects caused by or related to the Project. While geology is important from a technical point of view, it is not of any major relevance from an environmental point of view, especially since in the case of Mt. Coffee HPP there is no risk of landslides triggered by the reservoir, nor are there other issues related to geology.

In Chapter 7, a short description of climatic conditions of the project area is given. The main point here is the very strong seasonality of rainfalls. While large reservoirs (in the order of magnitude of several hundred km² can have effects on the local climate, Mt. Coffee Reservoir is by far too small for having such an effect.

Chapter 8 addresses the issue of water. The seasonal variation of rainfall is reflected in the very large seasonal variation of river discharge, which, as a monthly average, varies between 1'600 m³/s in September and 108 in March, with an annual mean of 564 m³/s; variation between extreme values is still much larger. The power plant will basically be operated as a run-of-river (ROR) structure, with a very limited potential for load following during dry season, and with a basically constant reservoir level. During almost half of the year, the amount of water flowing into the reservoir will be more than the capacity of the four turbines, and during this time the surplus water will be spilled. During the driest months, there will be on average 4 days per year where the amount of water is even not sufficient for operating one turbine at the technically possible minimal output. The reservoir is not large enough as to provide storage for compensating these seasonal fluctuations. For this reason, water discharge downstream of the power house will be influenced only very marginally, and only during the driest part of the year. However, since during half of the year there will be no spilling, a residual flow will have to be released from the main dam in order to keep the roughly 4 km of river between dam and tailrace channel outlet functional. Given the absence of a legal basis for determining this residual flow, and considering the conditions of the river, an amount of 8 m³/s is recommended. It is also recommended to evaluate the possibility for installing a small unit at the dam site which would allow to pass this amount of water through a turbine, in order to minimise the loss in energy production and the economic loss, and to create a possibility for local rural electrification.

Water quality in the river at present is good, without signs of a considerable charge of pollutants; this might change in case the Bong Mines would be reactivated. In this case, appropriate measures would have to be taken at the mines to prevent water pollution from this source. Small scale artisanal gold mining upstream of the dam presents a risk of water contamination with mercury; although the available water quality data do not indicate such a contamination, mercury will have to be included in the water quality monitoring programs. Presently, the only value which is not within drinking water standards is the biological one (*Escherichia coli*), indicating a contamination of the river with domestic waste water.

The submerging of a large amount of biomass (vegetation) can lead to water quality problems and, in extreme cases, to massive greenhouse gas emissions from the reservoir. However, the amount of water flowing through the reservoir in relation to reservoir volume, with an average turnover time of 2 days, will not allow the development of such a situation. Still in order to reduce the risk of water quality problems especially also in the downstream area, to create suitable conditions for fisheries in the reservoir, and for making use of timber and fuel wood (for charcoal production) as valuable resources, a pre-impoundment clearing of the reservoir area is recommended.

Chapters 9 to 11 deal with issues related to biodiversity (vegetation and flora, terrestrial fauna, fish). A short description of the situation in Liberia, especially regarding rare and endangered species, is provided. Vegetation of the reservoir area was identified as potentially important issue, and was analysed and described in detail. No rare or endangered species, and no especially valuable habitats, were identified in the reservoir area. This is easily understandable, since there was a reservoir until 20 years ago, and the vegetation is a secondary forest or fallow area type of vegetation, a type which is very frequent in the entire area and beyond. Considerable parts of the reservoir area are also cultivated. No specific mitigation measures, except for the pre-impoundment clearing and a general restriction for using additional areas during the construction period (in addition to the really required ones), are required. Nevertheless, in the interest of a sustainable development of the area, and for reducing pressure on remaining forests, it is recommended to evaluate the need for and possibility of local development programs, like e.g. the plantation of fast growing trees for charcoal production.

As for the vegetation, no important populations of any rare, protected or vulnerable species of terrestrial fauna (mammals, birds, reptiles and amphibia) were recorded. Hunting is an important activity of the local population, mainly for getting meat for own consumption. The main hunted species is the grass cutter or cane rat. The only impact on local fauna of some importance could occur during reservoir impoundment, where some species might be trapped on islands forming temporarily, and then drown. Reservoir area clearing could also minimise this impact, since this activity would drive most animals out of the area before the water rises. The loss of habitat as such due to the formation of the reservoir is not considered as relevant.

The fish fauna in St. Paul river is rather diversified, with 92 species recorded so far. 42 species could be identified during the study. The following species are the dominant in the project area: *Labeo sp.* (rock fish), *Barbus sp* (horse fish) and *Tilapia sp.* in dry season, then *Hydrocynus sp* (leopard fish), *Gymnarchus sp* (plain fish), and *Chrisichthys sp.* (white catfish) during the rainy season. Brackish water species as *Machrobrahium sp.* and *Cynoglossus sp.* are observed downstream of the studied area. Brackish water species as *Machrobrahium sp.* and *Cynoglossus sp.* are observed downstream of the studied area.

Nearly all people living in the vicinity of Mount Coffee hydropower do at least some fishing as a complementary activity to agriculture which is the main occupation in the area. A total of 566 fishers including 500 household heads (out of about 3000 inhabitants) could be inventoried. One third of the fishers are women. Most fishermen are adults (82% are above 30 years old). Total yearly fish production resulting from fishing activity in the Mount Coffee area is estimated at 972 tons, generating a market chain amounting to 150'000 USD/year. Home consumption in fishermen household is estimated at 25%. Local fisheries consistently contribute to the nutritional equilibrium of populations, with a strong presence of women in processing and commercialization. Smoked fish constitutes 20% of sales in average, with higher amounts in upstream part of Mount Coffee (35%). Fishing activities are done all year round, with peaks in January-April. Women are directly involved in fishing activity mostly in the middle of the dry season (February-March), using hand nets and baskets in drying pools. The state of the fisheries is currently not overexploited, even if training in sustainable management is necessary to prevent destructive fishing gears. Fish farming is marginally practiced in Bensonville area, and the potential of this activity is very high given different good sites, and the availability of the national aquaculture station at Klay. Interviews of old fishermen who were in activity prior dam breakage said that the situation with reservoir functioning from 1970 and 1990 have provided more fish to the population than currently, and the refection is positively awaited by all fishers.

The rehabilitation of the dam and the re-creation of the reservoir will change the situation. As is known form many other examples of man-made lakes, diversity will locally decrease, given the fact that a number of fish species adapted to or depending on river conditions will disappear from the reservoir area (increase of species such as tilapia and African catfishes and decrease of species like *Barbus sp., Labeo sp.*). On the other hand, the reservoir itself will have a high productivity, since a limited number of species will find suitable conditions there. Fish catches will therefore increase. A surge in fish productivity could also attract fishermen from other areas. With the dam rehabilitated, annual potential production estimates stands at 1,340 tons that is 1.4 times current production. This increase, if well managed may generate, in addition of new fishers (30 professional fishermen may find full occupation within the reservoir), many side jobs with fishing gears manufacture, fish transformation and commercialization. In order to be able to observe the development, and to introduce, if required, a proper fisheries management program in the reservoir, it is recommended to carry out a thorough fish monitoring program in cooperation with the Fishery Bureau throughout the construction period, and well into the operation phase of the power plant.

The topic of Chapter 12, impact on protected areas, is also related to biodiversity issues. Protected areas of Liberia are indicated. No such area will be affected by Mt. Coffee HPP.

The next main section of the report deals with the human environment of the area. A short and, at this point in time, still rather preliminary description of the situation is provided. This will then be expanded in the RAP.

A number of settlements are located in the wider project area. During the initial phase of work on the ESIA, it was assumed that only very few, if any, resettlement (in the sense of actual physical relocation of houses and their inhabitants) would be required, since the area had been under water until 20 years ago. On the other hand, it was quite obvious from the beginning that cultivated land would be affected. This second point was confirmed during field work. However, field work also revealed the presence of a number of settlements within the area to be submerged, and obviously these will have to be relocated before impoundment. In part, these are people who lived in these sites before the construction of the original Mt. Coffee dam, were then resettled and subsequently moved back to their original village location after the breaching of the dam. So far, the presence of 107 HH with a total of 382 persons in 6 settlements has been identified to be in this situation. Obviously, they also have all or part of their fields within the area to be submerged. In addition, HH from surrounding villages also cultivate land in this area. Overall, it can be said that resettlement and compensation will be required, however, that it is not a very big issue due to the limited number of affected people. The aspects of local human population and land use are described in Chapters 13 and 14. The details of this will be dealt with in the RAP, which will have to be developed as a separate document.

However, one major problem has been identified during the field work: given the local topography, consisting of rather smooth, albeit partly quite marked hills covered with high an dense vegetation make it difficult, not to say impossible, to determine in the field exactly what will be within the reservoir and what will not. GPS localisation was used, but this is not precise enough in terms of elevation. Therefore, it is strongly recommended that LEC carries out a topographical survey with the aim of clearly marking in the field the elevation of the future reservoir; an elevation of 30 m asl is recommended, to provide a safety margin for flood situations. These marks would also be required for reservoir area clearing, mainly to prevent the clearing of vegetation above the future reservoir level.

Infrastructure in the project area (Chapter 15) is rather basic, and will not be affected by the project; on the other hand, one main component of infrastructure, namely the access roads to the area, will have to be improved for the construction of Mt. Coffee HPP, and the local population will also benefit from this improvement.

One area of special concern is water supply, and not only on a local level. The most important (if not the only) drinking water treatment plant, supplying drinking water to the Monrovia area, is located some km downstream of the dam site (Chapter 16). When the original Mt. Coffee HPP was in operation, a pipe line carried water from the reservoir to the White Plains water treatment plant. Presently, this pipe line is no longer in working order, and the treatment plant has an intake directly from the river at the location of the plant itself. Since this intake is located barely above sea level, there is a risk of salt water intrusion during high tides in the dry season, when river discharge is minimal. This risk has been minimised, if not excluded, by the construction of a low weir made from rocks across the river a short way downstream of the intake. As mentioned above, Mt. Coffee HPP will have a very marginal effect on d/s river discharge. The risk of salt water intrusion under these conditions is small. Still, the possibility of rehabilitating the pipe line for securing water supply for the plant directly from the reservoir should be evaluated.

Aspects of human health are discussed in Chapter 17. This focuses mainly on two issues, namely, on health infrastructure, which is not well developed, and water borne and water related diseases, which play a major role in the area. Health infrastructure might be influenced in a positive way by the project, if health services to be provided for the work force will also be made available to the local population. The effects on water borne diseases are expected to be different depending on disease and on their vectors. River blindness might decrease when flowing water is transformed to stagnant water (reservoir). On the other hand, this might increase the risk for higher incidence of schistosomiasis, and also of malaria, which already now is the main health problem in the area. Appropriate measures will have to be taken to monitor this development and to define the required actions. An additional heath issue could arise due to the influx of workers from outside into the project area; this includes, among others, the risk of an increase in HIV/AIDS; here, a carefully planned and implemented program for awareness rising, prevention and treatment will be essential.

The topic of cultural heritage is mentioned briefly in Chapter 18. There are some graves within the reservoir area which will have to be relocated. No indications on any other sites or objects of cultural, historical or archaeological importance were encountered.

The last part of the report provides a synthesis of the main findings of the report.

Chapter 19 describes in detail the identified impacts, the relevant of which were discussed shortly above. Impact identification is done by means of a matrix, which provides an overview of the main structures and project related activities and the impacts they cause. While impacts obviously will arise, the overall conclusion, however, is that there are no impacts which would have to be qualified as strongly negative. Mitigation is possible for all identified impacts for which mitigation is required. These mitigation measures are summarised in Chapter 20, while Chapter 21 provides a provisional environmental and social management plan (ESMP). This plan also outlines organisation and structures required for the implementation of the plan. It is important to see that the project proponent as well as the contractor(s) will have to develop their own specific ESMPs, and will need to have the required organisation on site, since the most sensitive phase it the construction period.

Chapter 22 describes very shortly the resettlement plan; this is work still under way. Public participation (Chapter 23) is an on-going process, which will go into its next decisive phase as soon as this report will have been accepted and will be presented to the affected population.

The next chapters deal with a number of specific projects related issues. Project alternatives are discussed in Chapter 24. The main alternative to using hydropower would be to continue and expand the use of fuel oil for producing electricity. This is not a sustainable solution, neither from an economic (high costs) nor from an environmental (air pollution, GHG emissions) point of view. Concerning dam site or main dimensions of the scheme here are no real alternatives to Mt. Coffee HPP as planned; the "no project" case is not considered as a valid alternative for the country. Alternative engineering design (e.g. roller compacted concrete instead of an earthfill dam are not of relevance from an environmental and social point of view. There is a possibility to increase installed capacity from 66 to 80 MW. This would cause a minor change in downstream flow conditions (less spilling, since more water would pass through the turbines); this change would not have any relevant negative impact.

An economic evaluation of the project was also carried out as part of the ESIA (Chapter 25). For this purpose the latest information and reports were collected in Liberia, documenting the conditions prevailing in the power market of Liberia and the main features of the Mount Coffee Hydropower Plant Rehabilitation Project. The review of the collected material showed that Liberia is in an urgent need for electricity. Under these circumstances and taking into account that the implementation of the Mount Coffee Hydropower Plant Rehabilitation will take four to five years, one can expect that within a short period of time the complete production of Mount Coffee Hydropower Plant can be absorbed by the consumers of Liberia.

The various possible other options to supply the growing need for electricity were identified and compared. Mount Coffee Hydropower Plant and HFO thermal power plant turned out to be the most promising options. To perform the economic analysis updated information (end of February 2012) on the Mount Coffee Hydropower Plant Rehabilitation Project could be obtained. Especially relevant were the mean annual energy production and the construction cost. The value of the energy generated by Mount Coffee Hydropower Plant was taken as equal to the unit cost of electricity produced by a HFO thermal plant. The economic analysis was performed for the Base Case with a discount rate of 10% and for various Sensitivity Cases. For the sensitivity analysis, discount rates of 12% and 8% were used, the construction cost increased by 25% and the fuel cost (HFO) raised also by 25%. For all the cases studied, the Net Present Value (NPV) was always significantly higher than zero. The Economic Internal Rate of Return (EIRR) was higher than 17% and the unit cost of the generated electricity, below 9.5 US cents per kWh.

Under these circumstances Mount Coffee Hydropower Plant Rehabilitation Project is surely economically a very attractive option for the supply of electricity to the Greater

Monrovia area. This conclusion is in line with the ones drawn in the reviewed previous studies.

Issues related to the emergency case of a dam break (Chapter 26) and to plant decommissioning (Chapter 27) are also discussed briefly. Finally, Chapter 28 is a Cumulative Impact Assessment of the entire St. Paul river cascade. This cascade would consist in three additional dams upstream of Mt. Coffee, one of which, Via, would include the creation of a very large reservoir capable of providing seasonal storage for the entire cascade. The potential effects of this, directly on river discharge pattern, which would have positive as well as negative consequences, are discussed.

Overall, it can be said that the negative impacts of Mt. Coffee HPP will be rather limited and are well manageable (Chapter 28). The positive effects, mainly through power generation, prevail, this obviously also under the condition that the presently very deficient transmission and distribution system will be rehabilitated and/or expanded. The Project is also largely in compliance with WCD guidelines, as far as these are applicable to the Project.

PART A BASELINES

1 INTRODUCTION

1.1 The Assignment

With a letter dated November 10, 2011, WAPP General Secretariat, Cotonou, Bénin, mandated Pöyry Energy Ltd., Zurich, Switzerland with the preparation of the

Environmental and Social Impact Assessment and Resettlement Action Plan

for the project of rehabilitation of the

64 MW Mount Coffee Hydropower Plant, Liberia.

The effective date of the Contract was defined as the date of this letter, November 10, 2011. The Consultant arrived in Monrovia on November 13, 2011.

According to this contract, Pöyry Energy Ltd., on behalf of WAPP and LEC, will prepare a full ESIA and ESMP for the Project. The ESIA and ESMP will follow the requirements of Environment Protection and Management Law of Liberia (Section 8), dated November 26, 2002 and the Republic of Liberia Environmental Protection Agency Environmental Impact Assessment Procedural Guidelines as well as applicable International Standards. The main applicable international standards for the Mt. Coffee HPP ESIA are the Operational Policies (OPs) of the World Bank (WB; see Chapter 2.4). The Terms of Reference for this assignment are presented in Annex 1.1.

Work on the assignment officially started with the kick-off meeting held in LEC's premises on November 14, 2011.

1.2 Scope of the Report

This is the ESIA Report for Mt. Coffee HPP. The main aims of this Report are:

- To provide a description of the Project.
- To provide the baseline, i.e. a description of the prevailing environmental and socio-economic situation of the project area, on the basis of the original TOR and, where applicable, on the precision made in the Scoping Report of March 2012.
- To identify all relevant impacts of the Project on the environment and the human population of the project area.
- To identify and describe the required mitigation measures.
- To prepare a Draft Environmental and Social Management Plan; this will then by finalised in a later stage of the assignment, taking into account the observations from the involved parties.
- To come to an overall conclusion on environmental and social acceptability of the Project.

According to the TOR, the ESIA also has to evaluate, in the form of a CIA and to the extent possible with the available information, the cumulative impacts of the entire St.

Paul river hydropower cascade, which is planned to ultimately consist in a cascade of four dams, of which Mt. Coffee is the lowermost and at the same time the smallest. This analysis is presented in Chapter 27.

1.3 The Team

The members of the Consultant's team involved in report preparation are listed in Annex 1.2.

2 LEGAL AND ADMINISTRATIVE FRAMEWORK

2.1 Environmental Legislation

First of all, like in any case of an ESIA, this has to be established according to the relevant national legislation (laws, decrees, procedures, standards).

The most relevant document in this respect is the

- Environmental Impact Assessment Procedural Guideline (EPA 2006).

  This document describes in detail the procedure to be followed for preparing an EIA in Liberia. Following steps have to be followed:

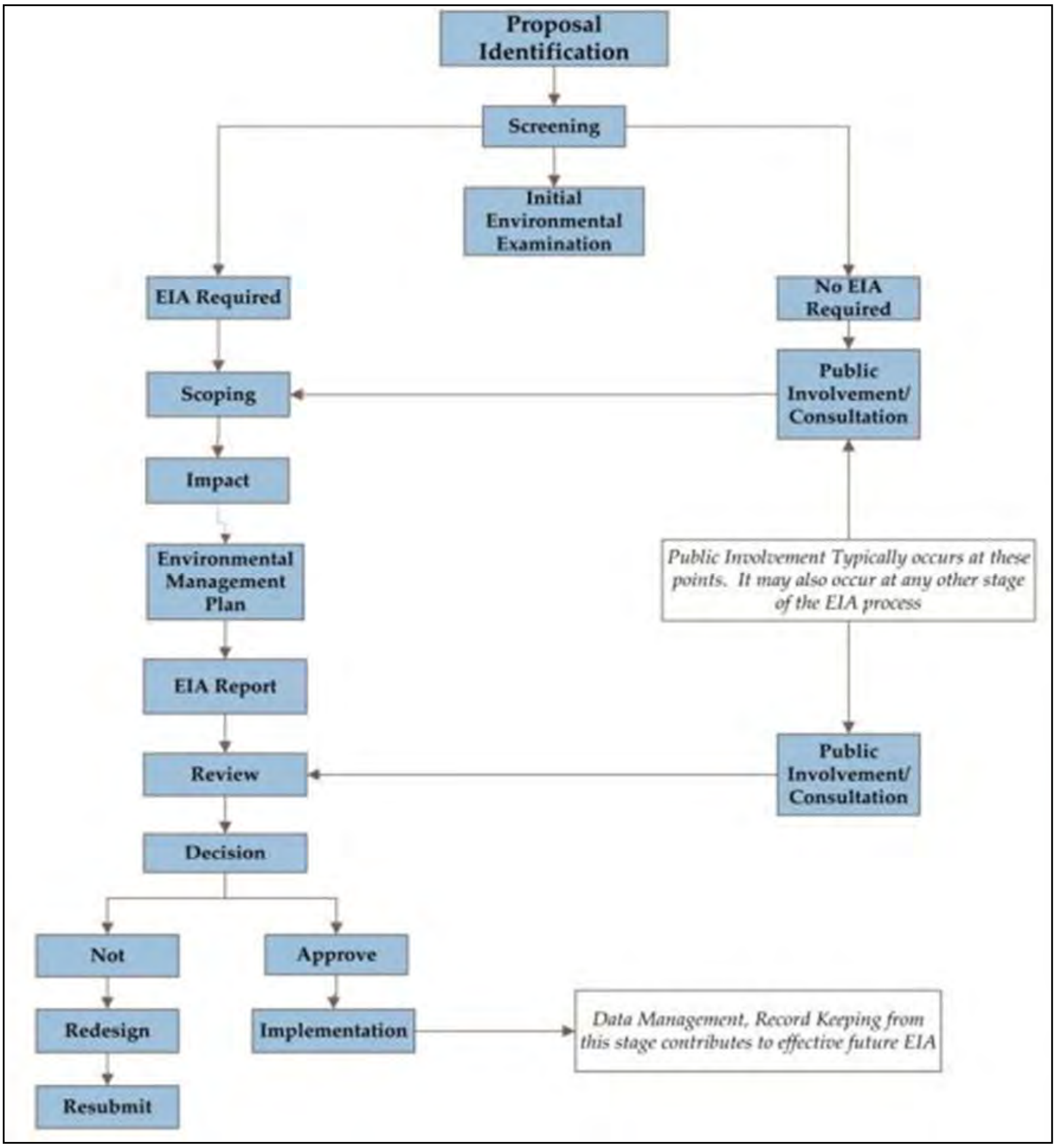


Figure 2-1: EIA process in Liberia.

Further relevant Liberian environmental legislation concerning Environmental Impact Assessments are:

- The Environment Protection Agency (EPA) Act, (EPA, 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, (EPA, 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, (EPA, 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.

Other relevant texts related to environment are listed in the Table below.

Table 2-1: Additional 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, 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 New Minerals and Mining Law	2000	The Law and its resulting policy call for restoration of land to its previous state as much as possible after mining activities. All medium to large-scale mining activities are to submit Environmental Impact statements. Environmental audits and periodic assessments will be undertaken to ensure compliance.
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.

2.2 Legislation on Resettlement and Expropriation

Resettlement, expropriation (legal situation): this will have to be evaluated in detail for the RAP. Liberia does not have an official Resettlement Policy. However, the following Liberian Legislation spells out how land can be acquired and also the rights of individuals to own property and be compensated for their losses:

- The Constitution of Liberia 1986
- Land Act 1856
- County Act 1969
- Land Acquisition Act 1929

2.2.1 The Constitution of Liberia 1986

Article 22 (a) and (b) of the Constitution vests in all individuals the right to own property either on individual basis or in conjunction with other individuals, as long as they are Liberian citizens. This right however does not extend to mineral resources on, or beneath the land.

2.2.2 Land Act 1856

Prior to independence, land acquisition and distribution was done on the basis of relationship and class system. Opposition to this system of land tenure led to the establishment of a set of rules known as the '*digest of law to govern the affairs of the settlers in terms of land distribution'*. This later culminated into the Land Distribution Act of 1856 which removed the restriction to land distribution based on citizenship. This Act was repealed by the 1950 Land Act which restricted land ownership to citizens and naturalized citizens especially those of Negro descents.

2.2.3 County Act 1969

This Act officially distributed and demarcated land boundaries in Liberia. Prior to the Act, counties were created through political means. For instance the three older counties in Liberia, Montserrado, Sinoe, and Maryland were all products of political events.

2.2.4 Land Acquisition Act 1929

The Act lays down the procedure for obtaining rights to any piece of land in Liberia through purchase. The Act distinguishes land in Liberia into two categories, namely: the Hinterland and the County areas.

The procedure for obtaining land located in the Hinterland is as follows:

- Obtain consent of Tribal Authority to have a parcel of land deeded to the individual by the Government,
- Pay a sum of money as a token of his intention to live peacefully with the tribesmen,
- Paramount or clan chief signs a certificate which the purchaser forwards to the office of the District Commissioner (who also acts as the Land Commissioner for the area),

- The District Commissioner after satisfying himself that the land is not encumbered (overcrowded) in any way approves that the land be deeded to the applicant and issues a certificate to that effect.

The procedure for obtaining land located in the County Area is as follows:

- Apply to the Land Commissioner in the county in which the land is located;
- The Commissioner shall issue a certificate if he is satisfied that the land is not encumbered.

Upon completion of the above steps, the purchase shall pay the Bureau of Revenues the value of the land valued at a minimum rate of 50 cents per acre (Land article 24 of the 1986 Constitution of Liberia). He shall obtain and submit a receipt to the President for an order to have the land surveyed. A deed will then be drawn up by the Land Commissioner, authenticated, and given to the purchaser.

2.2.5 Land Tenure in Liberia

Liberia has three kinds of land tenure and these are briefly described below. The tenure system is important as title to all land in the country is vested in the state.

Customary Tenure

Customary tenure involves the use of land which the government has granted to people in the hinterland through customary rights. Such rights begin with the Town Chief, then the Clan or Paramount Chief and lastly the District Commissioner. The District Commissioner prepares the Customary Land Grant Certificates, which are then legalised by the President of Liberia.

Freehold Tenure

Freehold tenure has its legality from the Constitution and its occurrences from the written law. It involves holding land in perpetuity or a term fixed by a condition and enables the holding to exercise, subject to the law, full powers of ownership.

Leasehold Tenure

This tenure is created either by contract or by operation of the law. It is a form under which the landlord or lessor grants the tenant or lessee exclusive right of the land, usually for a specific period in return for a rent, granting the tenant security of tenure and a proprietary interest in the land.

2.2.6 Land Valuation System

Title to all land vests in the state. Thus the government is the original grantor of land and the public are all grantees. One who obtains land from the state has a bona fide title and the right to full possession and use of the land. However, the state has the right to revoke any previously granted title. Before such power can be exercised, the state through its institutions is statutorily obliged to first evaluate the current market value of the property to be acquired with the aim of providing just compensation to the affected owner. Where the land to be revoked is in public use, the state has the burden of replacing it with one of commensurate value.

In the case of public land, section 31 of the 1986 Liberian Code provides the procedure for determining the cost as follows:

- One dollar per acre for land on the margin of a river
- Fifty cents per acre for land in the interior
- Thirty dollars per lot for town lots

2.2.7 Compensation

Article 24 of the 1986 Constitution of Liberia provides the basis for compensation for acquired land.

It states that, *"expropriation may be authorized for national security issues or where the public health and safety are endangered, or for any other public purposes, provided."*

For expropriation to be successful the following issues should be addressed:

- Prompt payment of just compensation;
- That such expropriation or the compensation offered may be challenged freely by the owner of the property in a court of law with no penalty for having such action; and
- That when property taken for public use ceases to be soused, republic shall accord the former owner the right of first refusal to reacquire the property.

2.3 Multilateral Environmental Agreements

The following Table provides the International Environmental Conventions, which have been signed/ratified by the Government of Liberia (GOL)

Table 2-2: International Environmental Conventions Signed/Ratified by the GOL.

Convention	Status	Year	Objectives
African Convention on Conservation of Nature and Natural Resources	Ratified	1978	• 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 greenhouse gas concentration 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 rising 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.
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 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 labour 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)

2.4 International Standards

The main applicable international standards for the Mt. Coffee HPP ESIA are the **Operational Policies (OPs) of the World Bank (WB)**. The following Table lists these standards and comments on whether or not they are applicable in the present case.

Table 2-3: Applicable World Bank Operational Policies (OPs)

OP No.	Title	Dated	Comments
4.01	Environmental Assessment	Jan. 1999	Applicable. The project is clearly of a type and size (Category A Project) which requires a full environmental assessment.
4.04	Natural Habitats	Jun. 2001	Applicable. Some natural habitats are affected directly (by submersion at filling of reservoir) and indirectly (by change in river discharge conditions).
4.09	Pest Management	Dec. 1998	Not applicable.
4.10	Indigenous Peoples	Jan. 2005	Not applicable. The population of the project area is not considered - and does not understand itself - as an ethnic minority.
4.11	Physical Cultural Resources	Jan. 2006	Potentially applicable. It will have to be checked whether any cultural (historical, archaeological) sites exist in the project area.
4.12	Involuntary Resettlement	Dec. 2001	Applicable. Provisions will have to be made for people living in the affected area, and for the loss of cultivated land; in this special case, these are people who moved into the reservoir area, and fields created in this area, after the breaching of the dam approximately 20 years ago.
4.36	Forests	Nov. 2002	Applicable. Some forest areas are affected by the project.
4.37	Safety of Dams	Oct. 2001	Applicable. Technical aspects of dam safety obviously are within the scope of the Technical Consultant.
7.50	Projects on International Waterways	June 2001	Not applicable. While St. Paul River originates in Guinea and is therefore an international river, Mt. Coffee HPP is located quite close to the estuary of the river, will in no way have an impact on the situation in Guinea.

Furthermore the **European Investment Bank's (EIB) Statement of Environment and Social Principle and Standards (2009)** and the Environmental and Social Practices Handbook (Version 2 of 2010) has to be taken into account. The EIB applies a set of environmental and social requirements throughout the project cycle.

In general the EIB refers to EU environmental law as the primary source of its environmental principles. The aims are, in accordance with EU policy on the environment, at a high level of protection based on the application of the precautionary principle, and on the principles that preventative action should be taken, that environmental damage should be rectified at source, and that the polluter should pay.

Just as environmental standards aim to protect and improve the natural and built environment, social standards aim to protect the rights and enhance the livelihoods of people directly and indirectly affected by projects financed by the EIB. Social standards are intended to promote outcomes to the benefit of individual well-being, social inclusion and sustainable communities. The project needs to respect human rights and needs to comply with EIB social standards, based on the principles of the Charter of the Fundamental Rights of the European Union and international good practices.

The approach to social matters needs to be based on the rights-based approach mainstreaming the principles of human rights law into practices through the application of its Social Assessment Guidelines (SAGs). These requirements are also consistent with the social safeguard measures developed and applied by those MFIs with whom the Bank works closely.

The social standards include involuntary resettlement, indigenous people and other vulnerable groups, the core labour standards of the International Labour Organization (ILO) and occupational and community health and safety and public participation.

In addition, the **African Development Bank Group's Policy on the Environment (February 2004)**, the Environmental and Social Assessment Procedures (2001) and the Policy on Involuntary Resettlement (2003) have been taken into account.

The Environmental Policy is based on the following main principles:

- A strong and diversified economy shall be recognized as a just means to enhance the capacity for environmental protection; however, all development-related decision-making processes shall integrate economic, social and environmental considerations.
- Environmental management tools, like environmental assessments, shall be used to ensure that economic activities are environmentally sustainable, and to systematically monitor their environmental performance.
- Community involvement in natural resource management decisions that affect the most marginalized and vulnerable groups shall be provided for, and the value of traditional knowledge shall be recognized and preserved.
- Transparency, accountability of governance structures and institutions, which are more responsive to the needs and priorities of affected communities in general, and poor people and vulnerable groups in particular, shall be encouraged.
- A coordinated approach to effective environmental interventions in the region shall be pursued by building partnerships with development partners, including other MDBs, bilateral organizations, UN agencies, research institutions and NGOs.

The purpose of the Environmental and Social Assessment Procedures (2001) is to improve decision-making and project results in order to ensure that Bank-financed projects, plans and programs are environmentally and socially sustainable as well as in line with Bank's policies and guidelines. At the project identification phase the project should be categorized into 4 different categories. Mt. Coffee is a category 1 project and needs therefore a full ESIA. The steps which have to be taken from the project identification up to the project completion including the responsibilities are described in the ESAP. Currently the African Development Bank is in the process of implementing an Integrated Safeguard System ISS. In addition, the ISS will contain a revised set of Environmental and Social Assessment Procedures (integrated Safeguard System Working Progress, March 2012) with a focus on following Operational Safeguards (OS):

- OS 1: Environmental and Social Assessment
- OS 2: Involuntary Resettlement: Land Acquisition, Population Displacement and Compensation.
- OS 3: Biodiversity and Ecosystem Services.
- OS 4: Pollution Prevention and Control, Greenhouse Gases, Hazardous Materials and Resource Efficiency.
- OS 5: Labour Conditions, Health and Safety.

In addition, where relevant, assessments have to consider cultural heritage and environmental flow.

The primary goal of the policy on involuntary resettlement is to ensure that displaced people are treated equitably, and that they share in the benefits of the project that involves their resettlement. The Objective is to ensure that the disruption of the livelihood of people in the project's area is minimized, ensure that the displaced persons receive resettlement assistance so as to improve their living standards, provide explicit guidance to Bank staff and to borrowers, and set up a mechanism for monitoring the performance of the resettlement programs. Most importantly, the resettlement plan (RP) should be prepared and based on a development approach that addresses issues of the livelihood and living standards of the displaced person as well as compensation for loss of assets, using a participatory approach at all stages of project design and implementation.

2.5 Institutional Setup

2.5.1 The EPA

The EPA (Environmental Protection Agency) is the national authority in charge of the ESIA process. The EPA was founded in 2003 (MFA 2003a). The EPA will receive the ESIA Report for checking and approval, and, once it will have approved the report, and defined the conditions under which it is approved, it will issue the Environmental Impact Assessment License.

The main functions of the EPA are:

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

2.5.2 Other Institutions Involved

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

2.5.2.1 Ministry of Lands, Mines and Energy

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.

2.5.2.2 Liberia Electricity Corporation (LEC)

The Liberia Electricity Corporation was created in 1973 to generate, transmit, distribute, and sell electricity throughout the country at reasonable rates. In July 2006, electricity was restored to parts of Monrovia for the first time in fifteen years.

2.5.2.3 Forestry Development Authority

The FDA is the body responsible for the protection, management and conservation of government-owned forests and wildlife on a sustainable basis. It manages commercial, conservation and community uses of Liberia's forests. It is the authority through which forestry policy, law and administration are provided. It provides permits for the commercial and non-commercial use of the forests. The 2006 Forestry Reform Law revised the institutional framework of the FDA and created a Department of Conservation which is made up of the Division of National Parks and the Division of Wildlife with the responsibility for development and management of protected areas and wildlife respectively.

2.5.2.4 Ministry of Planning and Economic Affairs

The Ministry of Planning and Economic Affairs (MPEA) responsible for intersectoral coordination for the development of policies, plans and programs for the economic, financial, social, cultural and physical development of Liberia. In fulfilling its various duties it serves as the direct link between implementing Ministries/Agencies, NGOs, private voluntary organizations, and the international community. Coordination occurs at the national, sectoral and regional planning levels and also involves the implementation of crosscutting initiatives.

3 THE PROJECT

3.1 The Project Site

The Republic of Liberia is a country in West Africa. The neighbouring countries are Sierra Leone to the west, Guinea to the north and Cote d'Ivoire to the east; to the south it is bordered by the Atlantic Ocean. Liberia covers an area of 111'369 km^2 and has an estimated number of 3.7 million inhabitants. Liberia is divided into 15 counties, which are further subdivided into districts and then into clans. The assigned project is sited within the Montserrado County and there within the Careysburg District. The main ethnic groups within the Careysburg District are Kpelle, Bassa, Mano, Kissi, Loma and Gola.

Figure 3-1: Map of Liberia and the Counties

The Mount Coffee Hydropower Project (in this report sometimes referred to as MC HPP) is located on the St. Paul River about 25 km upstream of Monrovia and 3 to 4 km west of Arthington town. The St. Paul River has a length of about 500 km and originates as Diani River in south-eastern Guinea. It flows in a south-westerly direction through Liberia and empties into the Atlantic Ocean. The estuary of the St. Paul River is located at Cape Mesurado in Monrovia, separating Monrovia from its suburb Brewerville.

Figure 3-2: Location of Mt. Coffee HPP in Montserrado County

3.2 The Project Proponent

The Liberia Electricity Corporation (LEC) is the project proponent. LEC was established by an act of National Legislature on July 12, 1973, is a Public Corporation solely owned by the Government of Liberia (GOL) with a mandate to produce and supply economic and reliable electric power to the entire nation.

Prior to the civil war, the total installed electricity capacity in Liberia was estimated at 412 MW. LEC had a total installed electricity capacity of 191 MW (Mt. Coffee hydro and Bushrod Island thermal plants), industrial concessionaires produced 212 MW and a rural electrification system provided 13 MW.

In 2006, after fourteen years of civil war during which time LEC facilities were severely damaged or destroyed, donor agencies funded programs to support the LEC.

3.3 Short Project History

The Mount Coffee Hydropower project, a Run-of-River scheme, was constructed between 1963 and 1966 and went in operation in 1967. The initial generating capacity was 30 MW produced by two turbines, which was increased by two additional turbines to 64 MW in 1973.

Mount Coffee HPP was the most important power plant in Liberia until the civil war started in 1990. On June 28, 1990, the National Patriotic Front of Liberia (NPFL) took control of Mount Coffee HPP. The plant operator was ordered to stop supplying electricity, therefore only Unit 1 was kept in operation to supply the station and the staff quarters. After the plant operator left on June 30th, 1990, Unit 1 was taken out of operation. With no units on-line the spillway gates could not be raised and the Forebay Dam 1 broke on August 12, 1990. Since then powerhouse, substation and spillway structures have suffered considerable looting and damage.

During the study the consultant made the effort to contact persons, who have lived in the project area before the Mt. Coffee HPP was build the first time and who have been resettled due to the construction of the HPP. There was only one family (household head: Tommy Urey, 82 years old) who was resettled from there and moved back to the project area in 1991. Likewise, information was sought on the effects of the dam break in the downstream area, since this would provide valuable information on risks associated with such an event. No records of any kind have been found.

3.4 Required Rehabilitation Measures for Mount Coffee HPP

Main Dam and Spillway are located north of the powerhouse, the main dam and spillway is a reinforced concrete structure with ogee-shaped spillway (crest elevation is 60 ft) and was designed to support a 2,000 acre impoundment. Ten tainter gates supported by concrete piers maintain normal pool elevation of 95.4 ft. Tainter gate rehabilitation will require refurbishment of stoplogs, replacement of seals, rollers, bushings, and chains, new paint system, new gate hoist system, new gantry crane and rail system. A reinforced concrete bridge spans the spillway to provide access across the St. Paul River and to the tainter gate hoist machinery. The bridge handrail, guardrail and splash wall will require replacement. The spillway is flanked by earthen embankments.

The equipment house will require complete reconstruction of the electrical facilities in addition to structural rehabilitation. The roadway access across the embankments is in disrepair and rehabilitation would require the replacement of compacted subgrade with laterite overlay.

The reservoir on the upstream side of the dam will have at full supply level a surface area of 8.1 km^2 (2001 acres) at a height of 29.08 m asl (95.4 ft). Maximum flood level will be at 29.56 m asl and the minimum operation level will be at 27.43 m asl. The drawdown area will have a surface area of 0.91 km^2 (225 acres). It is estimated that 200 acres of the reservoir, originally cleared, have vegetation encroachment and that re-clearing will be required. The reservoir will have a total volume of 62.6 million m^3 and a live storage of 54.3 million m^3.

Forebay Dams 1, 2 and 3 are located near the powerhouse to retain water in lower areas, three zoned earthen embankments were constructed for a total length of approximately 2,600 ft with heights ranging from 10 to 70 ft. The 3,200 ft access roadway is located between the main dam/spillway and Forebay Dam 1. A 600 ft section of Forebay Dam 1 was breached in 1990 and the original overburden foundation has been eroded to bedrock. The reconstruction of the forebay dam breach will follow the typical existing section constructed from laterite and rock available onsite.

Rehabilitation of the remaining forebay dams will involve vegetation removal, grading and compaction. Other ancillary work will include new splash wall and guardrail, forebay canal restoration, and electrical service.

Intake Structure. The Mt. Coffee intake structure consists of four 18-foot diameter steel penstocks embedded in concrete serving Bays 1-4 and intakes for future Bays 5 and 6. The intake structure will require the replacement of head gates, hoists and supporting structures, trashrack and trashrack cleaning system, stoplogs and lifting beams, and north abutment wall repair. Vegetation on the intake structure embankment and all engineered surfaces will be removed and slopes regraded and compacted. A new laterite roadway section will be constructed for access across the intake structure.

Powerhouse. The powerhouse is a reinforced concrete structure built to accommodate the four turbine-generator units. The powerhouse consists of generating bays, erection bay and control room. Above the generator floor, the north end of the building is a temporary wall designed to accommodate future expansion. The powerhouse roof is a concrete slab supported by reinforced concrete beams and wall columns and had been retrofitted with a truss-supported, sloped metal roof system. Interior and exterior surfaces of the powerhouse will be rehabilitated and the roof system rehabilitated. A new bridge crane is required. No major structural work is required. Generating equipment will consist of four new vertical Francis turbines and associated generators, governors, switchgear, and control system.

Substation and Transmission. The existing substation has largely been removed leaving only the foundation intact. The new substation will be designed to reuse the original foundation and will accommodate four transformers and four transmission lines with space for expansion. It will be energized at 66 kV with clearances established for 115 kV and will provide service power to Mt. Coffee. The substation will include a station service transformer for 22 kV primary distribution through new switchgear to the spillway and the powerhouse. The original 69 kV transmission line to Bushrod Island consisted of 15 miles of wood pole construction paralleling the Mt. Coffee access road and remnants of this system remain intact. The transmission line will be reconstructed, including replacement of all towers, conductors, and hardware along the existing right-of-way. The new line will operate at 69 kV initially and be constructed to allow it to be energized at 115 kV.

Access Roads. The original construction included approximately 16 miles of access road from Monrovia to the Mt. Coffee power plant. The first 11 miles of roadway leading out of Monrovia are in an acceptable condition for reuse. The last 4 miles of roadway leading into the Mt. Coffee facility are not paved and are severely rutted, making that section impassable during the rainy season. This roadway segment will be reconstructed to an all-weather surface. Along the original access roadway alignment, there are approximately 84 drainage structures including two bridges, four reinforced-concrete double box culverts, and three large diameter steel plate culverts. Vegetation clearing along the entire roadway is required along with physical inspection and replacement, where warranted, of existing drainage structures.

3.5 Mount Coffee HPP

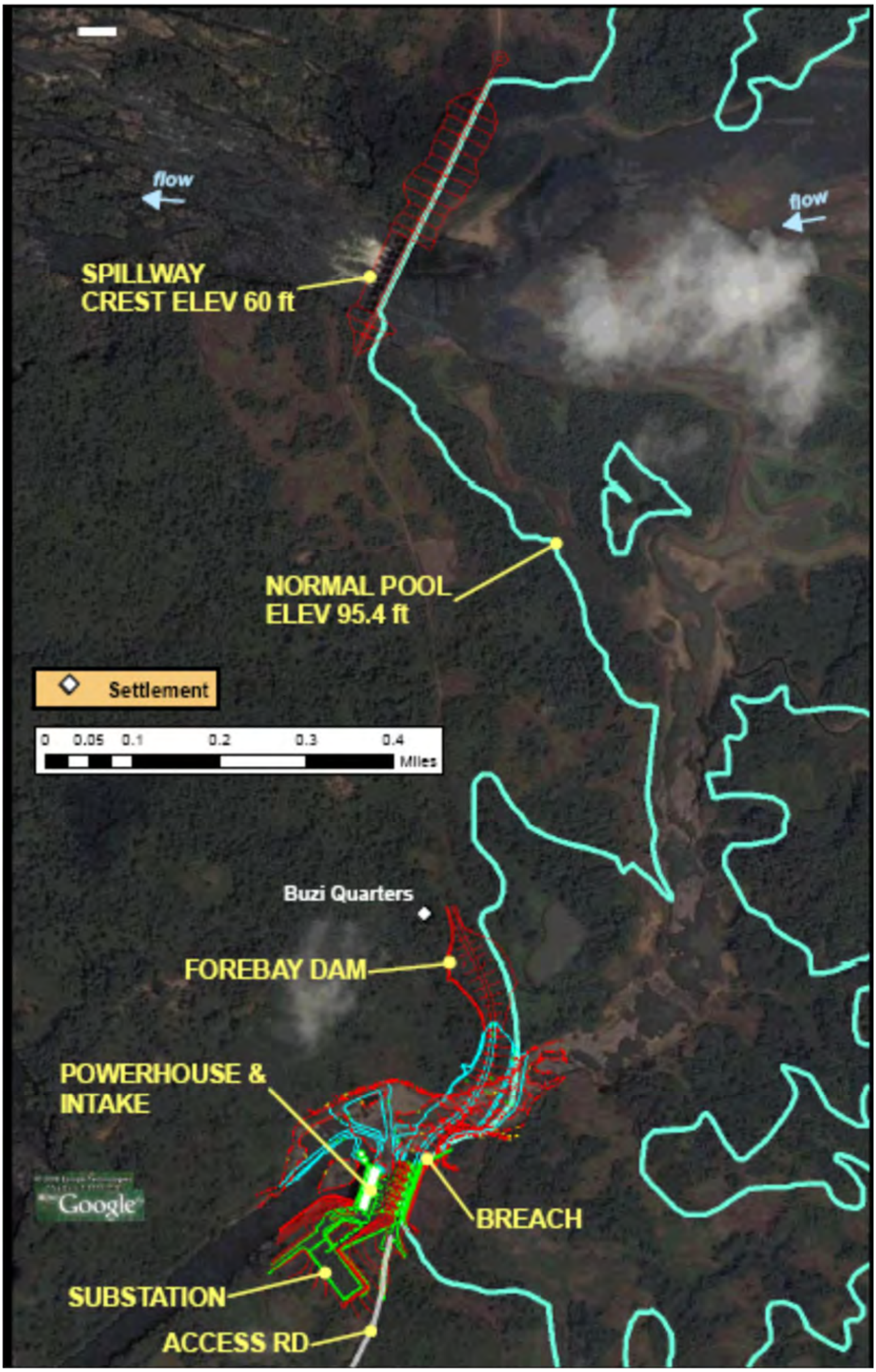


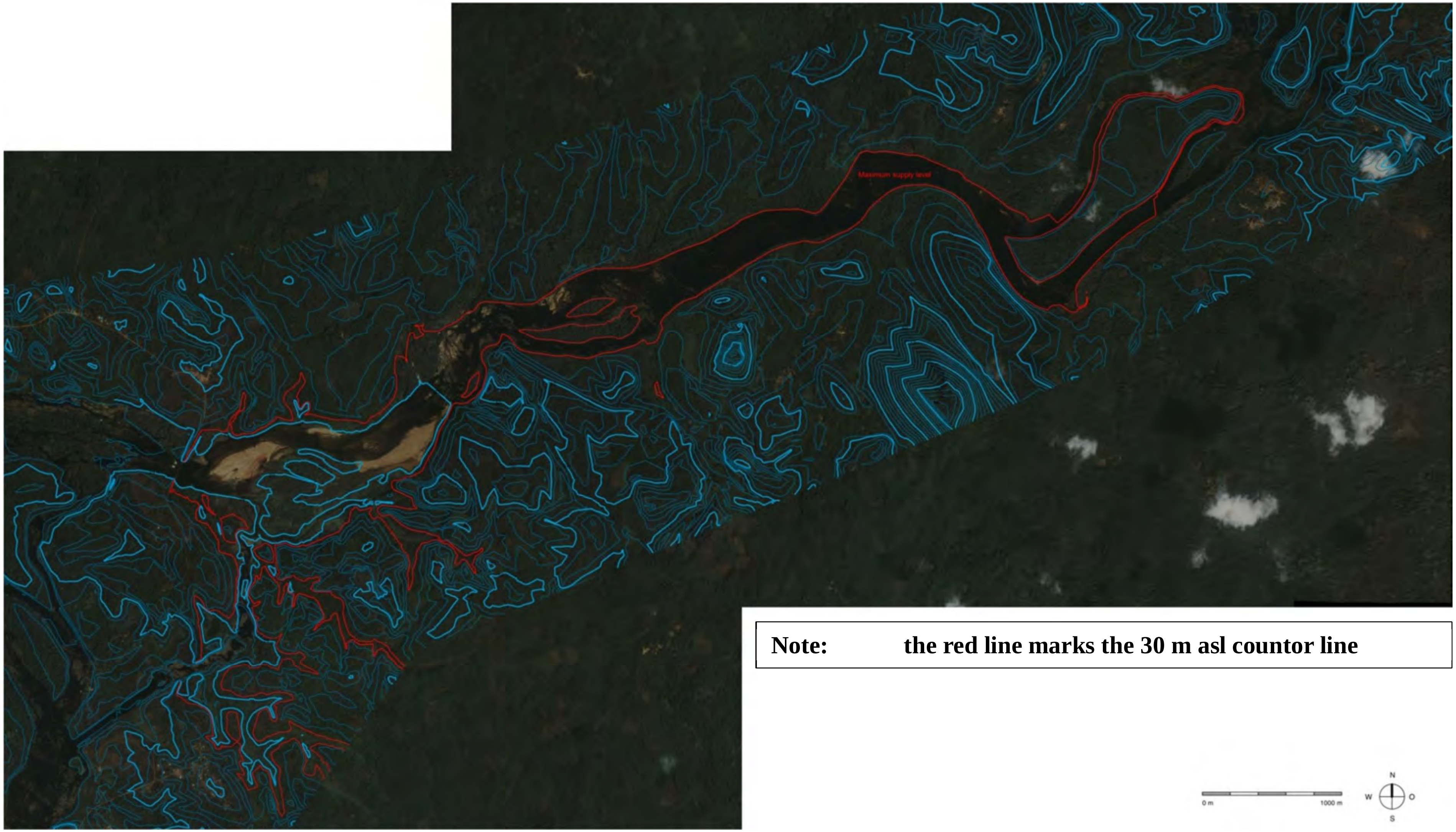
Figure 3-3: Mount Coffee hydroelectric powerhouse and water control facilities

Source: Technical and Financial Feasibility Study for the Reconstruction and Expansion of the Mount Coffee Hydropower Facility in Liberia, Stanley Consultants Inc, 2008.

Table 3-1: Main parameters of Mount Coffee HPP

Parameter	Unit Metric System	Mount Coffee HPP	Unit Imperial System	Mount Coffee HPP
Main Dam and Spillway				
Spillway Type		Reinforced concrete		Reinforced concrete
Spillway Height	M	18.3	ft	60
Spillway Crest Length	m	121.9	ft	400
Spillway Crest Elevation	m asl	31.09	ft asl	102
Riverbed Elevation	m asl	15.2	ft asl	50
Dam Type		Earthen embankment		Earthen embankment
Dam Height	m	21.6	ft	71
Dam Crest Length	m	466.35	ft	1530
Dam Crest Elevation	m asl	31.09	ft asl	102
Forebay Dam 1				
Type		Not yet defined		Not yet defined
Height	m	19.8	ft	65
Crest Length	m	426.7	ft	1400
Crest Elevation	m asl	31.09	ft asl	102
Bottom of Tailrace Channel	m asl	-1.57	ft asl	-5
2. Reservoir				
Max. Flood Reservoir Level	m asl	29.56	ft asl	97
Full Supply Level (FSL)	m asl	29.08	ft asl	95.4
Area at FSL	km²	8.1	acres	2001
Approx. Area for Vegetation Clearing	km²	0.81	acres	200
Total volume at FSL	10^6 m³	62.6	10^6 cuft	2’211
Live volume	10^6 m³	54.3	10^6 cuft	1’917
Minimum operation level (MOL) /	m asl	27.43	ft asl	90
Area at MOL	km	7.19	acres	1776
Normal Drawdown	m	1.65	ft	5.4
3. Power house and capacity				
Total Installed Capacity (tentative)	MW	66	MW	66
Turbine Type		Francis		Francis
Number of Units	N	4	N	4
Capacity of Turbines	MW	16.5	MW	16.5
Turbine output	m³/s	340 (4 x 85)	cfs	12'000 (4 x 3'000)
Total Head	m	22	ft	72.4
4. Waterways				
Penstock Length	m	71.8	ft	235.8
Tailrace Channel Length/Width	m	823/45.72	ft	2700/150
5. Hydrology				
Catchment Area	km²	19’992	Sq.mi	7719
Average River Discharge at Dam Site	m³/s	564	cfs	19'900
Annual Rainfall	mm	~3’800a	in	~150
6. Transmission lines				
Nominal Voltage	kV	66	kV	66
Length	km	26/24	miles	16.16/14.91
7. Access Roads				
Construction (new road)	km	none	miles	none
Improvement of Existing Road	km		miles	

[a] = average between Bong Mines and Monrovia stations



Note: the red line marks the 30 m asl countor line

Figure 3-4: Mount Coffee reservoir area

Source: Stanley Consultants Inc.

3.6 Project Implementation

The Project phases can be divided into different stages. First there will be the design and manufacturing, then the mobilisation, followed by construction and rehabilitation respectively, and finally the operation phase.

Mobilisation of equipment, materials and construction personnel will commence after the final design has been carried out and when all necessary permits and approvals have been obtained. In this phase the construction camp, including workshops for equipment and machinery, storage areas and the procurement of the work force will be carried out. The construction phase contains the reconstruction of the forebay dam, main dam and the refurbishment of the powerhouse and all appurtenance structures of the Mount Coffee HPP, see Chapter 3.4. The operation phase will start following the commissioning of the first unit, the impoundment of the reservoir and the availability of the transmission line.

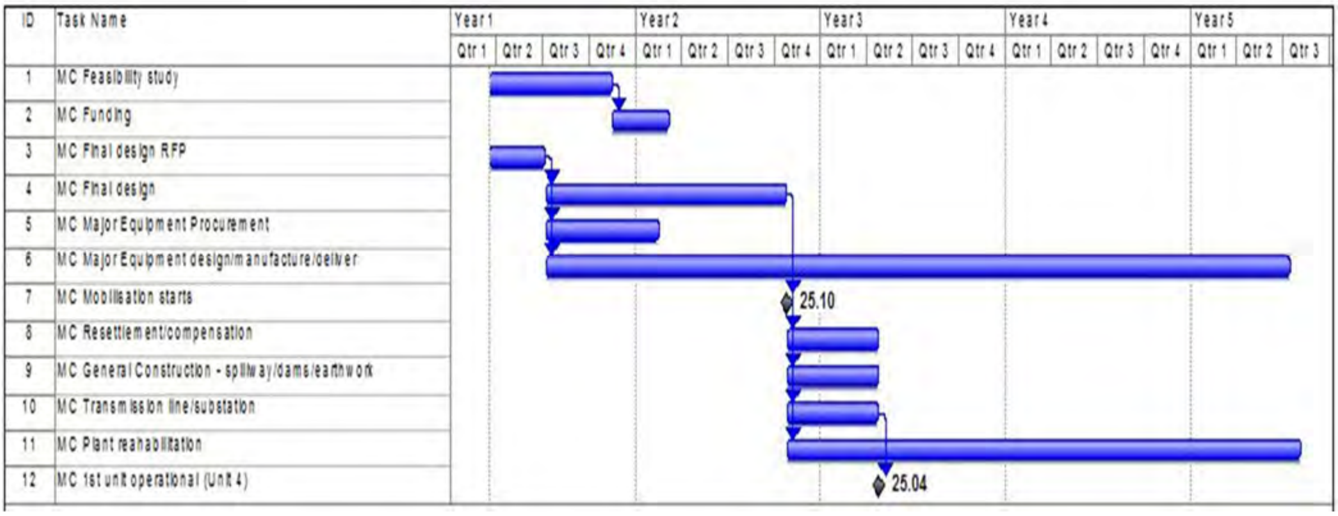


Figure 3-5: General implementation Schedule.

3.7 The St. Paul River Cascade

The planned development of the St. Paul River Cascade as described in the "Technical and Financial Feasibility Study for the Reconstruction and Expansion of the Mount Coffee Hydropower Facility in Liberia", which has been prepared by Stanley Consultants Inc., will be stepwise.

- The first step will be the rehabilitation of the Mount Coffee HPP and the implementation of the Via reservoir.
- The second step would be the implementation of stage 1 SP-1B and SP-2.
- The third step would be to implement the stage 2 of the Via reservoir (Storage of St. Paul river including the diversion tunnel of Via river), SP-2, Sp-1B and Mount Coffee.

Figure 3-6: St. Paul River Drainage Basin including the HPP Developments.

Source: provided by LEC during Kick-off-Meeting

Project Name	Stage 1	Stage 2
Mount Coffee	66 MW	122 MW
SP-1B	78 MW	143 MW
SP-2	120 MW	220 MW
Via	---	132 MW
Total:	264 MW	617 MW

The Cumulative Impact Assessment (CIA) on the St. Paul River developments takes into account the above listed hydropower plants and will is done on the basis of existing plans and documents.

Since the CIA was carried out on the basis of existing documents, the impact assessment cannot be as detailed as for an ESIA. The main issues are the following:

- Hydrology: change of discharge pattern due to the implementation of the Via reservoir Stage 1 and Stage 2, the resulting effects on the downstream area.
- Water quality: risk and effect of sea water intrusion, and need and possibilities for relocating the water intake of the White Plains Water Treatment Plant upstream of Mount Coffee HPP, including environmental and social impacts of such a measure.

- Aquatic fauna: impact on fish fauna, due to migration barriers and habitat fragmentation.
- Vegetation and terrestrial fauna: are there any relevant habitats in the region affected by the developments (national parks). Impact of the cascade on the St. Paul estuary.
- Social: will it have an impact on fishery; this is strongly related to aquatic fauna.

These issues are addressed and analysed to the extent possible at this stage and with the available information.

4 THE STUDY AREA

4.1 Subdivisions of the Study Area

For the purpose of this ESIA, the study area was divided into several specific areas, which not all needed the same level of detail in the study. In general, the following are the main parts:

- Dam and powerhouse sites and surroundings, which in this case were subdivided into the following two categories:
    - The existing structures of Mount Coffee HPP: This area was assessed in detail, since the new construction site has to be included, damaged structures will have to be demolished, actions against erosion will have to be taken and waste will have to be disposed of properly, etc. An additional is health and safety within and on the old structures (all holes on structures and unstable areas need to be fenced off to implement safe working conditions).
    - The new construction area, which has to be integrated into the old one, mainly dam and power house site, appurtenant structures and immediate surroundings (construction sites, construction camps, quarries, borrow and disposal areas, etc.): this is where most of the construction activities take place, and where a large amount of the environmental impacts happens. This area was considered with much detail, especially for the construction phase. Furthermore, it will be affected in a relevant and permanent way by the Project.
- Reservoir area: the future reservoir, i.e. the area which will be covered by water (approximately 8.1 km^2), is also an area in which the effects of the Project will be very apparent and which therefore was considered in detail (especially the plantations and potentially other forms of land use within the reservoir area).
- Immediate reservoir catchment: this is the area directly surrounding the reservoir, which can be influenced by the project in different ways (e.g. change in groundwater regime, triggering of landsides, increasing pressure on habitats, etc.).
- Downstream area during the construction phase: The main effect on the downstream area is the risk of water pollution and its potential impacts on water users in this area. This includes the risk of an increase in sediment load due to construction activities, which is potentially quite considerable.
- Downstream area during operation phase: Starts below the powerhouse outlet, where the river discharge pattern will be influenced by turbine operation. The impact will be small in the case of a run-of-river scheme like Mount Coffee HPP with a very limited regulation capacity, and can potentially be very important in the case of storage schemes with intermittent (e.g. peaking) power production (e.g. by implementing the Via HPP with the storage reservoir), which can cause seasonal changes in river discharge pattern and important short term fluctuations. The extent of the area to be taken into account depends on the specific situation. Potential issues are flow conditions as influenced by the project, cumulative impacts with existing power plants, water quality issues, effects on floodplain habitats, and effects on d/s water users. For Mount Coffee HPP the downstream area can be divided into three parts as follows.

  - The most impacted part of the downstream area will be the stretch of the old riverbed between the spillway and the outlet of the tailrace channel, which has a length of about 4 km. The impact in this part of the river will strongly depend on the discharge pattern of the Mt. Coffee HPP. The HPP will be operated during rainy season as a Run-of-River scheme; during this period there will be no impacts, but during the dry season the natural river flow will be significantly reduced, and could even be zero at times, which would have a strong negative impact on the environment. Therefore a residual flow taking into account the environmental, economic and social needs has been defined.
  - Another part of the downstream area is the tailrace channel itself. During the past 20 years it was functioning as a more or less natural branch of the river. As already mentioned above, during the rainy season discharge will remain constant (full capacity of plant operated on a ROR basis), while during the dry season it will be influenced by the discharge pattern. Here, the impact compared to the original riverbed very small since all the water used for energy production during dry season will be in the tailrace channel. Nevertheless, the changes between full load and reduced operation will be noticeable.
  - The third part will be downstream of the confluence between tailrace channel and original riverbed and will reach until the Atlantic Ocean since no larger tributaries are entering into the St. Paul River within this river stretch (salt intrusion was assessed).

- Catchment area: the catchment or watershed area of Mount Coffee HPP will not be affected by the Project as such, but the situation in this area can greatly influence the reservoir. The most important of these effects are eutrophication and pollution of the reservoir water by input of nutrients (stemming mainly from agriculture, mining activities and human settlements) and siltation of the reservoir (due to erosion in the catchment, which again is often caused or at least considerably exacerbated by human activities). In addition, plans for other HPPS within the catchment were taken into account.

- River basin: for some effects, other developments in the same river basin have to be taken into account, since they can increase or reduce environmental (or social) effects of the project in question. However, it has to be pointed out that this is an ESIA for a specific project and not a CIA of all the projects in the St. Paul river basin, nor a SEA for the entire development plan of this river basin.

- Access roads: access roads can have major direct or indirect environmental impacts. However, the project does not require the construction of any new access roads. Work for upgrading the existing roads from Monrovia to Mount Coffee on both sides of the St. Paul river is part of the project.

- Other areas, as might be relevant. This can comprise, e.g., transmission line corridors, resettlement areas.

5 THE ENVIRONMENT: GENERAL CONSIDERATIONS

5.1 Main Environmental Impacts of Hydropower Projects

The major direct and indirect impacts of any hydropower project are always the same; their relative importance, of course, will be determined by the site- and project-specific conditions. These main impacts are listed as follows (from Zwahlen 2003):

1. Interruption of a river continuum. The fact that a dam is built across a river will always interrupt a system that was, up to now, an entity. Direct consequences of this interruption are a change in river flow patterns, a change in sediment transport (mainly due to sediment retention in the reservoir), an interruption of fish migration (complete for upstream migration, obstacle and risk for downstream migration), and the interruption of drift (i.e., the more or less passive movement of various organisms downriver).
2. Change in river discharge pattern downstream of the dam. This effect is closely related to the first one. In this respect, two main parts of the river can be identified: (1) between the dam and powerhouse outlet, where discharge is reduced, in extreme cases to zero, and (2) downstream from the power house outlet, where river discharge is influenced by plant operation.
3. Change from river to lake conditions in a part of the former river at the formation of the reservoir. Water quality will change due to this effect, and the new lake is a habitat very different from that of the former river.
4. Destruction of terrestrial habitats. All terrestrial habitats within the reservoir area will be permanently destroyed, because they are going to be covered with water. This has effects on vegetation and fauna, as well as on the human population living in this area.
5. Access to the area provided by new access roads. Although the direct impact of the roads (e.g., on vegetation) might be rather small, the roads can trigger a development, especially in cases when hitherto inaccessible areas are opened in this way, that can have very considerable environmental effects.
6. Social impacts. These can be manifold. The most important in many cases is the involuntary resettlement as a consequence of a dam project, but there are also other socioeconomic effects, such as effects on the population in the downstream area (through disruption of river floodplain dynamics, groundwater table changes, etc.); immigration into the area, especially during the construction phase, as a consequence of job opportunities; and effects on the host population for the resettlers. A hydropower project has also positive effects on the local community, like providing jobs and therefore income (although often limited to the construction phase), improved access through better roads, improved infrastructure, rural electrification etc. These positive items have to be evaluated, planned and implemented carefully in order to have the expected effect.

Most other impacts that may arise are likely to be related to these major effects, very often as secondary consequences.

5.2 The Case of Mt. Coffee HPP

In a first general appraisal, concerning the list of main types of impacts given above, the following can be said for the specific case of Mt. Coffee HPP:

1. Interruption of a river continuum. This is certainly the case for Mt. Coffee HPP.
2. Change in river discharge pattern downstream of the dam. Given the fact that MC HPP is a ROR structure with a very limited regulation capacity, the effect will be small.
3. Change from river to lake conditions in a part of the former river at the formation of the reservoir.
4. Destruction of terrestrial habitats. The reservoir will cover an area of about 8.1 km². Obviously, these habitats are just what could develop in the 20 years since the breaching of the dam.
5. Access to the area provided by new access roads. In the case of Mt. Coffee HPP, no new access road needs to be built, since access is provided by existing roads.
6. Social impacts. The main social impact is the fact that the power plant will considerably improve the electricity supply in the county. The main negative effect will be the relocation of six settlements and the loss of some areas which are currently used for agricultural purposes; this will have to be compensated. The effect of the construction phase (job creation on the local, regional and national scale; influx of population from outside) also has to be considered.

While in this sense Mt. Coffee can be considered as a “normal” hydropower project producing the effects generally associated with such projects, it still presents a condition that makes it different from most other such projects for which an ESIA has to be done, namely, the fact that it is not a new project: there already was a reservoir and a functional power plant until the dam was breached 20 years ago.

PART B SECTORAL STUDIES

I. THE PHYSICAL ENVIRONMENT

6 GEOLOGY AND SOILS

6.1 Theoretical Considerations

The geological conditions of the project site are decisive for the design and layout of a dam and hydropower project, and for this reason, geology has to be investigated a part of the technical studies for the project. However, the geology as such will not be influenced by the project. This Chapter only provides a short description of the situation.

6.2 Geology

For the purpose of the ESIA for Mt. Coffee HPP, geology is of minor concern. No specific investigation or in-depth analyses are foreseen in this respect. The risk of a dam break, and the measures to be taken for such a case, will have to be considered. However, the reservoir is very small and will certainly not lead to a reservoir-induced increase in seismicity.

Furthermore it can be stated that the Mount Coffee Hydropower Plant has been in operation 20 years ago. No noticeable old landslides have been seen in the project area. For this reason, because of the small drawdown, given the local topography (gentle hills without steep slopes and because of the fact that all land not immediately used for agriculture is covered by dense secondary forest it is expected that the risk that Mt Coffee reservoir will trigger landslides is negligible.

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 structures and schistosity dip at high angles in most places and are often vertical.

Geologically, the Mount Coffee HPP project location is described on the USGS geological map of the region (see detail of this map in Figure 6-1) as a Pre-Cambrian leucocratic (meaning light coloured), medium to coarse grained, commonly banded biotite bearing granite to quartz diorite gneiss. The gneiss forms a wide northwest to southeast belt in which the Mt Coffee site is situated.

Figure 6-1: Geological map of the project area

6.3 Soils

Regionally, the dominant soil type is laterite. The climate of Liberia can be classified as tropical, with high temperatures and distinct wet and dry periods. As a result of the weather, lateritic soil types, rich in iron and aluminium, have formed. Nearly all laterites are rusty-red because of iron oxides. They develop from intensive and long-lasting weathering of the underlying parent rock through a prolonged process of chemical weathering. The resulting soil varies in thickness, grade, chemistry and mineralogy; depending on the original parent rock.

6.4 Impacts

The main impact on soils is the erosion and contamination of soils due to construction activities.

6.5 Mitigation Measures

Good engineering practices will help controlling soil erosion both at construction sites and in peripheral areas, particularly in borrow and dumping areas and along access roads. Following measures have been mentioned:

- Install sediment traps
- Drainage channels where necessary
- Prevent steep slopes, define optimum height of work evaluating the instability of the rock, soil etc.
- Stabilise, compact and strengthen steep slopes
- Adequate selection of road tracks, taking into account the landscape, technical environmental and social aspects
- Construct drainage ditches at roads if there are passing through mountainous area If the slope is more that 16 % they have to be paved
- install culverts with enough capacity for strong rains, drainage pipes and channels have to be of an adequate size and should be equipped with screens at entrance and exit points to reduce the risk of clogging
- Re-vegetation

Following mitigation measures should be implemented to reduce the contamination of soils:

- The maintenance of machinery and lorries has to be done in work-shops, liquids including cleaning water should be collected in tanks.
- Storage of fuel and lubricants has to be in tight containers placed on sealed surfaces under nice a roof. The storage has to be equipped with all safety measures to prevent oil spilling including fire fighting equipment. The area needs to be marked.
- In the case of an oil spill sufficient quantities of oil absorbent have to be stocked. The contaminated absorbent has to be disposed of properly.
- Hazardous waste has to be stored in designated closed tanks or areas.
- Solid waste generated during construction and at campsites will be properly treated and safely disposed of only in demarcated waste disposal sites.
- All activities which could contaminate the soil have to be carried on a sealed surface and if accidental spillage occurs that the contaminated soil has to be excavated and disposed properly.
- Awareness has to be raised within the workforce to properly dispose of the waste.

7 CLIMATE

7.1 Theoretical Considerations

Large water bodies influence the climate of their surroundings, especially temperature and humidity. The most noticeable effects are a general cooling in summer, a warming in winter, and a reduction of the daily and seasonal temperature variation. This effect can be clearly seen when the climate of a place on the seashore, with maritime climate, is compared to the one of a place far away from sea influence, with a continental climate type. Direct measurements have documented this effect. So it has been demonstrated that for instance a small island in the Finnish Bay exhibited a January temperature that was 1.3°C higher than that of a station in the nearby land some distance away from the coast, while the average May temperature was 2.5°C lower. Similar, although smaller effects have been demonstrated in the vicinity of two lakes (Lake Peipus, Lake Chelkap), although in these cases the differences were smaller, reaching only +0.3° in winter, -0.7° and -1.8°, resp., in summer (Alissow et al., 1956). This is also illustrated for Lake Aral in Figure 7-1.

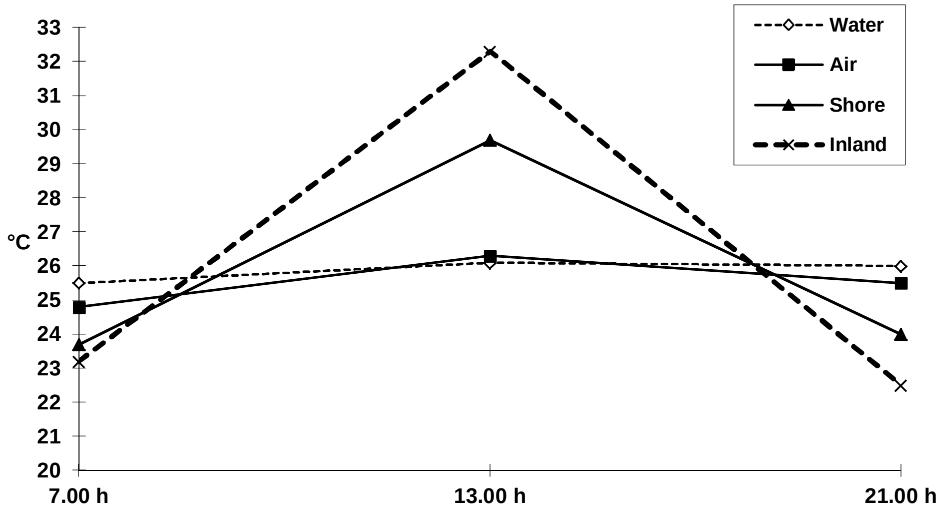


Figure 7-1: Daily temperature variations as influenced by a lake

Measurements from Lake Aral, August 1902. The daily amplitude of water temperature is merely 0.6°, of the air above the water 1.5°, at the shore 6.9° and in greater distance from the lake 9°C (Alissow et al., 1956).

This is mainly due to the fact that the water is able to store a considerable amount of heat, and that it reacts very slowly to changing temperatures. While on land the temperature (soil and air layers close to it) can exhibit large daily fluctuations, this is not the case for water. In Irkutsk, the daily variation in summer is 13.5 to 21.7°C, in winter 5.7 to 14.5°C (air 2 m above ground), the soil surface variation is even greater (29.8° in summer, 6.2° in winter; measurements for a day with rather low air temperature variation). It will be noted that Irkutsk is exhibiting a continental climate in spite of the proximity of Lake Baikal, which is one of the largest inland water bodies of the world. The biggest daily variations in air and soil temperature are recorded from deserts, which lack the cooling effect of evapotranspiration. In African deserts, daily surface temperature differences of up to 43°C have been recorded, in middle Asian deserts up to 50°C.

In larger water bodies (seas and very large inland waters), normal daily fluctuations of temperature close to the surface are usually below 1°C (and smaller for deeper layers), and this is also the case for the air layer of approximately one meter above the water surface, this difference is getting more pronounced in higher air layers (Alissow et al., 1956; Geiger, 1950).

In the case of smaller lakes, it is very difficult to define clearly the effects of the proximity of the lake on ambient temperatures, as the complex mixing processes due to local winds tend to blur this influence. Nevertheless, it can be said from experience that, as a general rule, lakes have a beneficial effect on the local microclimate. This is shown by the fact that, in temperate regions, some plants normally limited to a warmer climate grow exclusively or at least much better in the vicinity of lakes (e.g. vineyards in central Europe). Furthermore, settlements tend to concentrate around lakes. While this has certainly different reasons, historical and scenic ones among others, the microclimate certainly contributes to it.

In temperate and cold regions, the effect of a lake on the climate takes place only while it is not covered with ice. A compact ice layer covering the water body effectively blocks temperature exchange of the lake with its surroundings.

A few publications are concerned with the question of evaporation from lake surfaces (Kuhn, 1977; Hoy and Stephens, 1977). However, there does not seem to exist, to date, a thorough climatic study in relation with a man-made lake, which would compare temperature and humidity values before and after dam construction. The studies that at least mention potential climatic effects of artificial lakes attribute to them a minor or almost negligible effect (e.g. Odingo, 1979; Olivetti, 1983). this seems perfectly understandable given the fact that, while artificial lakes certainly create considerable impacts on the environment, climatic changes can, in the light of the details given above, be considered as of minor importance and, if at all noticeable, then rather beneficial.

7.2 Climatic Situation

A short description of the climatic situation is given here, based on data from meteorological stations in the project area. Since there is no climatic station in the immediate vicinity of the Project, data from three stations are used as follows (see Figure 7-2):

- Monrovia: a station on the coast, near the estuary of St. Paul River.
- Bong Mine, within St. Paul River basin, upstream of the HPP site; these two stations should characterise the project site rather well.
- Zorzor: this is a station in the upper section of the Liberian part of the St. Paul river basin, near the border with Guinea; the two latter stations characterise the climate in the catchment area of Mt. Coffee HPP. It has to be noted that the records for Zorzor are very incomplete.

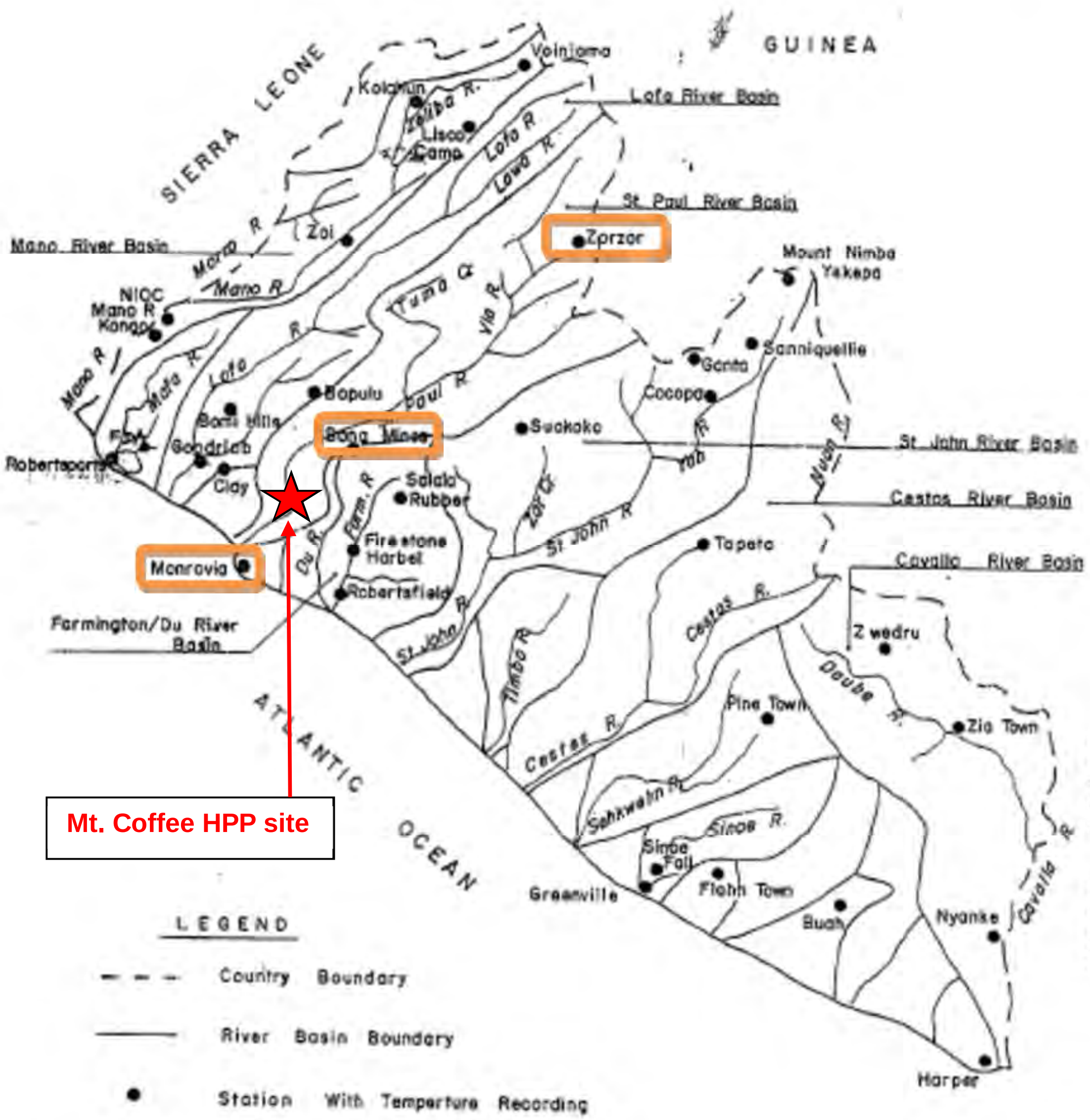


Figure 7-2: Meteorological stations in the project area

Source of map: LHS 1982

7.2.1 Temperature

The following Figure provides average monthly maximum and minimum temperature for the three stations. The main characteristics are:

- Seasonal variation in temperature is very little, as would be expected for sites at these latitudes.
- This is true especially for Monrovia, which exhibits a climate strongly influenced by the immediate vicinity to the sea.
- Temperature variations, and especially the difference between maximum and minimum temperature, gets more marked as the distance to the sea increases; Zorzor exhibits the most continental climate of the three stations.

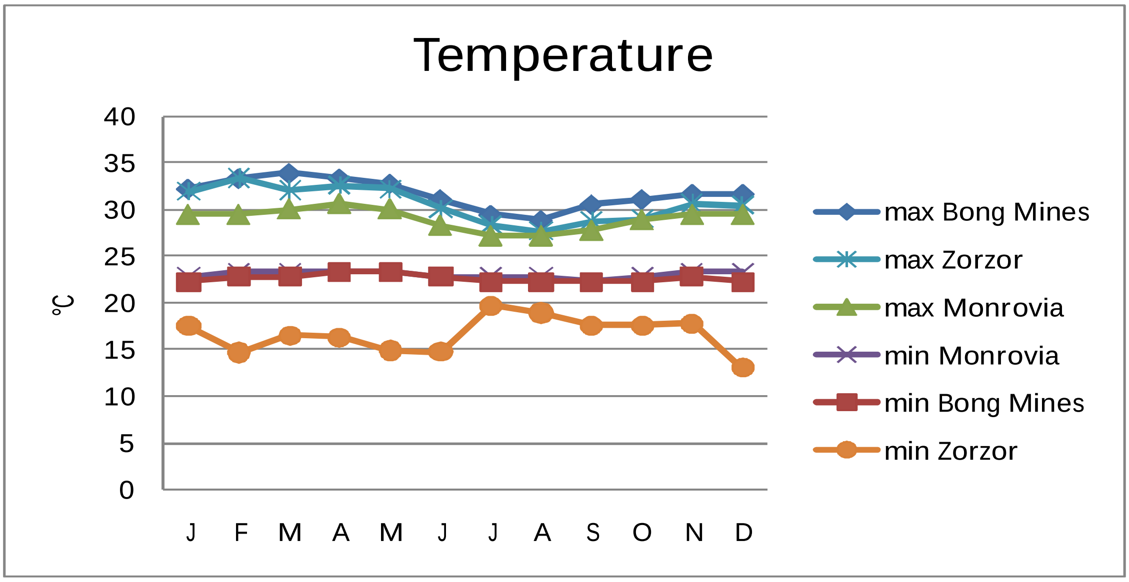


Figure 7-3: Monthly mean temperature in the project area
Source: LHS 1982

7.2.2 Precipitation

Rainfall shows a clearly seasonal pattern, with a dry season from November till April/May and a rainy season from May/June till October. This is true for all three stations, however, overall rainfall decreases markedly from south to north, i.e. from the coast to inland, being on average, in mm/year, 4'540 in Monrovia, 2'508 in Bong Mines, and 1'983 in Zorzor.

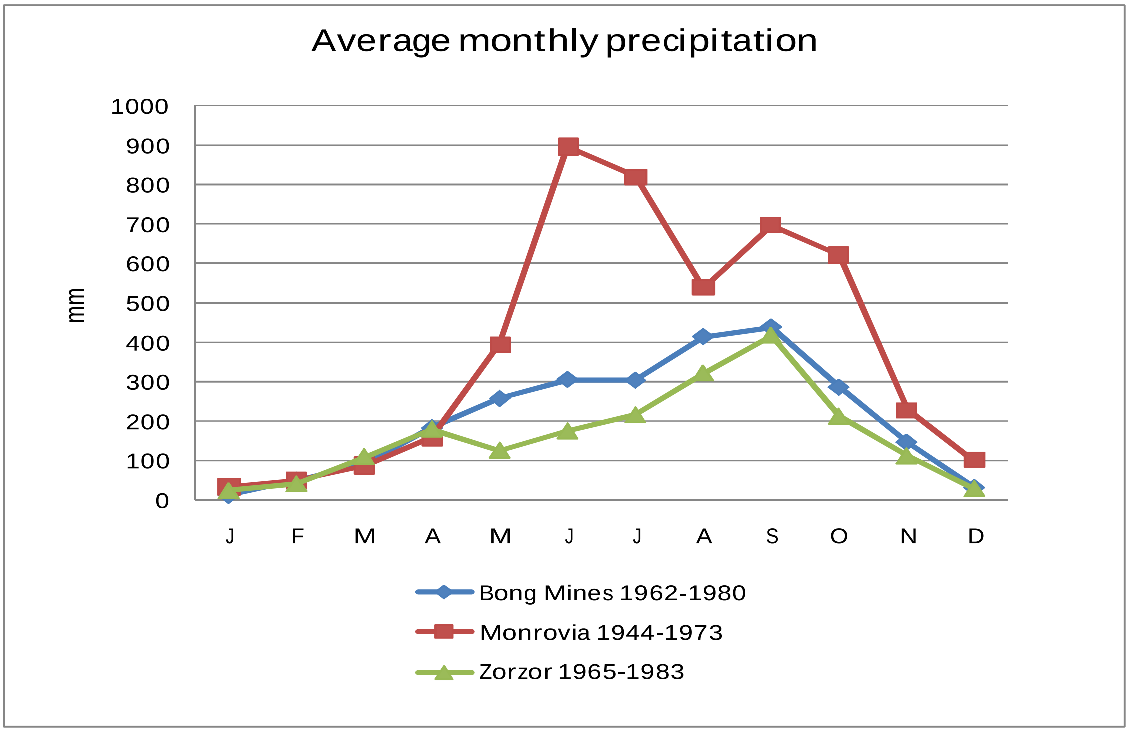


Figure 7-4: Average monhtly rainfall in the project area
Source: LHS 1981

7.3 Effects of Mt. Coffee Reservoir on Local Climate

The presence of a surface of water of 8.1 km² will increase evaporation, and it can have a moderating effect on temperature. However, evapotranspiration from dense evergreen vegetation is similar to evaporation from an open water surface, therefore the difference will be very small. The lake will be far too small to have a noticeable effect on the climate. The effects (reduction of temperature variation, increase in humidity), if any, will be limited to the immediate surroundings of the reservoir, and they will be too small to play any decisive role. In any case, as shown above, seasonal temperature variations are minimal, no additional attenuating effect can take place here.

7.4 Climate Change

It has to be stated clearly that the concept of Climate Change refers to the effects observed on a global level, induced by man-made greenhouse gas emissions, and that this is a very different issue as regards the effect of the reservoir on local climate, which has been discussed above. Here, the focus is on effects of climate change on water availability for hydropower production (and for irrigation, as far as this is of concern in the context of this ESIA). Obviously, the fact that reservoirs, under certain conditions, can be sources of greenhouse gasses has to be taken into account (see Section 8.4.5).

7.5 Conclusions

Mt. Coffee HPP will not have any effect on the local climate. No mitigation measures are required.

Issues related to climate change and GHG emissions are addressed below.

8 WATER

8.1 Theoretical Considerations

An HPP will normally have influence on surface water bodies in three ways, namely:

- By changing water discharge patterns downstream of the dam.
- By creating a lake, i.e. by changing a portion of the river from its natural running water into a stagnant water condition; this also has implications on water quality.
- By potentially changing the water balance locally (gains from direct precipitations, and losses from evaporation and infiltration).

8.1.1 Downstream Hydrology

A hydropower plant can influence river discharge in the downstream area in the following three ways:

1. Change in seasonal distribution pattern. This is the case for storage reservoirs with seasonal or interannual storage capacity, where water is being retained during the high flow season for being used during the low flow season.

   Mt. Coffee reservoir is too small for having such an effect, storage capacity is very limited (to a few hours, maximum of about 1 day during low flow conditions).

2. Reduction of river flow, in extreme cases to zero, between the dam and the power house outlet, in cases where the power house is not located directly at the foot of the dam.

   In the case of Mt. Coffee, this will be the case for the stretch of river between main dam (spillway) and the confluence with the tailrace channel, for a length of about 4 km. This has to be considered for the determination of the required residual flow.

3. Short term fluctuations in river discharge due to intermittent turbine operation (peaking production).

While the Mt. Coffee reservoir is too small for actual peaking, some load following operation will be possible or required during certain periods. This is an effect that will be discussed in detail below.

8.1.2 Residual Flow

Other effects of the HEP are short term fluctuations caused by turbine operation. When the powerhouse is not situated directly below the dam, but further downstream, a stretch of the river between dam and water outlet will eventually become completely dry. Hydropower projects designed for peaking production can lead to very marked short term fluctuations in river flow directly below the power house. This is shown for one example in the following Figure.

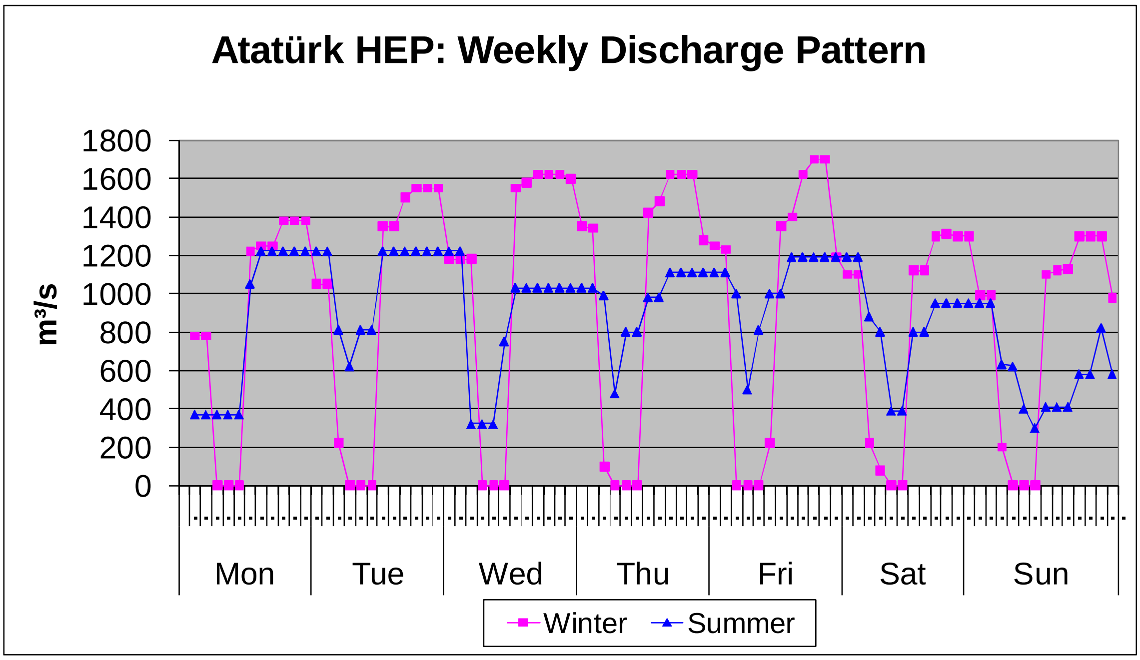


Figure 8-1: Discharge from a peaking hydropower plant

Example of Attatrürk dam, Turkey; it is evident that discharge, and therefore river flow below the power house, change very markedly each day. In winter, there are a few hours each day with zero flow.

In cases where zero flow can occur, the definition of a residual (often called environmental or ecological) flow has to be defined in order to (i) maintain the river as a habitat for aquatic species and (ii) preserve downstream socioeconomic water uses.

8.1.3 Changing River to Lake Habitat

A reservoir or a lake presents very different living conditions for aquatic organisms in comparison to those that prevail in a river. Many riverine species will not be able to adapt to these new conditions, while others will thrive.

8.1.4 Water Quality

Reservoir water quality will depend to a great deal on the preimpoundment condition of the reservoir area. Whenever a large amount of biomass is submerged, the rotting plant material will lead to water quality deterioration in the deeper layers of the reservoir. This in turn can lead to fish deaths, but it can also impair water quality downstream of the dam. This aspect is especially important when the river or the reservoir itself are used as a source of drinking water. Water quality in the reservoir will also be influenced by input from the catchment area. Namely, large settlements and/or industrial activities without proper waste water treatment will influence water quality. Effluents from agricultural areas can lead to high input of fertilisers into the reservoir, which in turn leads to reservoir eutrophication.

8.2 Hydrology: River Discharge Downstream of the Dam

8.2.1 Present Situation

Hydrology is a central issue of the study, especially in view of any downstream effects of the Project.

The total catchment area of St. Paul River is 20’500 km² (7’900 sq. miles), or of which 11’500 km² (4’450 sq. miles) are in Liberia, and 9’000 km² (3’450 sq. miles) in Guinea.

River flow data are available from a gauging station at Walker Bridge. The situation at this site is reflected in the following Figure.

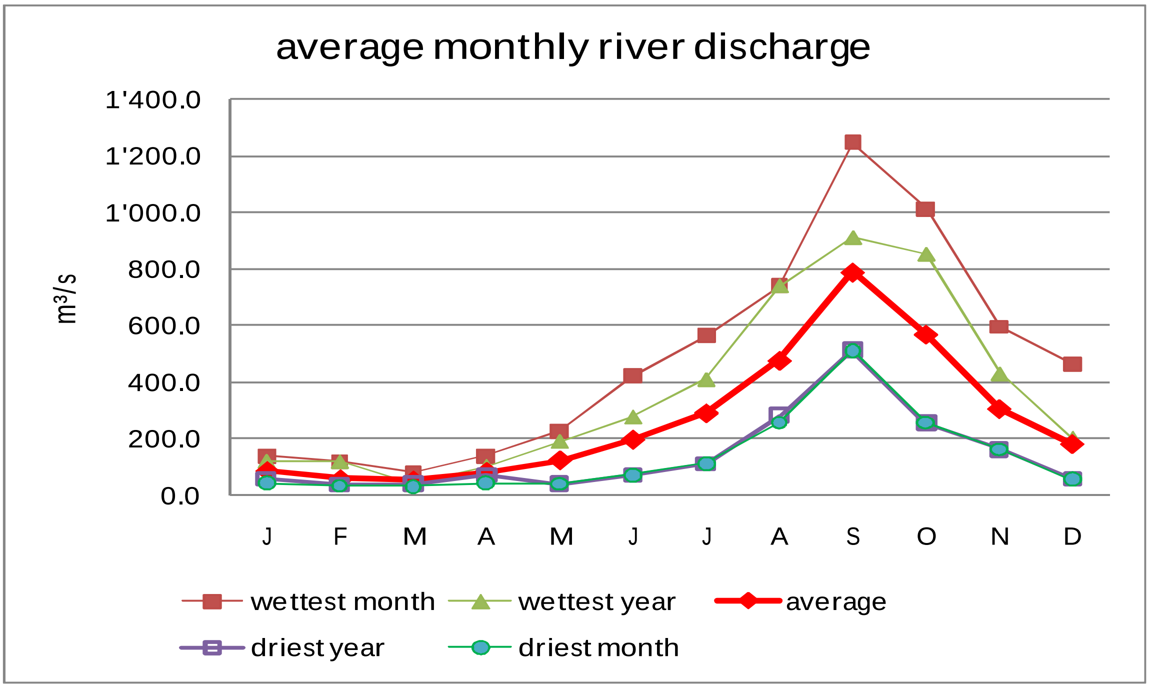


Figure 8-2: Average monthly river discharge

Site: Walker Bridge; values for 1958-1976

Source: LEC 1982

The Technical Consultant, Stanley, carried out an analysis of the hydrological data in order to simulate the situation at Mt. Coffee dam site; this simulation takes into account the intermediate catchment between Walker Bridge and Mt. Coffee dam site. The corresponding values are shown in the following Figure. It becomes evident that the intermediate catchment yields a considerable amount of water.

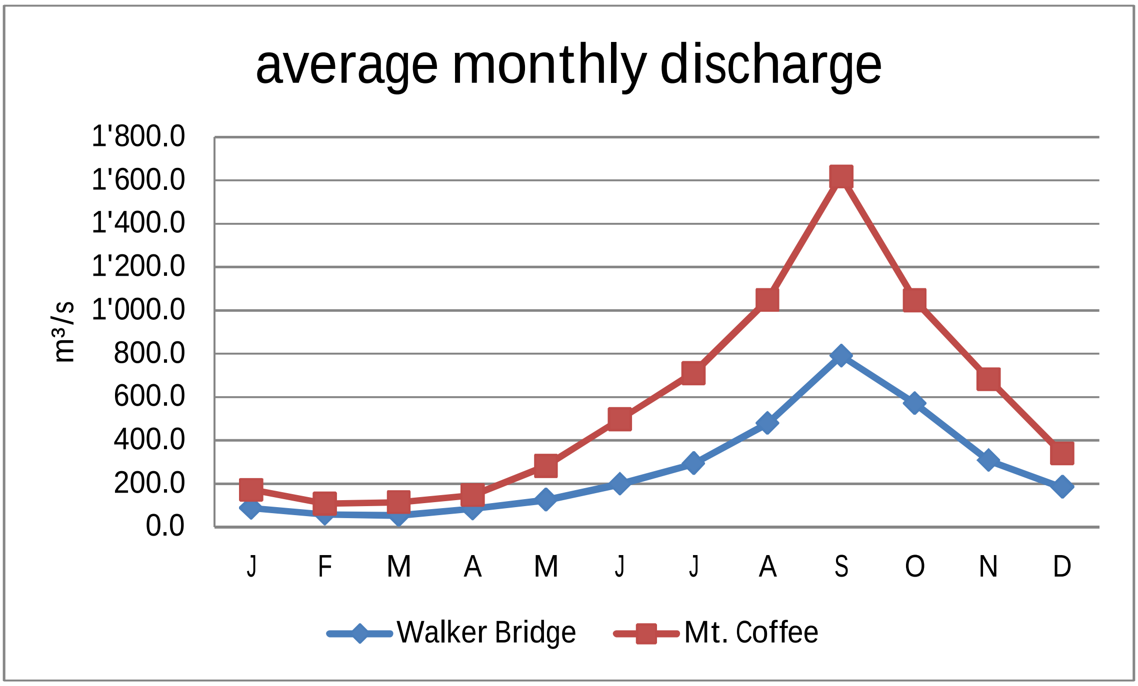


Figure 8-3: Average monthly river discharge at Mt. Coffee dam site

Source: Stanley 2011: Feasibility Report

All considerations concerning plant hydrology are based on these figures.

8.2.2 Plant Operation

Some key figures of relevance for plant operation are summarised in the following Table.

Table 8-1: Key figures for plant operation

Parameter	Unit Metric System	Amount	Unit Imperial System	Amount
Reservoir area	km²	8.1	acres	2'001
Reservoir volume	M m³	90	M cf	3'200
Mean annual river discharge				
• annual	m³/s	564	cfs	19'917
• wettest month (S)	m³/s	1'617	cfs	57'138
• driest month (F)	m³/s	108	cfs	3'814
• driest month on record	m³/s	32	cfs	1'129
• driest day on record	m³/s	2	cfs	70
Turbine output				
• 1 unit, 100%	m³/s	85	cfs	3'000
• 1 unit, 65%	m³/s	55	cfs	1'950
• 1 unit, 40% (minimum)	m³/s	34	cfs	1'200
• 4 units, maximum output	m³/s	340	cfs	12'000

Based on these figures, in the following Table a comparison is made between turbine output on the one hand and inflow into the reservoir under certain conditions on the other.

Table 8-2: Comparison between turbine output and inflow to the reservoir

Turbine output	**per second**		**per hour**		**per day**		**daily output in % of reservoir volume**
	m³/s	**cfs**	**M m³**	**M cf**	**M m³**	**M cf**	
1 unit @ 40%	34	1'200	0.12	4.32	2.94	103.68	3.3
@ 65%	55	1'950	0.20	7.02	4.77	168.48	5.3
@100%	85	3'000	0.31	10.80	7.34	259.20	8.2
4 units full (400%)	340	12'000	1.22	43.20	29.38	1'036.80	32.6
Inflow to reservoir							**Comment**
yearly average	564	19'917	2.03	71.70	48.73	1'720.84	full operation of all units
av. dry season flow	184	6'500	0.66	23.40	15.89	561.60	sufficient for 2 units
av. wet season flow	835	29'500	3.01	106.20	72.13	2'548.80	full operation of all units
av. wettest month	1'617	57'103	5.82	205.57	139.71	4'933.68	full operation of all units
av. driest month	108	3'814	0.39	13.73	9.33	329.52	sufficient for 1 unit
av. driest month on record	58	2'048	0.21	7.37	5.01	176.97	at limit for 1 unit @ 65%
av. driest day on record	2	71	0.01	0.25	0.17	6.10	no operation possible

The relevant points of this comparison are as follows:

- During the dry season, there is on average not enough water for operating the plant at full capacity.
- On average, during the driest month of the year, there would be enough water for operating one turbine at 100% capacity.
- In extremely dry months, with average flows of 34 m³/s (1'200 cfs) or less, there would be barely enough water for operating one turbine at 40% capacity. During the 18 years of records, this has never happened, the driest month recorded ever had a mean flow of 58 m³/s (2'045 cfs).
- Still, there can be days with flows considerably lower than the minimum requirements for turbine operation. This situation occurs on average on approximately 4 days per year.

As shown in the flow exceedance curve (Figure 8-4) during much of the time (47%), there will be some amount of spilling and the scheme can be operated as a run-of-river plant at full capacity. During the remaining time (53%), all available water would be used for energy production, and during much of this time the plant will not operate at full capacity. Without spilling, the original river bed below the spillway would remain completely dry.

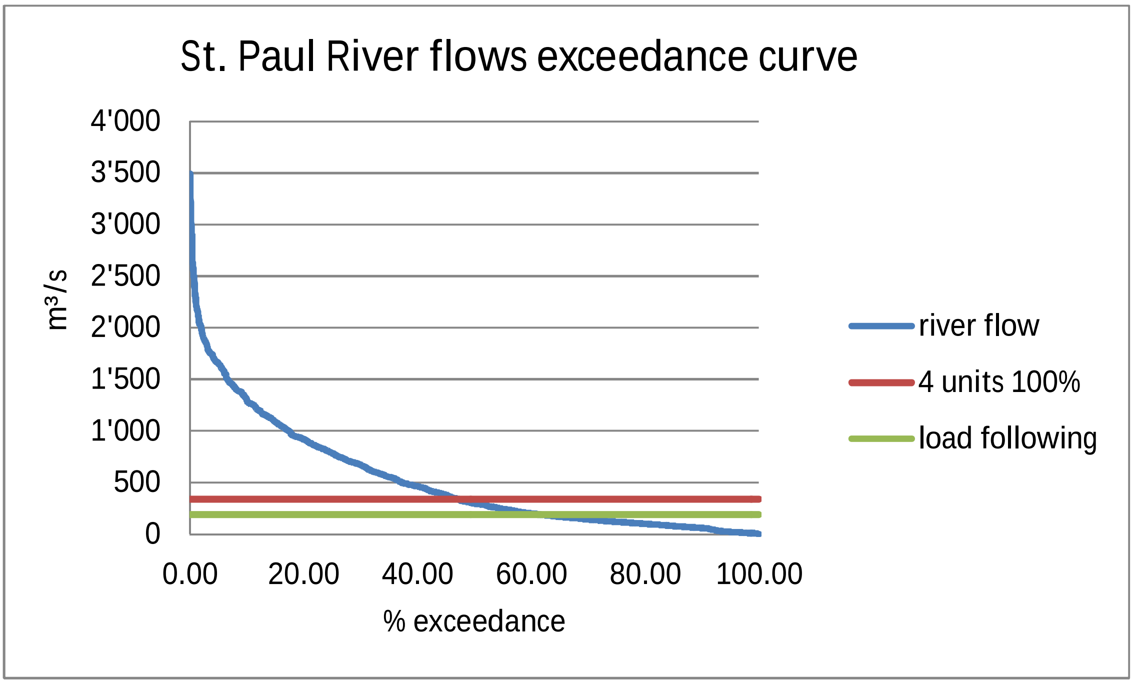


Figure 8-4: River flow and plant operating conditions

During part of this period (14%, see Chapter 16.2.3), an operation pattern including load following will be chosen. The flow in the tailrace channel would vary from potentially minimum flow (about 34 m^3/s; only one turbine operating at part of its capacity) to nearly maximum flow (340 m^3/s; all units operation at full capacity). Within the low flow season (discharge below 190 m^3/s), which occurs on 39% of the time, the plant will operate in some kind of a pseudo load following scenario. During 7.2% of the time there is not enough water to operate one unit even with 40% capacity, and during this time the power plant would have to be shut down for about 4 h for each hour of operation.

8.2.3 Residual Flow

8.2.3.1 Need for Residual Flow

Presently, at the project site water is flowing through two ways, namely (i) through the spillway and in the original river bed, which splits into several branches below the dam site, and (ii) through the breach in the embankment dam into the tailrace channel (see following Figure).

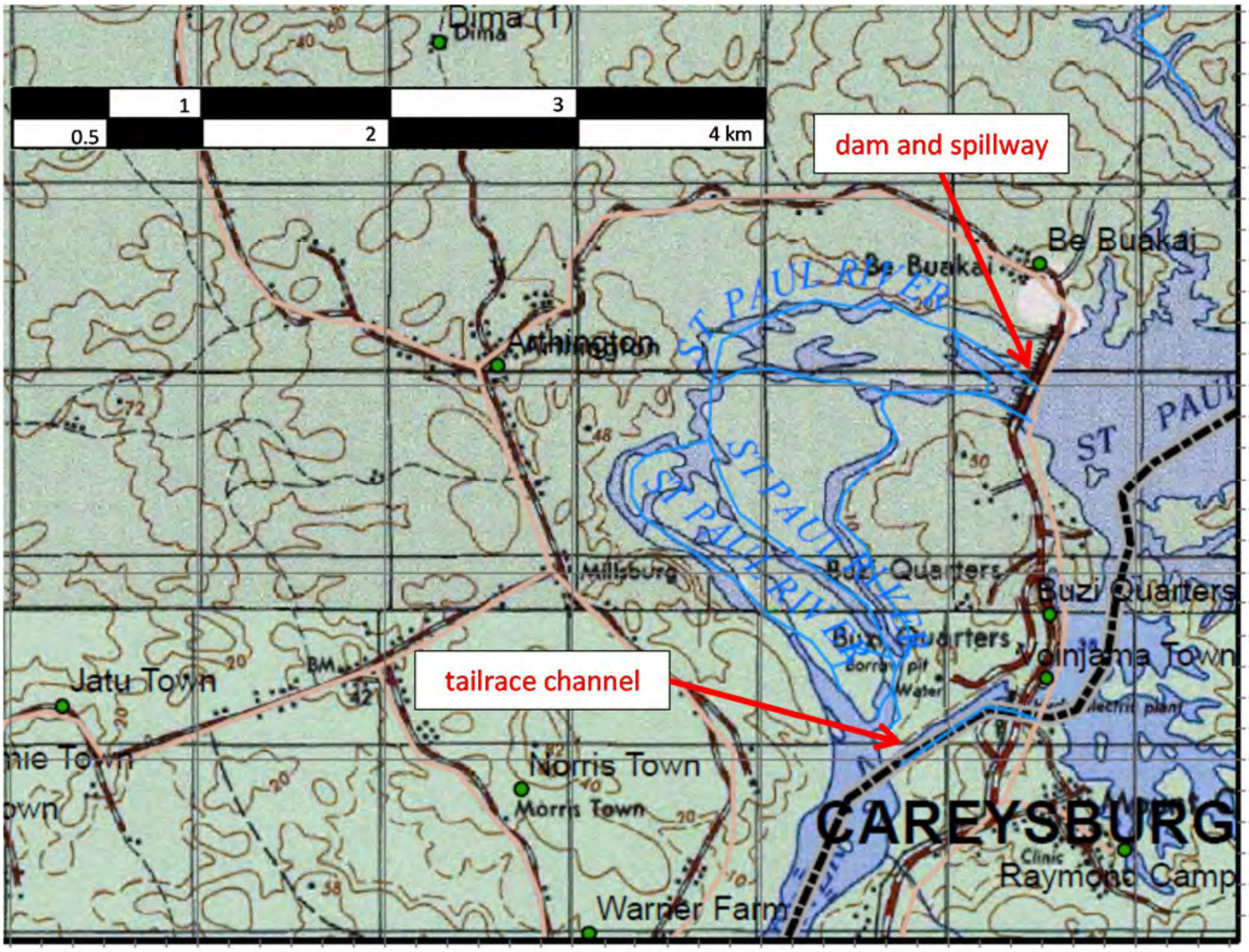


Figure 8-5: St. Paul river d/s of dam and power house.

The Inspection Report (Stanley 2012: 2-28) indicates that the bottom of the tailrace channel is at least in part below average sea level; the lowest points measured are at -2.4 m (-8 ft, see Figure 8-6). This means that even when the turbines will be shut down, this part of the river will not get dry, there will always be some water left.

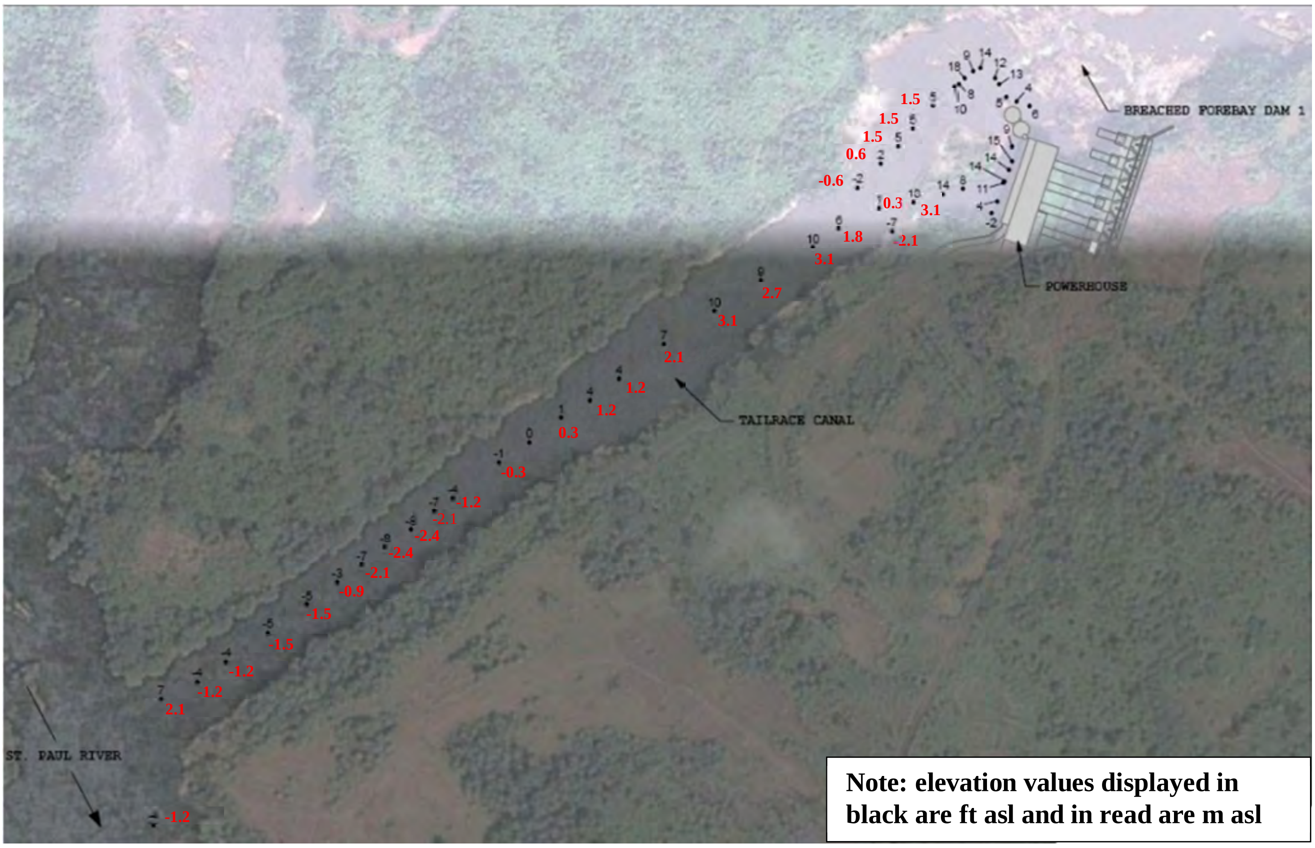


Figure 8-6: Tailrace channel

The situation is different for the original river bed below the dam and spillway structure. Once the dam in place, no water will be left flowing there if the spillway gates are completely closed. During much of the time (47%, see Figure 8-4), there will be some amount of spilling, but the rest of the time basically all water will be used for producing energy. This means that unless a minimum flow is defined which will have to be released at all times from the spillway structure, these approximately 4 km of river would be dry for about 50% of the time, or at least without flowing water, with just some pools left in the deeper parts of the river bed. Since this would be detrimental to aquatic fauna in this part of the river which is an important habitat for the rock fish (*Labeo curriei*, see Chapter 11), and would be in contradiction to international best practice, a riparian flow needs to be defined and maintained.

8.2.3.2 Options

Liberia does not have a legal basis for defining such a minimum flow, and there is no generally accepted rule for this. In this case, the following possibilities can be considered for determining the amount of water to be released as minimum flow:

- Application of a rule used in or defined for other sites. Such rules could be e.g.:
  - Defining the residual flow as $Q_{(95\%)}$ or Q_{347}, i.e. as the flow exceeded in 95% of the time or on 347 days per year on average; this is a rather simple approach used in a number of countries, with an easily determined quantity of water; in the case of Mt. Coffee HPP this would be 22 m³/s.

- Application of a value which would be reached according to Swiss legislation. Here, residual flow is based on Q_{347}, and determined by means of a stepwise increase, leaving a higher proportion of water in smaller rivers. This rule was formulated mainly for highly seasonal rivers in alpine conditions. Applied to St. Paul river (which is not an alpine, but definitely a highly seasonal river), this would result in a residual flow of 4.3 m³/s. However, this law also specifies that this is a minimum value, which might have to be increased depending on specific site characteristics.
- Using the 7Q10 value; this value represents the lowest 7-day average flow that occurs once every 10 years. This would result in a residual flow of 8 m³/s. This corresponds approximately to the lowest flow values recorded in St. Paul river.

- Determination of a value based on site-specific considerations.

8.2.3.3 Evaluation of Options

The affected stretch of the river, between dam and tailrace channel, is rather short, and given the fact that the slope is very gentle and some riverbed pools even her might actually be below seas level, it will not dry out completely. Still, it is certainly a habitat for fish, and a minimum flow, i.e. a minimum amount of actually flowing water, as opposed to stagnant water in some pools, must be maintained. It has also to be considered that the river in this part is divided into several branches. If the residual flow is too small, it would not have the desired effect. On the other hand, the water left flowing from the spillway means a loss in energy production, a fact which also has to be taken into consideration. The following Figure illustrates the effect of different amounts of residual flows on water availability for electricity generation (only situation during low flow conditions).

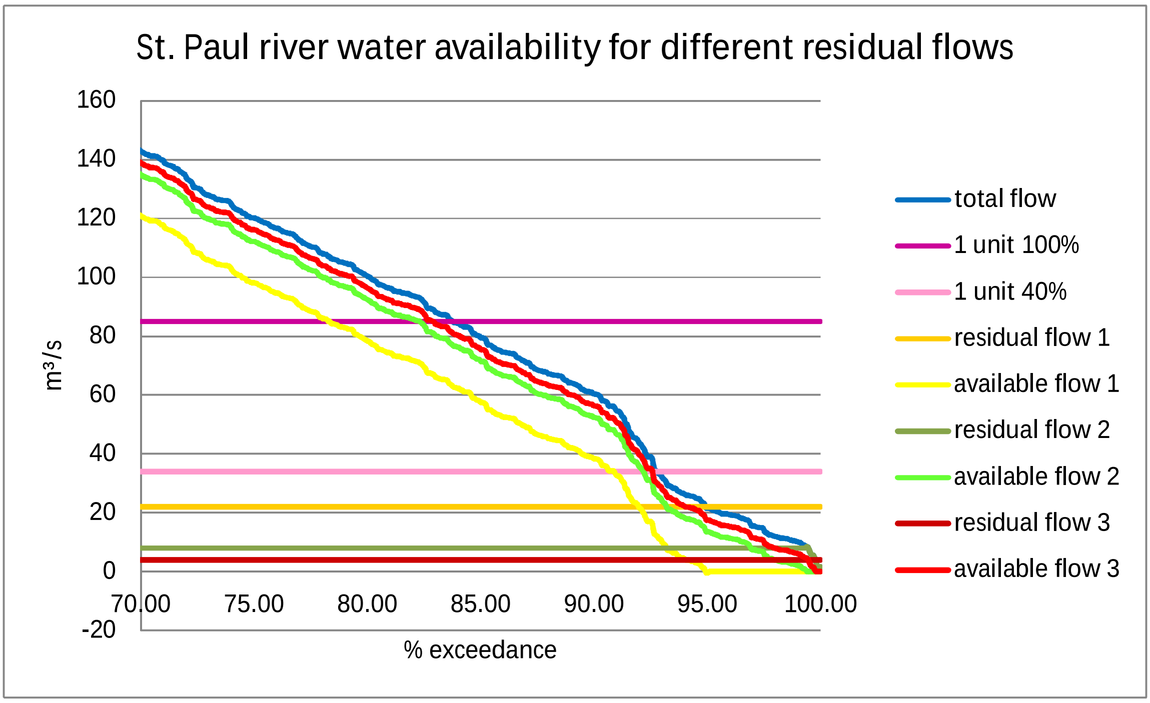


Figure 8-7: Water availability with different amounts of residual flow

The horizontal lines in the graph indicate water requirements for operating one unit at full capacity (100%, 85 m³/s) or at minimum capacity (40%, 34 m³/s), and the three values identified above for residual flow (1 = 22 m³/s, 2 = 8 m³/s, and 3 = 4 m³/s). The flow duration curves indicate water available for turbine operation under the different scenarios.

It is quite obvious from this Figure that the difference in water availability is rather small between cases 2 and 3 (residual flow of 8 or 4 m³/s, respectively), but quite considerable for case 1 (22 m³/s). This is illustrated further in the following Table.

Table 8-3: Consequences of applying different residual flow regimes

Residual flow	Exceedance time for operating one unit at (in % of time)		Loss* (in days on average per year)	
m³/s	**100%**	**40%**	**for 1 @ 100%**	**for 1 @ 40%**
0	83.9	92.8	0	0
4	82.9	92.6	4	1
8	82.3	92.2	6	2
22	78.3	90.9	20	7

* "Loss" here is expressed as the number of days per year during which the respective operation pattern cannot be maintained in comparison with the base case (0 m³/s); it has however to be noted that even in the basecase there are on average 59 days per year (16.1%) with a discharge of less than 85 m³/s, i.e. not enough for operating one turbine at full capacity, and 26 days (7.2%) with less than 34 m³/s.

In addition, the costs of the loss in million USD and the CO_2 production, if this loss of energy will have to be generated with a Thermal Power Plant using Light Fuel Diesel with an efficiency of 3.33kWh/litre (12.6kWh/gallon) is shown in following Table.

For the calculation on CO_2 emission it has been assumed that 1 litre of diesel contains 733g of carbon, which results in the production of 2.68 kg CO_2/l. With an efficiency of 3.3 KWh el. per litre this would result in an emission of about 807 kg CO_2 per produced MWh. Furthermore, 10 kg CO_2/MWh which are generated by Hydro Power Plants have been deducted. For the calculation of cost of loss 0.45 USD/kWh (the actual tariff applied by LEC) has been used.

Table 8-4: Loss in energy production assuming different residual flows

Residual flow m³/s	Mean annual electricity production GWh	Loss GWh	Loss %	Value in million USD	Loss in million USD	CO_2 emission for the replacement of the loss with diesel (TPP) [t]
0	364	0	0	163.80	0	0
4	360	4	1.1	162.00	1.80	3'189
8	357	7	1.9	160.65	3.15	5'580
16	351	13	3.6	157.95	5.85	10'363
22	346	18	4.9	155.70	8.10	14'349
30	340	24	6.6	153.00	10.80	19'131

Source: Stanley Consultants

The different options are discussed here shortly:

- No residual flow (0 m^3/s): this option is listed here mainly as the base case for showing the consequences of the different amounts of residual flow identified above. From an environmental point of view this option is clearly not acceptable since it would mean that the approximately 4 km of river between main dam and tailrace outlet would be dry for over 50% of the time.
- Application of the Swiss rule for residual flow determination (4 m^3/s): in a similar case in Switzerland, this would be the minimum amount to be released. Given the site characteristics (very gentle slope, splitting of the river bed in several branches, generally broad river bed, rocky habitat below the spillway being an important habitat for the rock fish *Labeo curriei*, see Chapter 11), this amount of water is not sufficient from an environmental point of view. . The loss in energy production is considered as acceptable.
- 7Q10 value (8 m^3/s): this amount of water is a considerable improvement, environmentally, as compared to the former case. The additional loss in energy production is considered as acceptable.
- Application of the Q_{347} rule (22 m^3/s): from an environmental point of view, this would be the preferred option, since this could assure a continuous flow of water, presumably in all river branches of the affected stretch. On the other hand, the losses in energy production would be quite considerable, increasing the number of days per year without the possibility of operating at least one unit at full capacity from 59 to 79, and the number of days without any production at all from 26 to 33 (note that these figures are not cumulative). Such a loss, also considering the costs incurred of about 8 million USD per year, does not seem acceptable from a socio-economic point of view.

8.2.3.4 Recommendations

Based on this analysis of the situation, the following recommendations are made:

- A minimum of 8 m^3/s should be released from the spillway structure as the required residual flow.
- The possibility of installing a small unit at the spillway for turbining this water should be investigated (for technical and economic feasibility). This would reduce the loss in energy production due to allocating this residual flow, and it might be possible to use the energy generated there for electrification of the surrounding villages.
- Once the power plant in place and operating, a more detailed assessment of the river bed, the flow conditions throughout the year (with emphasis on the dry season), the presence of species and habitat utilisation should be carried out in order to identify requirements and possibilities for additional measures that might have to be taken for improving the situation (see suggestions below). It is important that a baseline for this is established, i.e. a detailed assessment of present conditions; this will be done by means of the fish fauna monitoring proposed to be carried out during the construction phase.

The two specific recommendations, small unit in the spillway structure and additional study of river flow conditions during operation in order to maximise the benefit of the residual flow, are discussed shortly.

8.2.3.5 Small Unit for Turbining Residual Flow

One very valid argument against a residual flow of 8 m³/s is the costs - or the loss - caused by this measure, estimated to be 3.5 million USD annually.

Here, first of all, it has to be stated that the actual cost might in reality be very much lower. As noted above and explained with more detail in Chapter 25, present tariffs are extremely high, due to the high costs caused by using fuel oil for energy production. Depending on the financing model for MC HPP, generation costs and tariffs might decrease very considerably, to about half of the tariffs applied today (see Table 25-8). This would mean that the "value" accorded to electricity in Table 8-4, as well as the calculated loss, would diminish accordingly.

On the other hand, it would certainly be possible to install a small unit for using the residual flow of 8 m³/s. The result would be as shown in the following Table (it should be noted that investment costs and power generated are rough estimates and not based on a detailed analysis).

Table 8-5: Esitmated costs and benfits of a small unit

Item	Unit	Amount
Installation of turbine of 900 kW	Million USD	4
Yearly generation	GWh/year	7.8
Value of production	Million USD/year	3.51
Loss (acc. to Table 8-4)	GWh/y	7.0
Costs (acc. to Table 8-4)	Million USD/year	3.15
Net benefit	Million USD/year	0.36

Note: investment costs are calculated on the basis of 4000 USD/kW installed. Annual monetary gains and losses are calculated assuming the same tariff as was used for Table 8-4.

The small unit would have a head of approximately 51 m (as compared to the 22 m of the main turbines) and would therefore produce less energy per m³ of water than the main turbines. However, while the loss caused by the residual flow is restricted to the dry season (no loss during the time when there is spilling), the small unit would be operating the whole year round, during the dry season using an additional 8 m³/s of water which would otherwise be spilled. This explains the fact that overall, gain would be slightly higher than the loss, resulting in a small net benefit.

If in addition this electricity could be used for electrification of nearby settlements, this would be an additional benefit for the local population, a measure entirely in the sense of sharing benefits.

8.2.3.6 River Management Measures

The release of a residual flow serves the purpose to keep intact, to the extent possible, the functioning of the affected 4 km of river which would otherwise be completely dry during a considerable period of the year. The main objective of a residual flow is to maintain a certain amount of water flowing in the river bed at all times in order to preserve is function as an aquatic habitat for fish and other aquatic organisms, and in this way also maintain the possibilities for using this river by the local population (mainly for fishing and washing, since there is no major use of the river for drinking water, and there is no irrigation).

Still, it is clear that the river will not remain unchanged. The Project will inevitably have effects on it, the main being the fact that river flow would be limited to the residual flow during the dry season, but can still be quite substantial during periods with spilling. However, as explained above, 8 m^3/s would be sufficient for maintaining a constant flow during the dry season, preventing it from drying up completely.

In the present situation, it is impossible to say how this amount of 8 m^3/s would flow in the river bed (distribution on several channels, or all in one channel; visible river over the entire stretch, or running hidden below boulders and gravel in some places; joining all the important parts, i.e. the deep ponds, or leaving out some of them, which could lead to the death of fish trapped in them; etc.). It is therefore recommended to carry out a study, as part of the monitoring of fish populations proposed), to identify measures that might be required for improving the situation, i.e. for getting the most benefit (environmentally and economically) from this measure.

The following is recommended:

- To make an inventory of relevant habitats (spawning areas, deep ponds, etc.) in the affected part of the river.
- To observe the flow pattern, especially of the residual flow during the dry season (channels with and without water, characteristics of the residual flow in the river bed).
- To identify (potentially) important structures (ponds, gravel beds suitable for spawning, feeding places) and the degree to which they are affected by the changed river flow pattern.

These observations will have to be carried out during the first years of operation of the power plant. Monitoring results obtained during the construction phase will serve as a baseline.

The results of this study will then show if the situation is satisfactory, or if there is a need for improving it, and possibilities to do so. Some measures that might be useful for improving the situation could be the following:

- Modifications of the river bed immediately below the spillway in a way which would allow to distribute the released water to separate into two or more channels (or for keeping it in one channel, if this should be considered as more beneficial).
- Digging a longitudinal channel into the river bed in order to concentrate the limited flow there and to prevent it from spreading too thinly in the existing river bed. This is a measure applied mainly in rivers with low gradients and a wide

bed covered with large amounts of alluvions (gravel, larger boulders), where the water would otherwise be too shallow as to serve as a habitat for fish).

- Digging of local channels for connecting all existing deep ponds and for thus preventing that fish get trapped and finally die in such ponds left without connection to the remaining parts of the river.
- Digging of ponds (deep parts of the river bed) which would provide shelter mainly for bigger fish). This measure might be required if none or an insufficient number of such structures are present in the river bed naturally.
- Changing some parts of the river bed (e.g. by bringing in sediments of specific grain size) for creating suitable spawning habitats for valuable species.

It goes without saying that the decision on what such measures to take - if any - will have to be based on a thorough analysis of the situation. If required, a bathymetric and topographic survey of the river bed or parts of it will have to be carried out.

8.3 Water Use

8.3.1 Present Situation

The water of the St Paul river is used upstream and downstream of the spillway for fishing, washing, bathing and in some cases for irrigation with pumps. Drinking water is collected from streams (tributaries to St. Paul river) because of to better water quality. Only in case of a water shortage during the dry season, which does not occur very often, the water of the St. Paul river is used as drinking water.

Furthermore, canoes are used for transportation in the reservoir area for reaching remote villages, like Gbally Village.

8.3.2 Project Impacts

It is expected that the project will not have any major impacts on water use.

The impact on transportation in the reservoir area will be beneficial since the current especially in the rainy season will be reduced and it will be safer to cross the reservoir by canoe. On the other hand, during the dry season people who do not have a canoe cross the river on foot; this will not be possible any more due to the higher water level.

Since the water is not used as drinking water except during very dry seasons the impact will be negligible as long as the mitigation measures and best practice related to waste water of the construction site are in place.

Impact on washing activities is not anticipated, since no major changes will occur with the exception of the area where it will be prohibited to enter the water due to safety reasons (construction site and the area near the dam and spillway).

8.3.3 Recommendations

It is recommended to provide some larger motorised canoes to the population for crossing the reservoir at suitable locations, so that they are able to cross the reservoir during all times to do their market activities.

8.4 Water Quality

8.4.1 Present Situation

Water quality is an issue not in the least due to the fact that the main source of drinking water for Monrovia is While Plain, a treatment plant located a short stretch d/s of the dam site and the efforts made for rehabilitating the pipe line for taking water directly from the reservoir. Measures will have to be taken for preventing a deterioration of water quality due to the project.

The following Table summarises the few water quality data available from St. Paul river (see also Annex 8).

Table 8-6: Water quality data for St. Paul river

Item	Symbol	Unit	1.	2.	3.	4.	5	6	7	WHO
pH		s	6.17	6.3			6.5	6.9	6.9	6.5-8.5
Oxygen	O2	mg/l	-	-	-	-	6.4	8.1	-	-
Copper	Cu	mg/l	0.003	0.0023	0.034	0.037	-	-	-	1.0
Iron	Fe	mg/l	4.3	0.52	1.45	0.79	2.2	1	1	0.3
Lead	Pb	mg/l	0.0028	0.034	0.0016	0.0123	-	-	-	0.05
Mercury	Hg	mg/l	<0.0005	<0.0005	<0.0005	0.0003	-	-	-	0.0006
Manganese	Mn	mg/l	0.031	0.0046	0.032		-	-	-	-
Sodium	Na	mg/l	5	4	4	4.5	-	-	-	200
Potassium	K	mg/l	0.8	1.1	1.5	1.1	-	-	-	-
Calcium	Ca	mg/l	<0.4	1.2	4	2.4	-	4	4	-
Magnesium	Mg	mg/l	2.1	1.7	1.5	1.7	-	-	-	-
Chloride	Cl	mg/l	5.2	5.0	4.2	3.6	-	-	-	250
Nitrate	NO3	mg/l	7.0	8.5	<2.0	2.0	-	-	-	-
Total dissolved solids	TDS	mg/l	14.2	13.6	10.0	9.09	-	-	-	1000
Total hardness	CaCO3	mg/l	9	10	16	13	4.3	5	5	500
Conductivity		µS/cm	28.7	27.1	20.1	18.6	-	27.3	27.3	-
Turbidity		NTU	15.2	2.3	18.8	3.8				5
Temperature		°C	25.5	26.8	27.1	26.6	-	-	-	-
Total coliform		N/100 ml	1500	>500	2300	4500	-	-	-	3
Faecal coliform		N/100 ml	1240	466	40	1700	-	-	-	0

Samples sites and date:

1. Mt. Coffee, 2009-01-22
2. White Plain, 2009-01-22
3. Mt. Coffee, 2009-07-16
4. White Plain, 2009-07-16
5. St. Paul river, 1984-10-13
6. St Paul river, dam, 1985-10-25
7. St. Paul river, White Plain, 1985-10-25

WHO: values for drinking water standards

The 2009 measurement campaign (Samples 1-4) included a high number of additional samples (see Annex 8). As this shows, most items, especially heavy metals, are below detection limits; this was the case for arsenic, boron, cadmium, chromium, mercury, molybdenum, nickel, and for the non-metals cyanide, selenium, sulphate and ammonium.

The samples indicate water with a very low mineralisation (low content in overall dissolved solids, low conductivity) and of a generally good quality, in most parameters reaching drinking water standards. The only parameter which is constantly above the limits is coliform bacteria, both in terms of total and faecal coliform, indicating contamination of the water with human waste.

8.4.2 Project Impacts

During the construction phase for rehabilitating Mt. Coffee HPP there is a risk of water contamination mainly from the following sources:

- Increased load in suspended solids stemming from the construction site.
- Contamination with concrete, resulting in a higher pH which could potentially be toxic for fish.
- Contamination with hydrocarbons (fuel, lubricants etc.) and other toxic substances used on site.
- Contamination with human waste from the worker's camp.

During operation, there could be a small risk of an increased load in organic matter shortly after reservoir impoundment (see Section on GHG below). Otherwise, there is no risk of water contamination from the power plant, as long as it is well maintained and operated according to standards (e.g. transformer oil).

8.4.3 Other Sources of Contamination

Upstream of Mt. Coffee reservoir there are no major industrial activities which could lead to water contamination. One additional potential source of contaminants, mainly heavy metals, were the Bong Mines; however, these are no longer in operation. If operation should resume there, measures would have to be taken for preventing water contamination.

Presently, in the project area there is one potential source which could lead to water contamination: small scale artisanal gold mining (see Section 14.2.3). The miners use mercury for extracting the gold, and this is known to be a serious water contaminant. Available water quality analyses (see Table 8-6) so far have not detected any water contamination with mercury which would be above the WHO limit value for drinking water. Nevertheless, the risk does exist, and could be acute if this type of activity should be intensified. A check for mercury will have to be included in water quality monitoring programs.

8.4.4 Conclusions and Recommendations

During the construction phase, the required measures will have to be taken to prevent water contamination (like sedimentation basins for water with a high load of suspended solids and/or contaminated with concrete; appropriate storage of fuel, lubricants and chemicals; good maintenance of vehicles and machines to prevent losses of oil; maintenance and repair of vehicles and machines in suitable sites (equipped with oil skimmers), no such activities in or close to the river; waste water collection and treatment. The measures are listed in the provisional ESMP (see Chapter 20 and 21).

An additional potential source of contamination of the St. Paul river would be the Bong Mines, which are presently closed. If the mines should be opened again, the EIA to be done for it at that time would have to assess the risk for water contamination, and would have to propose the required mitigation measures.

Routine water quality monitoring will have to include mercury as a standard parameter, given the fact that this heavy metal is used in the small gold mining activities u/s of Mt. Coffee dam. The importance of this measure is given mainly for the White Plains drinking water plant.

8.4.5 Reservoir Stratification

Large and deep reservoirs in temperate climates, like natural lakes, usually show a thermal stratification during summer, when water temperature at the surface is rather high, while water in greater depth is much colder.

An empirical dependence of reservoir stratification on residence time (τ) to the maximum temperature difference between the surface and hypolimnion (i.e. water in the deeper areas of the reservoir) was found by Straskraba and Mauersberg (1988; cited after EAWAG 2006) for several reservoirs in the Czech Republic, approximated by the equation:

$\Delta T_{0-30} = 20\ (1\text{-}\exp\ (-0.0126 * \tau))$

whereby ΔT_{0-30} is the difference in water temperature between the surface and a depth of 30 m, and τ is the residence time of the water in the reservoir.

Mt. Coffee HPP has a relatively small reservoir with a maximum depth of only about 15 m, and since it will be operated mostly as a run-of-river project (the level of the reservoir being kept at a constant elevation of 29 m asl, and as a maximum some daily peaking during the dry season) the turnover time of the water in the reservoir is short; in fact, it is only about 2 days as a yearly average. Temperature difference between reservoir and river water will be small, a condition which does also not favour stratification, and strong winds can lead to a mixing of water from different layers.

As a conclusion it can be stated that there is very little probability that a stable thermal stratification will develop in Mt. Coffee reservoir.

8.4.6 Oxygen and GHG Emissions

8.4.6.1 Importance

Reservoir stratification is also important with respect to oxygen content of the water. During a stable thermal stratification in summer, oxygen in deeper layers can be depleted if large amounts of organic matter have to be broken down. In the case of a reservoir, this can be the case under two conditions, namely:

- after first filling, if large amounts of biomass (vegetation) was submerged and is now being broken down, and
- in cases where eutrophication of the reservoir happens, i.e. when large amounts of nutrients are being brought into the reservoir, which lead to a high plant (algae) productivity close to the surface, where there is enough light for photosynthesis.

Both situations can lead to anoxic conditions in the reservoir, and this in turn will lead to methane (CH_4) production; methane is a very powerful greenhouse gas (GHG). This is the case mainly in large tropical reservoirs, where often very large amounts of biomass are submerged.

8.4.6.2 Expected Situation in Mt. Coffee Reservoir

Mt. Coffee reservoir, with a surface of about 8 km² and a maximum depth of about 18 m, is a rather small and shallow reservoir. In such a situation, the risk of stratification and oxygen depletion is usually rather small. In the following Table, a calculation is made which illustrates the expected outcome in this project.

Table 8-7: Oxygen requirements in Mt. Coffee reservoir

	Parameter	**Unit**	**Mt. Coffee**
1	Biomass total (soft only)	t	60'075
2	Reservoir area	ha	801
3	Biomass average (soft biomass only)	t/ha	75
4	Mean annual river discharge	m³/s	564
5	Water in res., total volume	M m³	90
6	Annual inflow	M m³	17'766
7	Oxygen in inflow water	mg/l	8.00
8	Oxygen per m³	g/m³	8.00
9	Oxygen total at first filling	t	720
10	Oxygen total in annual inflow	t	142'128
11	Oxygen demand /t biomass	t	1.07
12	Oxygen demand total	t	64'280
13	O2 balance 1: O2(1st filling) - O2 demand	t	-63'560
14	O2 balance 2: O2(annual inflow) - O2 demand	t	77'847
15	O2 balance 1: % of O2 required available at 1st filling	%	1.1
16	O2 balance 2: % of O2 required available yearly	%	45

Explanations:
1 = total soft biomass (leaves, twigs) in the reservoir area to be submerged at first filling
2 = reservoir area in ha
3 = soft biomass per ha (estimated in comparison with other sites with similar vegetation)
4 = mean annual river discharge at dam site
5 = total reservoir volume at FSL
6 = total amount of water flowing into the reservoir per year
7 = mean concentration of oxygen in inflowing water
8 = total oxygen per m³ of inflowing water (assuming saturation at about 25°C)
9 = total amount of oxygen in amount of water required for filling the reservoir
10 = total amount of oxygen flowing into the reservoir per year
11 = amount of oxygen required to decompose 1 to of biomass
12 = total amount of oxygen required to decompose the submerged soft biomass
13 = O2 balance at first filling (meaning that an additional 63'560 t of oxygen would be required for decomposing all the soft biomass after first filling)
14 = O2 balance after one year (meaning that after breakdown of all soft biomass in the reservoir, from first year input there is a surplus of about 78'000 t of oxygen)
15 = the water after first filling of the reservoir contains only 1.1% of the oxygen required for breaking down all the soft biomass submerged
16 = breaking down all the soft biomass submerged requires only 45% of the oxygen content of the water flowing into the reservoir in one year

For additional explanations of the model see Zwahlen (2003)

8.4.6.3 Conclusions

From the Table above, the following conclusions can be reached:

- Water turnover in the reservoir is very high; in fact, the entire content of the reservoir is replaced almost 200 times per year, which means an average retention time of less than 2 days.
- The reservoir is too small, and mainly too shallow, to develop a stable thermal stratification. This means that also the deeper layers of the reservoir will be renewed and will receive oxygen constantly, there will be no development of anoxic conditions.
- The high water turnover rate will also mean that a considerable part of the soft biomass will be flushed out of the reservoir; this will mean an increase in organic matter in the river d/s of the power house.
- The breakdown of the soft biomass is a process which will last several months. Sufficient amounts of oxygen will be available in the reservoir for this process.

This leads to the main conclusion that there is no risk of oxygen depletion, no formation of anoxic conditions in the deeper part of the reservoir, and that therefore no GHG emissions are to be expected from the reservoir, even if no measures are being taken to minimise the amount of biomass before impoundment.

8.4.6.4 Proposed Measures

However, even in the absence of this risk, it is still recommended to take certain measures which would result in a reduction of the amount of biomass, even if no total per-impoundment clearing is undertaken. The following measures are recommended:

- Cutting of trees which can be used, either for timber or for producing charcoal. The local population should be encouraged to use all timber resources within the reservoir to the extent possible. The main reason of this measure is to make use of a valuable resource which would otherwise be lost.
- Cutting and burning of all trees which cannot be used, before impoundment. The main reason for this measure is the elimination of trees which would otherwise remain standing in the reservoir, possibly for years, and would constitute obstacles and dangers for boats and fishing gear.
- Shortly before impounding (if possible; this would have to be done in the last dry season before impounding) cutting of as much vegetation as possible, and burning it. This should be done mainly in the deeper areas of the reservoir.

These measures would have the following beneficial effects:

- Reducing the amount of biomass left, and thereby reducing the risk of water quality problems, in the reservoir.
- Reducing the amount of biomass to be flushed into the river d/s of the dam.
- Reducing the amount of wood debris floating on the reservoir and/or getting into the trash racks of the power house.
- Reducing the number of dead trees standing in the water, which would represent dangers for boats and obstacles for fishing in the reservoir.

II. THE BIOLOGICAL ENVIRONMENT

The biological diversity of an area is made up by the number of species of plants and animals that exist there, and by the number and extent of habitat types which they inhabit and help to form. Furthermore, some areas contain a high number of endemic species, i.e. species that exist only in this area and nowhere else on earth.

A large number of species have become very rare or even extinct through the progressive shrinking of specific habitat types as e.g. primary forests or wetlands, sometimes in combination with other influences like hunting. Species that are rare by nature, as the large predators, especially attractive for one reason or another, as furbearers or "trophy animals", or that depend entirely on a specific, threatened habitat type as amphibians (wetlands) are especially vulnerable.

Hydropower projects can affect biodiversity mainly in the following ways:

- direct destruction of habitats, mainly by submerging large areas through formation of a reservoir;
- indirect disturbance through improved access to hitherto inaccessible areas or through the resettlement of the people living in the reservoir area to formerly natural areas;
- disruption of a river by formation of a lake (reservoir), by impeding migrations of aquatic species through construction of a dam; and by changing the downstream flow pattern in this river.

The first two points affect mainly terrestrial vegetation and fauna, while the third point refers to impacts on hydrobiology (fish and other aquatic life). In addition to these points, the construction phase can have a major impact on specific species, e.g. by increasing pressure on certain plants or animals, mainly be collecting or (usually illegal) hunting carried out by the work force.

9 VEGETATION

9.1 Present Situation

Liberia is rich in plant biodiversity. This richness is a result of a combination of geographical and climatic factors including high temperature, high rainfall and low attitude that occurs in high forest-vegetation covering the major part of Liberia. Other vegetation types developed on limited areas as beaches, natural savannahs and poor drained swamps are either edaphic origin or degraded forests. In fact according to A. G. Voorhoeve (1965) and Dunken et al. 2003, this country belongs to the Guineo-Congolian forests of Congo-Basin which includes the evergreen forests of Upper Guinea and the mixed evergreen/semi-deciduous forests, separated by a steep and hill escarpment area.

Liberia can be roughly divided into four geographical zones: coastal plains, rolling hills, plateau and tablelands and northern highlands. This is also shown in the diversity of the vegetation in Liberia.

The coastal plain is characterized by lagoons, mangrove swamps, river-deposited sandbars, riparian and coastal vegetation. This zone extends up to 65 km inland with a maximum altitude of 50 m asl. The rolling hills are situated behind the coastal zone. This zone is characterized by hills, valleys and watercourses. Most of the agricultural land is situated in this zone due to the favourable climate and topography. The rolling hills have an elevation of 90 m asl, and in their natural state they are covered with tropical rainforests. Plateau and tablelands are up to 300 m in elevation and mountain ranges reach an altitude of 610 m asl. Important ranges within this zone are the Mano river mountains and the Bea, Bong, Gibi, Kpo, Putu and Tienpo ranges. The greatest width of this zone is 129 km between the Lofa and Saint Paul rivers. The northern highlands are located in the upper Nimba and Lofa counties (UNEP, 2004).

The forest ecosystem of Liberia can be divided into four classes:

- primary dense forest
- climax secondary forest
- secondary forest which has not reached climax
- other mixed vegetation.

The Mt Coffee HPP is located in the rolling hill zone. This area has been greatly influenced by human activities like shifting cultivation, fuelwood collection and charcoal production. The project area is characterised by patches of secondary forest, sugar cane plantations and some palms.

9.1.1 Description of Original Vegetation

In the dam's area of influence, three main original types of vegetation occur:

- Mixed evergreen and semi-deciduous forests with elements of evergreen low land forest predominant. This vegetation type occurs mostly in downstream area. The forest where it is existent, presents a closed canopy and opened areas are occasionally where the forest is poorly developed. The canopy is dominated by many trees species such as *Anthonotha fragrans, Calpocalyx* spp, *Canarium* *schweinfurthii, Lophira alata, Petersianthus macrocarpus, santiria trimera, Tabernaemontana crassa* and *Uapaca guineensis.* The undergrowth is dominated by *Haumania danckelmaniana, palisota ambigua* and *Heisteria parviflora.*

- Mixed evergreen and semi-deciduous forest with the predominance of the elements of semi-deciduous forest. This forest type which occurs in upstream area is similar to the forest described above, but it contains many more semi-deciduous elements than the former. The forest is characterised by a discontinuous canopy regularly with scattered plant species which include *Anisophyllea polyneura, Pycnanthus angolensis, Pentaclethra macrophylla, Santiria trimera, Lophira alata.* The undergrowth is dominated by *Haumaniana danckelmaniana* and rattan species such as *Calamus deeratus, Laccosperma* spp.
- The vegetal formation mostly monospecific of *Pterocarpus santalinoides.* Well developed sometimes on rocky soil and scattered along the river borders from downstream to upstream. Sometime this plant is accompanied by *Nauclea pobeguini, Uapaca heudelotii* and *Myrianthus arboreus.*

In some areas degradation is very severe, only few trees are still standing in secondary vegetation consisting of woody pioneer species like *Alchornea cordifolia, Harungana madagascariensis* and herbaceous species including *Chromolaena odorata, Nephrolepis biserrata* and *Buforestia mannii.*

9.1.1.1 Overview of the Flora in the Dam's Zone of Influence

Floristic diversity of the dam's zone of influence was assessed by sampling bases on the establishment of parcels 0.1 ha (100 m x 10 m). A total of 10 parcels were established (2 in downstream, 5 five in the reservoir and 3 upstream), covering a total surface of 1.0 ha. In addition plant species were identified here and there outside the parcels. Many types of plant habitus are nowadays found in the dam's zone of influence:

- The old secondary humid rain forests, characterized by high canopy and the understorey rich in shrubs such as *Rauvolfia vomitoria, Ficus spp, Bridelia micrantha.*
- Young secondary forests, characterized by short opened canopy and the presence of *Anthocleista vogelii, Anisophyllea meniaudi, Bridelia grandis, Harungana madagascariensis, Barteria nigritiana.* The undergrowth is rich in *Tetracera alnifolia.*
- Along certain tributaries of the main river there are swamping forests established in valleys, rich in *Spondianthus preussii, Nauclea pobegueni* and *Duguettia mannii.*
- Periodically flooded forests developing where water was flooded during the functioning of the dam and where water is flooded now during the raining season. Here the canopy is dominated by the abundance of *Pterocarpus santalinoides.* The undergrowth is completely absent.
- At some spots of the reservoir there are herbaceous meadow on rocky soils characterized by Graminaceae like *Acroceras* sp, *Aoranthe cladantha* and *Centothecea lappocea*.

There are significant physical differences between downstream, reservoir and upstream forests.

9.1.1.2 Characteristic of the Vegetation and the Flora in Downstream Area

The human activities have destroyed very much of the vegetation in the downstream. In 0.2 ha, only 99 trees were identified representing 25 plant families and belonging to 42 plant species. The most dominant plant families are Bombacaceae (mainly represented by *Ceiba pentandra*), Burseraceae (mainly represented by *Dracryodes klaineana*), Fabaceae-Caesalpinioideae (mainly represented by *Pterocarpus santalinoides*) and Humiriaceae (mainly represented by *Saccoglottis gabonensis*). The most abundant families are Burseraceae (represented by *Dacryodes klaineana*), Fabaceae-Faboideae (*Pterocarpus santalinoides*) and Fabaceae-Caesalpinioideae (mainly represented by *Tetraberlinia tubmaniana*).

In the downstream area, the most dominant and abundant species is *Dacryodes klaineana*, followed by *Ceiba pentandra* and *Pterocarpus santalinoides.* The following families and corresponding species were here and there identified in the downstream area: Bombacaceae for *Bombax bunopozens,* Sterculiaceae for *Sterculia tragacantha* et *Theobroma cacao,* Anacardiaceae for *Pseudospondia microcarpa,* Miliaceae for *Entandrophragma cylindrica*, Dracaenaceae for *Dracaena arborea,* Moraceae *for Ficus mucuso,* Gramineae for *Bambusa vulgaris,* Arecaceae for *Raphia hookeri*, Melastomataceae for *Memecylon blackeoides* and Rubiaceae for *Morinda geminata*. With the families of Anacardiaceae, Dracaenaceae, Graminaceae, Arecaceae, Melastomataceae recorded outside the parcels, 30 plant families in total were identified for 52 plant species.

Herbs like *Menanthera scandens, Passiflora foetida, Euphorbia hirta, Aspilia africana* were observed in wet medium.

9.1.1.3 Characteristic of the Vegetation and the Flora in the Reservoir

Two hundred and ninety two (292) trees were identified in 0.5 ha of the reservoir. They belong to 16 families and 33 plant species. The most dominant and abundant families here are: the Euphorbiaceae, predominantly represented by *Hevea brasiliensis*, the Fabaceae-Faboideae whose main representatives are: *Pterocarpus santalinoides* which constitutes a monospecific forest in some parts of the reservoir, the Rubiaceae, mostly represented by *Nauclea pobeguini* and *Nauclea diderrichii*.

Fabaceae-Faboideae is the most important local plant family, not taking into consideration *Hevea brasiliensis* (Robber tree, introduced by man in Agroforests).

Pterocarpus santalinoides is the most abundant plant in the reservoir followed by *Nauclea pobeguini*. Whilst it is *Pentaclethra macrophylla* and *Nauclea diderrichii* are the most dominant plant species.

The fallow land and the young secondary forests is characterized by the abundance of *Alchornea cordifolia, Chromolaena odorata, Phyllanthus* sp, *Nephrolepsis biserratta, Smilax kraussiana, Dalbergia ecastaphyllum, Tetracera alnifolia, Tetracera potatorum, Buforestia manni*, *Scleria verrucosa* and *S. naumanniana*. Dominant herbs grow very near the river bank. They are *Ludwigia decurrens, Polygonum lanigerum, Heliotropium indicum* and *Mimosa invisa.*

9.1.1.4 Characteristic of the Vegetation and the Flora in the Upstream Area

One hundred and ninety trees (190) were identified in 0.3 ha plot in upstream area. They belong to 29 plant families and 72 plant species. The family of Fabaceae-Caesalpinoideae is far more dominant, following by Olacaceae, Fabaceae-Mimosoideae and Burseraceae, respectly represented by *Pellegriniodendron diphyllum, Strombosia glaucescens, Piptadeniastrum africanum* and *Dacryodes klaineana.* The Olacaceae, the Burseraceae and the Fabaceae-Caesalpinoideae are the most abundant plant families. Amongst the most dominant species there are: *Pellegriniodendron diphyllum, Anthocleista vogelii, Rhodognaphalon brevicuspe, Dacryodes klaineana, Strombosia glaucescens, Lophira alata,* etc. *Strombosia glaucescens* is far more the abundant species, followed by *Dacryodes klaineana, Santira trimera, Lophira alata, Pellegriniodendron diphyllum, Carapa procera,* etc.

The undergrowth in the upstream forest is constituted by *Heisteria parviflora,* young trees of the high forest and shrubs like *Dracaena arborea, Diospyros* spp, *Strychnos* spp, *Elaies guineensis.*

The following families and corresponding species were here and there identified in upstream area: Bombacaceae for *Bombax bunopozens,* Sterculiaceae for *Sterculia tragacantha* and *Theobroma cacao,* Anacardiaceae for *Pseudospondia microcarpa,* Meliaceae for *Entandrophragma cylindrica,* Annonaceae for *Monodora tenuifolia,* Dracaenaceae for *Dracaena arborea,* Moraceae *for Ficus mucuso,* Gramineae for *Bambusa vulgaris,* Arecaceae for *Raphia hookeri,* Flacourtiaceae for *Lindackeria dentata,* Melastomataceae for *Memecylon blackeoides,* Sterculiaceae for *Pterygota mildbraedii, Cola lateritia, Cola digitata, Cola nitida, Cola chlamydantha* and *Heritiera utilis,* Myristicaceae for *Pycnanthus angolensis,* Passifloraceae for *Barteria nigritiana,* Samydaceae for *Casearia dinklagei,* Fabaceae-Caesalpinoides for *Sindora klaineana,* Pandanaceae for *Pandanus candelabrum* and Rubiaceae for *Morinda geminata.* With the families of Dracaenaceae, Anacardiaceae, Samydaceae, Melastomataceae, Passifloraceae, Graminaceae, Flacourtiaceae and Arecaceae recorded outside the parcels, 31 plant families in total were identified for 94 plant species.

9.1.1.5 Comparison of the Three Zones

In the three zones (downstream, reservoir and upstream) there are four common types of vegetation including: young secondary evergreen humid forest, fallow land, riparian forest and agroforest of *Hevea brasiliensis*. In upstream and downstream there is also the old secondary forest. So because of the uneven relief men has not cultivated in some places.

The plants in the reservoir are mainly pioneer or light demanding species like *Musanga cecropioides, Alchornea cordifolia, Harungana madagascariensis, Macaranga spinosa, M. schweinfurthii, M. hurifolia, Albizia* spp, dominated by *Anthocleista vogelii*. Very few young plants of the high forest are found there. All these sun shining species are found all over the place in the downstream and upstream areas. Another feature of the reservoir is the presence of many old stumps of trees that were killed by water 20 years ago.

All the 33 short height species found in the reservoir have been recorded elsewhere.

In terms of plant species recorded, the vegetation in the dam's zone of influence is characterized by the presence of *Lophira alata* in the storey of emergent trees, *Heritiera utilis*, *Saccoglottis gabonensis*, *Calpocalyx aubrevillei* in the closed canopy and lower storeys. Valuable timber trees that are relatively scarce include: *Guarea cedrata*, *Entandrophragma* spp, *Khaya anthotheca*. These species are characteristic of the evergreen forest Zone described by Voorhoeve, 1965. Particularities are observed in swampy forest and in river borders. In swampy forest, the common tree is *Hallea stipulosa* for *Mytragina stipulosa* forests, *Spondianthus preussii* for *Spondianthus preussi* forests. These forests were seen in swampy valleys which are not flooded during the whole year. In riparian forest, specific trees are *Cathormion altissimum, Monopetalanthus compactus* and locally gregarious *Pandanus candelabrum.*

9.1.1.6 Endemism and Conservation Status of Recorded Species

The following items are included in this paragraph as far as information is available: distribution of the species within Africa (White 1983), the phytogeographic areas referred to:

Upper Guinea. The upper Guinea refugium, covering the evergreen forest zone near the coast and the Mounts Nimba in Liberia, Sierra Leone, Ivory Coast, Ghana, separated from the Lower Guinea forests by a dry belt around Benin, Togo and western Nigeria.

Lower Guinea. Refuge area along the Atlantic coast, that extends from the extreme South-East Nigeria through Cameroon, Equatorial Guinea and Gabon, and into Democratic Congo Republic. **Congo basin**. Inland forests of Congo basin, that extends up to the mountain ranges of eastern Democratic Congo Republic.

Widespread, tropical Africa: Distribution extends beyond the above three areas of the Congo Basin forest.

Conservation status: Status assigned to the full identified species, based on a synthesis preliminary works published either by Jean Michel Onana National Herbarium of Cameroon, or A. G. Voorhoeve (1965) or developed by Limbe Botanic Garden: **Rare**. Narrow endemic, few records only. Hight conservation concern, equivalent of IUCN endangered threatened status. **Uncommon**. More recorded than rare. But still only known from one or two countries, equivalent of IUCN vulnerable (VU). **Common**. Recorded with few collections but flagged as a possible species of concern, equivalent to IUCN lower threat status. **Abundant.** No conservation concern, lower Guinea endemic, then common within the area. When no conservation status is listed then the status is unknown.

The table below lists the species identified in the project area that are in the IUCN red list or have a specific status in Africa.

Table 9-1: Plants with IUCN conservation status or with a specific african status

Scientific names	Zone of endemism or distribution	African specific conservation status	Reference	IUCN status
Rhodognaphalon breviscupe	Widespread			VU
Terminalia ivorensis	Widespread			VU
Guarea cedrata	Widespread			VU
Guarea thompsonii	Widespread	Abundant	Dunken and al., 2003	NT
Lophira alata	Upper and Lower Guinea	Some conservation concern	Dunken and al., 2003	VU
Hallea stipulosa	Upper and Lower Guinea	Some conservation concern	Dunken and al., 2003	VU
Nauclea diderrichii	Upper and Lower Guinea	Some conservation concern	Dunken and al., 2003	VU
Brachystegia leonensis	Sierra Leone, Liberia, SW. Ivory Coast		A. G. Voorhoeve (1965)	
Copaifera salikounda	Upper Guinea		A. G. Voorhoeve (1965)	

Scientific names	Zone of endemism or distribution	African specific conservation status	Reference	IUCN status
Cryptosephalum tetraphyllum	Sierra Leone, Liberia, SW. Ivory Coast		A. G. Voorhoeve (1965)	
Monopetalanthus compactus	Sierra Leone, Liberia, SW. Ivory Coast		A. G. Voorhoeve (1965)	VU
Stachyothyrsus stapfiana	Sierra Leone, Liberia, Ivory Coast		A. G. Voorhoeve (1965)	
Tetraberlinia tubmaniana	Liberia		A. G. Voorhoeve (1965)	VU
Newtonia aubrevillei	Sierra Leone, Liberia, SW. Ivory Coast		A. G. Voorhoeve (1965)	
Cassipourea hiotou	Liberia, SW. Ivory Coast, Ghana		A. G. Voorhoeve (1965)	VU
Guibourtia ehie	Widespread		www.iucnredlist.org	VU
Nesogordonia papaverifera	Widespread		www.iucnredlist.org	VU
Gilbertiodendron splendidum	Upper Guinea		www.iucnredlist.org	VU
Pellegriniodendron diphyllum	Upper and Lower Guinea		www.iucnredlist.org	NT
Anopyxis klaineana	Upper and Lower Guinea		www.iucnredlist.org	VU
Berlinia occidentalis	Upper Guinea		www.iucnredlist.org	VU
Khaya anthotheca	Widespread		www.iucnredlist.org	VU
Pterocarpus santalinoides	Widespread		www.iucnredlist.org	LC

Only *Pterocarpus santalinoides* is a threatened species identified in the reservoir. Because of human activities, plants which grow in the reservoir are quickly destroyed. This plant is the most representative species in the reservoir. But it is also outside, along river borders. Therefore, the dam does not have any negative influence on any plant. But the population is able to completely destroy them. Many of these plants are widespread, some endemic both in Lower Guinea and Upper Guinea and in Upper Guinea. *Cassipourea hiotou, Monopetalanthus compactus* and *Gilbertiodendron splendidum* are endemic in three countries: Liberia, Sierra Leone and SW of Ivory Coast. *Tetraberlinia tubmaniana* is the only timber tree which is endemic in Liberia. Despite of the human pressure on this valuable resource and its habitat (lowland forest), it occurs at high densities in a number of forest reserves.

Some threatened species in Liberia

Guibourtia ehie is a West African timber which occurs in moderate densities. It grows in different forest types, from closed rainforest to drier semi-deciduous forest. Exploitation rates of wood are high and causing population declines.

Lophira alata is tree of Lower and Upper Guinea which grows in wet evergreen forest, continues to experience large scale destruction. The slow growth rate, poor regeneration in less than optimum conditions and over exploitation as a timber species are contributing to the decline in population. Improved protection and management of existing forest reserves are done.

Pelligriniodendron diphyllum has experienced significant decline in the forests in all countries because of mining, Logging and commercial forestry activities.

Nesogordonia papaverifera is a timber species which grows in dense stands commonly in areas where savannah has been replaced by forest. It has good regeneration in disturbed forest.

9.1.2 Conclusion

- No habitat will disappear in the dam's zone of influence. Each vegetation chance in the reservoir and downstream is found in upstream.
- All the 33 short height species found in the reservoir have been recorded elsewhere.

As concerns plants, no species will disappear due to the future water reservoir. In fact these plants are also found outside the project impact area, and everywhere in the region. However, there is not cause to worry about availability of any one of them in the region, even though some plants are becoming scarce near inhabited areas.

9.2 Impact

Impact related to project limits

The submersion and clearing of forest-covered surfaces to construction works present several impacts.

- Vegetation change: Loss of land habitat and extension of adapted aquatic or river bank habitat, e.g. near the power house, the level of water will increase and trees like *Pterocarpus santalinoides* will be killed by submersion in and along the river borders.
- Submersion of areas used by populations will result in the reduction of family land.
- Loss of plants and very few traded timbers in the reservoir.
- Loss of agroforest of *Hevea brasiliensis* in the reservoir.
- Possibility of greenhouse gas emission.

Impact related to rehabilitation works

- The main risk during the rehabilitation of the dam and the power house is the overexploitation of the forest resources.
    - Influx of people to the project area will increase the charcoal production.
    - Illegal timber exploitation and charcoal production by the workforce, for firewood and construction wood.
    - Increase in production of charcoal by local people to sell it to the workforce.

Impact related to hydroelectric power plant greenhouse gas emission

- In addition to the reservoir, the project will clear considerable surface area situated outside the reservoir for keeping the building materials and for the following infrastructures:
    - Rehabilitation of the hydroelectric plant and power house,

- Rehabilitation of permanent roads and creation of temporary roads,
- Construction of the dam,
- Construction of staff lodgings.

<u>Impact related to human activities</u>

- The forests are constantly destroyed by anthropogenous activities like agriculture, timber trees exploitation and the trade of charcoal, principal activity in the country.

9.3 Mitigation Measures

- Clearing of vegetation can not be avoided at the areas specified for project structures, but damage to the natural vegetation should be minimized. It is recommended to use material (borrow areas) inside of the future reservoir and dump unused, uncontaminated material (excavation material) in the future reservoir (dumping areas). Keep additional sites as small as possible.
- The useful wood in the future reservoir area should be made available to the local population.
- Local population should be advised to use during construction period, timber in the future reservoir area for charcoal production. The full supply level should be market in the field so that the people are aware where they should go for harvesting, this would reduce the pressure on the surrounding forest for this period and it would already clear parts of the reservoir area.
- The clearing of forest should be monitored by the Forest Development Agency.
- Do not disturb vegetation especially trees at the riverbank downstream of the construction site.
- Do not use any herbicides for vegetation clearing (manual clearing rather than herbicides).
- Any illegal logging of the work force must be forbidden.
- To counterbalance increasing pressure on forests due to the loss of trees growing in the reservoir area and presently used for charcoal production, it is recommended to carry out a plantation program of fast growing tree species which are suitable for charcoal production, as e.g. *Anisophyllea meniaudi*, *Nauclea pobeguini* and *Uapaca heudelottii*; other suitable species might be available for this purpose. This activity should be developed as a community based program, developed, managed and used by the local population, with support of the Forestry Development Agency.

If the St. Paul River Cascade should be implemented (see Chapter 28), it would then be advisable to develop a watershed management plan for the entire cascade; to the extent possible, this should also include the part of the river basin located in Guinea. The main aims of this plan would be to reduce erosion in the catchment area of the dams, and thus to reduce siltation of the reservoirs.

10 TERRESTRIAL FAUNA

10.1 Theoretical Considerations

The statements made in the Chapter on Vegetation on biodiversity aspects in dam projects are largely valid for the terrestrial fauna as well, since animals largely depend on their habitats.

One specific issue that often needs to be considered is the potential impact of a project on migrating species (especially birds). This is insofar of importance that a specific site - as is the case for many wetlands - can be of high importance for the survival of animal populations and species even if they do not live there permanently, but use this area only at specific times of the year, e.g. as resting and feeding places during migrations or as overwintering areas.

In the framework of an EIA, it is never possible to study all the animal groups living in the study area. The efforts have to concentrate on groups of animals which can more or less readily be identified and whose habitat requirements are known well enough, and which can therefore serve as indicator organisms for the state of their habitats. As for plant species, the emphasis lies on either economically important species (food or other uses, pests) and on rare, endangered and/or endemic species. The most important groups in this sense are mammals and birds, and reptiles and amphibians. For the entire aquatic fauna, fish serve as indicator organisms.

10.2 Prevailing Situation

10.2.1 Mammals

In total there are 193 mammals in Liberia (Groombridge and Jenkins, 1994); the following 31 species can be found in the Red List of IUCN. 9 species are listed as endangered, 12 as vulnerable and 10 as near threatened.

Table 10-1: Mammal species of Liberia listed in the IUCN Red List

No.	Family	Species	Common name	IUCN
1	Tenrecidae	*Micropotamogale lamottei*	Nimba otter shrew	EN
2	Elephantidae	*Loxodonta africana*	African elephant	VU
3	Trichechidae	*Trichechus senegalensis*	West African Manatee	VU
4	Cercopithecidae	*Cercopithecus diana*	Diana Monkey	EN
5		*Procolobus badius*	Red Colobus	EN
6	Hominidae	*Pan troglodytes*	Chimpanzee	EN
7	Anomaluridae	*Anomalurus pelii*	Pel's Scaly-tailed Squirrel	NT
8	Soricidae	*Crocidura grandiceps*	Large-headed Shrew	NT
9		*Crocidura nimbae*	Nimba Shrew	VU
10	Pteropodidae	*Scotonycteris ophiodon*	Pohle's Fruit Bat	EN
11		*Scotonycteris zenkeri*	Zenker's Fruit Bat	NT
12	Vespertilionidae	*Kerivoula phalaena*	Spurrrell's Wolly Fruit Bat	NT
13		*Neoromicia brunneus*	Dark-brown Serotine	NT
14	Emballonuridae	*Saccolaimus peli*	Pel's Pouched Bat	NT

15	Nycteridae	*Nycteris intermedia*	Intermediate Slit-Faced Bat	NT
16		*Nycteris major*	Ja Slit-Faced Bat	VU
17	Rhinolophidae	*Rhinolophus guineensis*	Guinean Horseshoe Bat	VU
18		*Rhinolophus hillorum*	Hill’s Horseshoe Bat	VU
19		*Rhinolophus ziama*		EN
20	Hipposiderinae	*Hipposideros fuliginosus*	Sooty Roundleaf Bat	NT
21		*Hipposideros jonesi*	Jones’s Roundleaf Bat	NT
22		*Hipposideros marisae*	Aellen’s Roundleaf Bat	EN
23	Physeteridae	*Physeter catodon*	Sperm whale	VU
24	Felidae	*Profelis aurata*	African Golden Cat	VU
25		*Panthera leo*	Lion	VU
26	Herpestidae	*Liberritia kuhni*	Liberian Mongoose	EN
27	Hippopotamidae	*Choeropsis liberiensis*	Pygmyn Hippopotamus	EN
28		*Hippopotamus amphibius*	Hippopotamus	VU
29	Bovidae	*Cephalophus jentinki*	Jenktins Duiker	VU
30		*Cephalophus zebra*	Zebra Duiker	VU

Hunters have been interviewed for getting a clearer picture on the animals which occur in the project area. It has been mentioned that they see very seldom the *Hippopotamus amphibius* (hippopotamus), the *Loxodonta Africana* (African elephant) listed as vulnerable and the *Pan troglodytes* (Chimpanzee) listed as endangered; a captive specimen of this latter species was seen in one of the villages, proving that it actually exists in the area. The hippopotamus might live in the wider and quietly flowing parts of the river, and could certainly also live in the reservoir. However, the reservoir area itself is certainly not a suitable habitat for elephants and chimpanzees, although it cannot be excluded that occasionally both of these species venture into this area for feeding. Restoration of the reservoir will not affect either of them negatively.

Mammals are hunted be the local population, mainly for meat. The most important of these bushmeat species is the grass cutter or cane rat (*Thrionomys swinderianus*).

10.2.2 Birds

Depending on the source, the number of bird species identified for Liberia varies between 600 (NBSAP 2004) and 696 (http://avibase.bsc-eoc.org). *Phyllastrephus leucolepis* (Liberian Greenbul) is endemic to Liberia and critically endangered. It was described in 1985 and is known from two forest patches 20 km north west of Zwedru, near Cavalla river, Grand Gedeh County in the upper Guinean rainforest, i.e. far outside the area affected by the project. Furthermore *Puffinus mauretanicus* (Balearic Shearwater) is critically endangered and *Scotopelia ussheri* (Rufous Fishing-Owl) and *Malimbus ballmanni* (Ballman's Malimbe) are endangered. In addition, there are 8 species listed as vulnerable and 21 species as near threatened.

Table 10-2: Bird species of Liberia listed in the IUCN Red List

No.	Family	Species	Common name	IUCN
1	Numididae	*Agelastes meleagrides*	White-breasted Guineafowl	VU
2	Phoenicopteridae	*Phoenicopterus minor*	Lesser Flamingo	NT
3	Procellariidae	*Pterodroma feae*	Fea's Petrel	NT
4		*Puffinus griseus*	Sooty Shearwater	NT
5		*Puffinus mauretanicus*	Balearic Shearwater	CR
6	Fregatidae	*Fregata aquila*	Ascension Island Frigatebird	VU
7	Accipitridae	*Gyps africanus*	White-backed Vulture	NT
8		*Circaetus beaudouini*	Beaudouin's Snake-Eagle	VU
9		*Circus macrourus*	Pallid Harrier	NT
10	Falconidae	*Falco vespertinus*	Red-footed Falcon	NT
11	Otididae	*Neotis denhami*	Stanley Bustard	NT
12	Scolopacidae	*Numenius arquata*	Eurasian Curlew	NT
13		*Limosa limosa*	Black-tailed Godwit	NT
14		*Gallinago media*	Great Snipe	NT
15	Laridae	*Rynchops flavirostris*	African Skimmer	NT
16	Psittacidae	*Psittacus erithacus*	Gray Parrot	NT
17	Strigidae	*Bubo shelleyi*	Shelley's Eagle-Owl	NT
18		*Scotopelia ussheri*	Rufous Fishing-Owl	EN
19	Coraciidae	*Coracias garrulus*	European Roller	NT
20	Bucerotidae	*Ceratogymna cylindrica*	Brown-cheeked Hornbill	NT
21		*Ceratogymna elata*	Yellow-casqued Hornbill	NT
22	Malaconotidae	*Malaconotus lagdeni*	Lagden's Bushshrike	NT
23	Campephagidae	*Campephaga lobata*	Ghana Cuckoo-shrike	VU
24	Picathartidae	*Picathartes gymnocephalus*	White-necked Rockfowl	VU
25	Pycnonotidae	*Criniger olivaceus*	Yellow-bearded Greenbul	VU
26		*Phyllastrephus leucolepis*	Liberian Greenbul	E / CR
27	Cisticolidae	*Schistolais leontica*	Sierra Leone Prinia	VU
28		*Bathmocercus cerviniventris*	Black-capped Rufous-Warbler	NT
29	Pellorneidae	*Illadopsis rufescens*	Rufous-winged Illadopsis	NT
30	Muscicapidae	*Melaenornis annamarulae*	Nimba Flycatcher	VU
31	Sturnidae	*Lamprotornis cupreocauda*	Copper-tailed Glossy-Starling	NT
32	Ploceidae	*Malimbus ballmanni*	Ballman's Malimbe	EN
33	Estrildidae	*Parmoptila rubrifrons*	Red-fronted Antpecker	NT

VU = vulnerable EN = endangered E = endemic

NT = near threatened CR = critically endangered

The Project will submerge an area of 8 km²; a large part of this is already water (river) now, the rest is a mosaic of secondary forest (regrowth of the last 20 years since the breaching of the dam) and agriculturally used areas. The birds living in this area can only be species which are adapted to live in this type of regenerating and man-made vegetation, vegetation types which are not in short supply in the wider area and in other parts of the country dominated by shifting cultivation. Therefore, the project will not have a noticeable negative impact on the avifauna. Some species of aquatic birds will find a suitable habitat in the reservoir.

10.2.3 Reptiles and Amphibians

The National Biodiversity Action Plan (NBSAP 2004) of Liberia mentions 67 reptiles including two endemic species. There are three crocodiles in the country, the *Osteolaemus tetraspis* (African dwarf crocodile), the *Crocodylus niloticus* (Nile crocodile) and the *Crocodylus cataphractus* (African slender-snouted crocodile). The African dwarf crocodile is listed as vulnerable. There are two marine turtles, namely, the critically endangered D*ermochelys coriacea* (Leatherback), and *Chelonia mydas* (Green Turtle), is listed as endangered, and two terrestrial species, *Kinixys homeana* (Hinged-backed Tortoise) which is vulnerable and *Kinixys erosa* (Serrated Hinge-backed Tortoise). In addition to that, the field work carried out for this study revealed the presence of at least one species of freshwater tortoise, a soft shelled tortoise (cf. *Trionyx* sp.), which lives in the river in the project area. Additionally, there are at least 12 venomous and several non poisonous snakes, among them *Typhlops leucostictus* (Liberia Worm Snake), which is endemic to Liberia.

38 amphibians including 4 endemic species are recorded in the National Biodiversity Action Plan (NBSAP 2004). A study carried out in 2007 in 3 national forests in Liberia within 15 sampling days collected at least 40 species (Annika Hillers and Mark Rödel, 2007) (See Annex 10, Table 30-9). It is assumed that there are probably several more amphibians in Liberia.

10.3 Impacts

As mentioned above, the Project does not affect any valuable habitat, since it will submerge only exactly the area which already was a reservoir 10 years ago. Most importantly, no primary forests are affected by the Project. For these reasons, impacts of the project on fauna, if any, are very small and negligible.

The only moment where the Project can have a direct impact on the local fauna is the moment of reservoir impoundment. Animals which are not able to swim might get drowned, especially if they will be trapped by the rising water on plants or on islands forming temporarily, before being submerged. This undesirable effect can be substantially reduced by pre-impoundment reservoir area clearing (see Section 8.3.5), which will drive most animals out of the directly affected area before impoundment.

A further impact on fauna will be the increased pressure due to hunting activities of the local population and of the future work force.

10.4 Mitigation Measures

- Carry out reservoir clearing before impoundment; this will have a positive effect on water quality and will reduce the risk of animals drowning during impoundment.
- Hunting by members of the work force needs to be strictly forbidden.

Given the land use pattern and the absence of highly valuable habitats within and in the near surrounding of the reservoir, no other mitigation measures for fauna are required.

11 AQUATIC FAUNA

11.1 Theoretical Considerations

The main effect of a dam and reservoir project on fish populations is often the fact that the dam will constitute an obstacle to migration. Many species of fish carry out migrations, and some of them depend on these migrations for reproduction.

A second effect on fish is the fact that a part of the river will change from rive to lake conditions. While some species can adapt easily to this type of habitat, others cannot and will therefore diminish in numbers or will disappear altogether from this area.

A third potential effect on fish can be caused by a change in river flow pattern d/s of the dam, e.g. in cases where seasonally flooded areas serve as breeding grounds, and when this flooding no longer takes place due to the regulating effect of the dam.

Finally, fish populations can be affected by the indiscriminate introduction of exotic species (which is sometimes done as mitigation measure for a dam project, but very often independently of that, e.g. by introducing the exotic rainbow trout, a good sport fish, in European and Asian waters, often to the detriment of native species).

11.1.1 Changes in Fish Species in Man-made Lakes

From numerous observations on environmental modifications related to the creation of dams (Lowe-McConnell, 1966; Bolon & Coche, 1974; Lauzane, 1988; Levêque and Paugy, 1999; Pouomogne, 2000), the following need to be spelt out. If trees, shrubs and grasses are flooded, this generates a massive organic fertilization, which in turn leads to the development of phytoplankton, and periphyton on dead trees. Bottom water becomes poorer in oxygen, and rocky substrate is covered with mud and dead leaves, which provokes the disappearance of species depending on such substrates, namely Mormyridae. Those species with larger feeding niches (*Alestes spp*, *Schilbeidae*, *Clupeidae*, etc.) easily adapt themselves to the new condition. Microphages and macrophytophages heavily multiply (*Tilapias*, *Citharinus spp*, *Labeo spp*) alongside with their predators (*Hemichromis*, *Clarias*, *Lates spp*.). Some anadromous species as *Barbus spp*, having the habit of moving up into smaller running water bodies to reproduce diminish with the creation of the dam. It is however important to note that typical anadromous (moving from the sea or big rivers to sources) or catadromous (reproducing in fresh smaller water, and spending the most of the lifetime in the sea) are scarce in tropical waters. Tropical species are mostly potamodromous (i.e. they spend most of their lifetime in larger rivers where feeding resources are more abundant, but move upstream into tributaries, where predation is relatively less, to breed).

In most tropical man-made reservoirs, it is observed that the main biomass consists of a very small number of species, from 3 to 6, consisting of Cichlids and Clariids. In Volta river (Ghana), populations of *Mormyridae* tremendously decreased following the building of the dam. Year 1 following the closure of the dam showed the explosion of tilapias (*S. galileus*) with a huge decrease of *Labeo* and *Chrisichthys*, and also *Alestes nurse*: the latter species is more related to running water ecosystem. On the other hand, the number of species following the closure of Kainji dam (Nigeria) increased from 28 to above 40, in relation to more feeding resources, wider space and capabilities of escaping from predators. Fish species seem to easily adapt themselves to changing feeding habitats or niches, but have more difficulties in adapting to new breeding environments. This explains the population decrease/disappearance of running water species within the reservoirs.

Most often, man-made lakes attract new fishermen, with the outbreak of new diseases of which bilharziosis. To fight against this, it is recommended to reinforce stocks of species capable of contributing to a biological fight against the intermediate host of the disease, e.g. *Heterotis niloticus*. This species thrives best in shallow and calm water bodies, where it can easily build nests for reproduction. It feeds on vegetation under decomposition, insects, molluscs, worms and leeches. The arrival of new fishermen, specifically those with better equipment and more experienced in fishing than the local population can also generate conflicts; in this respect, measures for community management involving all stakeholders should be anticipated in this modified fishing site deriving from the dam project, initially designed for the only electricity supply purpose.

To sum up, benthic rocky species including Mormyriids usually disappear in reservoirs with their habitats and feeding niches being covered with mud; intermediary species including cyprinids (*Labeo, Chrisichthys, Alestes, Brycionus*) accommodate themselves, although with diminishing population, while tilapias, as well as most of their natural predators, proliferate. To secure biodiversity it may be necessary to facilitate the upstream movement of some potamodromous species using punctual devices as stairs and elevators predesigned while building the barrage.

Valorising reservoirs through stock enhancement:

China is the country where extensive aquaculture in man-made lakes is mastered. Millions of Chinese carps are stocked in reservoirs and fishponds alike, with massive maturing systems where night soil passing in specialised stations is treated and recycled as water fertilization. More than 1.2 million tons of fish is yearly produced through this system. Species composition (8 species occupying different habitats), densities and stocking sizes (>14.7 cm) are scientifically established for optimum production (Li and Xu, 1995). The productivity of stocked reservoirs averages 300 $kg*ha^{-1}*y^{-1}$ (Welcomme and Bartley, 1998; Lorenzen et al., 2001).

11.2 Methodology

11.2.1 Survey of Fishermen and Side Activities

Interviews were conducted using the Participatory Rural Appraisal method (PRA) to appraise fishing activities in the project site. Given the limited time length of the assignment, this method developed by social scientists focuses on local people's knowledge to gather in a joint-learning process the most reliable data available on the subject. The interview guide dealt with different aspects of fishing such as fishing gears and methods, seasons, species, transformation, organization of the profession (presence of common initiative groups, support from GOs/NGOs), and wishes in case the dam may be rehabilitated. Information on fish farming activities in the area was also collected while visiting some fish stations in the area.

Interviews were conducted on a distance of 8 km upstream and 6 km downstream of the dam site, given logical observations on spot, e.g., scheduled water extension limit of the future reservoir, and miscellaneous infrastructures linked to the proximity of Monrovia and the sea, respectively. Individual interviews and group meetings were organized in view of validating recorded information respectively in the following localities: Varnyi Town, Arthinghton/Millsburg-Gate, Geeto-Town, Harrisburg/ Joseph Ricks Town, Raymond Camp, White Plains, Lousiana/ Fofee, Banee Town, Clay Ashland/Zanna Town. Lists of attending fishermen/women are presented in Annex 11.2.

11.2.2 Fishing Practices and Fauna Inventory at Mount Coffee

While interviewing individual fishermen during fishing operations by the riverside or on wooden canoes, many pictures could be taken with the fisher`s approval. Caught fish were identified on the spot using available plates and taxonomic keys after Leveque and Paugy et al. (2003), and local names provided with fishermen's help. This identification was validated during PRA meetings.

11.2.3 Water Quality Analysis and Global Positioning

At specific points on river St-Paul upstream, downstream and nearby the dam site, water was analysed for temperature, pH and conductivity using a EUTECK Instruments EcoScan PH6 PH/mV/oC multi-meter. A GPS equipment (GARMIN Etrex summit) was used to record the location (latitude, longitude, elevation above sea level, etc.) of the main visited and monitored sites so as to update the available maps.

11.3 Present Situation

11.3.1 Aquatic Biodiversity

11.3.1.1 Fish

167 species of freshwater fish and 464 saltwater fish are known for Liberia, three of these species are endemic to Liberia and only one specie is introduced. 54 of Liberia’s fish species are listed in the Red List of IUCN, 14 as critically endangered, 18 as endangered and 22 as vulnerable.

For the St. Paul river basin 92 species have been identified (see Annex 11, Table 30-10) (www.fishbase.org). At least 3 of the species listed for the St. Paul river are amphidrom (migration from fresh to salt water or vice versa) and 20 species are potamodrom, which means that they migrate within the river. The current surveys allowed to identify 47 species during the mission, corresponding to commercial species usually caught by fishermen (Table 11-1). Of these, about 15 were effectively observed on spot. Those not observed could be identified by fishermen from pictures of previous assignments and drawings from the document after Paugy et al, 2003. *Labeo sp.* (rock fish, or Koligne in Mpelle, or Blue), *Barbus sp* (horse fish, or Tongnie), and *Tilapia sp* (ph or Ngouka) were the most frequent in catches during the survey (dry season), while *Hydrocynus sp* (leopard fish, or Nnan), *Gymnarchus sp* (plain fish or Odaa), and *Chrisichthys sp.* (white catfish or Kouloo in Ngola, or Ngiebong in Mpelle) were reported by the fishermen to be abundant during the rainy season. Brackish water species as *Machrobrachium sp.* and *Cynoglossus sp.* are observed downstream of the studied area.

Table 11-1: Fish species inventoried during the mission

Family	Scientific name	Common name	Environment, behaviour	Migration behaviour	IUCN
Polypteridae	*Polypterus sp*	Short fin, Ossowa	Freshwater; demersal; carnivore, substratum egg scatterers		
	Polypterus sp		Freshwater; demersal; carnivore		
Arapamidae	*Heterotis niloticus*	Klinklin	Freshwater; pelagic; plankton feeder, breeds in wet season in swamps/floodplains		
Mormyridae	*Mormyrops breviceps*	Dogfish, Ngwabeen	Freshwater; demersal		
	Campylomormyrus phantasticus	Klouma	Freshwater; demersal		
	Campylomormyrus tamandua	Ngwabela	Freshwater; demersal		
	Petrocephalus simus	Ndele	Freshwater; demersal	potamodrom	
	Brienomyrus brachyistius	Mbendje Odele	Freshwater; brackish; benthopelagic; prefers quiet, gently flowing stretches and muddy substratum or fine sand overlain with a layer of organic debris. It occurs mostly in shallow marginal water among aquatic macrophytes and in swamp pools. Feeds primarily on benthic invertebrates and detritus.		
Gymnarchidae	*Gymnarchus niloticus*	Plain fish: Oda'a; Mbamba	Freshwater; demersal; It breeds in well-vegetated, marginal areas of swamps and rivers, where a large, floating nest, about 1 m in diameter is constructed. Here the eggs are laid and later guarded by one of the parents.	potamodrom	
Hepsetidae	*Hepsetus odoe*	Segme, Nnan	Freshwater; demersal; adults occur in most coastal rivers, lakes and swamps. Prefer quiet, deep water, like channels and lagoons of large floodplains. Juveniles and fry inhabit well-vegetated marginal habitats. Adults feed on fish; juveniles feed on small invertebrates and fish. Multiple spawner.	potamodrom	
Alestidae	*Hydrocynus vittatus*	Kouke Tenpalm	Freshwater; demersal; prefers warm, well-oxygenated water, mainly larger rivers and lakes. Feeds on whatever prey is most abundant but *Brycinus, Micralestes, Barbus*, and *Limnothrissa* are favoured	potamodrom	
	Brycinus macrolepidotus	Flee, Kablaf	Freshwater; brackish; pelagic; more common in rivers than lakes. Feeds on insects, crustaceans, fish, vegetation and debris.	potamodrom	
	Brycinus sp.		Freshwater; pelagic	potamodrom	
	Micralestes occidentalis		Freshwater; pelagic		
	Micralestes sp.	Falla	Freshwater; pelagic		
Distichodontidae	*Nannocharax fasciatus*	Mpelle	Freshwater; pelagic; feeds on small invertebrates	potamodrom	

Family	Scientific name	Common name	Environment, behaviour	Migration behaviour	IUCN
Citharinidae	*Citharinus distichodus*	Ngongshile	Freshwater; demersal	potamodrom	
Cyprinidae	*Labeo curriei*	Rock fish, Koligne, Blue (ngola)	Freshwater; benthopelagic		VU
	Barbus spp.	Palm nut fish, Tognie			
	Barbus batesi	Doubia (ngola) Nkondile (mpelle)	Freshwater; benthopelagic		
	Barbus wurtzi	Bafoua (ngola) Koufou (mpelle), Doubia	Freshwater; benthopelagic		
	Raiamas steindachneri		Freshwater, demersal,		
Clarotidae	*Chrysichthys sp.*	Drama	Freshwater, demersal,	potamodrom	
	Chrysichthys nigrodigitatus	Bonbong Koulo	Freshwater, demersal, occur in shallow waters of lakes (less than 4 m), over mud and fine sand bottom. Omnivorous, feed on seeds, insects, bivalves and detritus. Feeding becomes specialized with age and size, larger fish may feed on decapods and fish	potamodrom	
	Chyisichthys johnelsi	Drama Mpopo	Freshwater; demersal		
Schilbeidae	*Eutropius spp*	Flat Kia			
	Schilbe mystus	(Fallavani) Nguibong	Freshwater; demersal; shoals in standing or slowly flowing open water with emergent or submerged vegetation. Generally more active at night or in subdued light. Feed from mid-water and surface waters on a wide variety of foods including fish, insects, shrimps, snails, plant seeds, and fruit. Breed during the rainy season and may be either a single or multiple spawner in different localities, laying eggs on vegetation	potamodrom	
	Schilbe mandibularis		Freshwater; demersal; feed mainly on terrestrial insects (Hymenoptera, Hemiptera, Coleoptera) washed into the water and on mayfly larvae	potamodrom	
Clariidae	*Clarias gariepinus*	Kwelekwe, Shallan	Freshwater; benthopelagic; occurs in lakes and pools, fast flowing rivers and rapids. Widely tolerant of extreme environmental conditions. The accessory breathing organ enables this species to breath air when very active or under dry conditions. Remains in the muddy substrates of ponds and occasionally gulp air through the mouth. Can leave the water at night using its strong pectoral fins and spines in search of land-based food or can move into the breeding areas through very shallow pathways. A bottom feeder which occasionally feeds at the surface. Feeds on insects, plankton, invertebrates, fish, young birds, rotting flesh and plants. Migrates to rivers and temporary	potamodrom	

Family	**Scientific name**	**Common name**	**Environment, behaviour**	**Migration behaviour**	**IUCN**
			streams to spawn.		
	Clarias laeviceps		Freshwater; demersal		
	Clarias spp		Freshwater; demersal		
	Heterobranchus isopterus	Nkona Ntehen; Nkouou	Freshwater; demersal	potamodrom	
	Heterobranchus longifilis	Truee	Freshwater, demersal, inhabits large rivers. Occurs in large deep rivers within the mainstream or in deep pools and lakes. Most active at night, feeding on any available food, including invertebrates and insects when small, fish and other small vertebrates when large.	potamodrom	
Malapteruridae	*Malapterurus punctatus*	Dogbo, Koulikouli	Freshwater; benthopelagic		
	Malapterurus sp				
Mochokidae	*Synodontis sp.*	Drama			
	Synodontis batesi		Freshwater; benthopelagic		
Amphilidae	*Doumea chappuisi*		Freshwater; demersal		VU
Poecilidae	*Poropanchax normani*		Freshwater; benthopelagic	non-migratory	
Cichlidae	*Hemichromis fasciatus*	Red belly, Koufou, Nkoo	Freshwater; benthopelagic; present in littoral riverine habitats and permanent floodplain lagoons with clear water. Feeds on shrimps, insects and small fishes. A nesting substrate spawner which breeds in the early summer.	potamodrom	
	Oreochromis sp.	Barakelly			
	Sarotherodon caudomarginatus	Kouonkouwo; Mboue	Freshwater; demersal		
	Tilapia spp				
	Tilapia buttikoferi	Gamadina (ngola) Koufou; Mboue	Freshwater; benthopelagic		
	Pelvicachromis humilis	Nguede (ngola) Koufou	Freshwater; demersal		
Latidae	*Lates niloticus*	Grouper (Ndenjou Koufou) Bee (Banso), Wouogoue	Freshwater; demersal; inhabits channels, lakes and irrigation canals. Adults inhabit deep water, while juveniles are found in shallow water. Feeds on fish especially clupeids and Alestes; smaller fish also feed on larger crustaceans and insects. Juveniles are planktivorous.	potamodrom	
Matacembelidae	*Mastacembelus liberiensis*	Ngaligne Babee Yeyee	Freshwater; benthopelagic		

19 families have been identified, with Cichlidae, Cyprinidae, Clariidae, Mormyridae and Alestidae being the most represented. Only 2 species, *Labeo curriei* and *Doumea chappuisi,* are listed as vulnerable in the IUCN list; *Labeo curriei,* was observed having significant contribution to fish production in the project area. Studies should focus on its acclimatation for aquaculture, as contribution to its preservation. At least 4 families/species, namely *Heterotis niloticus*, *Gymnarchus niloticus*, *Clarias gariepinus* and *Lates niloticus* are introduced from foreign river basins.

6 species have been selected as key species for the Mt. Coffee Project area either due to their natural value or economic value. A short description on their life cycle is given below:

***Labeo curriei* (rock fish) is vulnerable and has an economic value**. The reproduction cycle starts in the rainy season and last 9 to 11 months. Consequent ovulation is related to rain and rises in water level; laying is total, spread over a relatively long period. Female outnumbered males (1/1.42 sex ratio) and precocious sexual maturity of males is observed in *Labeo barbus batesi*. *Labeo sp.* dwell in rocky or sandy substrate, and in rapid flowing waters. They exploit all water strata, and show omnivorous feeding, including microorganisms (diatoms), plant detritus, crustaceans and rotifers; some preference for plants material. The growth is isometric (similar dual growth in length and weight), with maximum size recorded attaining 50 cm in total length. Reproductive patterns may justify the vulnerability of the species compared to spontaneous and multi-spawning species such as tilapias.

***Doumea chappuisi* (Amphilidae) is vulnerable:** Usually naked body, small size species (11.4 cm maximum size observed), benthic. Given the fusiform body, pointed head and small mouth, the fish is adapted to quick running water, making it a vulnerable species in case of impoundment. Few observations reported on the life cycle of the species.

***Barbus sp* (horse fish) has an economic value:** Large Barbus (big size) show normal well developed lips sometimes forming a mental lobe (differently to *Labeo sp* whose mouth opening is bottom oriented). 65 cm specimen were observed in *Barbus bynni occidentalis*. *Barbus sp*. are usually bottom strata feeders of insect larva, mollusks, aquatic weeds, but also copepods, ostracods, filamentous algae, crayfish and crabs, terrestrial insects and small fish. As the *Labeo*, *Barbus sp* perform reproductive migration upstream of the junction of small quick running water course during specific seasons of the year. Building of impoundment without developing corrective measures may threaten the sustainability of the species.

Tilapia (Ph or Ngoukna) has an economic value: Tilapia gonads are differentiated a few weeks after hatching, and sexual maturity is attained rapidly (within 6 months in natural water bodies, less than 3 months in captivity). Successive breeding occurs, with the same female spawning several times successively with few weeks interval, continuously. Social contact (e.g. ponds conditions) increases spawning frequency. This excessive spawning capability has led in culture conditions to adopt polyculture with a predator fish to control tilapia offspring, and generally for *Oreochromis sp*, to adopt sex-reversed fry. Young thrive on zooplanktons, and become omnivorous with preference to filamentous algae and macrophytes. In culture environment, tilapia has ability to valorize different feeding niches of the earthen pond environment. Although growth parameters remain among average, the above cited features made tilapia among the first ranking bony fish cultivated.

***Chrisichthys sp.* (white catfish or «Bonbong Koulo »):** As most catfish, have ancestral benthic feeding habits. Live on small mollusks, small fish and zooplankton. They are non-aggressive stalking predators that hunt at night or in turbid water using primary nonvisual sense organs. Weberian apparatus for sound production has probably resulted in some loss of buoyancy control. As most catfish, show single or twice spawning per year usually during flooding. Many studies were conducted in induced spawning of the species. The presence of adequate substrates placed in the ponds may be sufficient to provoke spontaneous spawning, but a large variety of hormones (fish gonadotropin, various steroids) has been tried successfully for massive production of Chrisichthys offspring. The species is well adopted in brackish water aquaculture in Cote d'Ivoire where it constitutes a luxury fish species (Ministers' fish). Maximum size reported 75 cm for *Chrisichthys nigrodigitatus*.

***Gymnarchus sp* (plain fish or «Oda'a»):** Ichtyophagous species, introduced to St. Paul River. May reach very big size, 1.5 m total length, 16 kg weight in Niger Basin.

11.3.1.2 Non-fish Aquatic Biodiversity

In non negligible amount, the following species were equally observed in catches and readily available in Bensonville and Lousiana town Markets: fresh water shrimps (*Macrobrachium sp.*), small white shrimp (juvenile Njouna), tortoise (*Trionyx triunguis*), bull frogs (*Conrua goliath*, Ngoong), crabs, shells (kiss me, Tchan, Njiakouling), clams (NDODO; Njô). Otters (*Lutra maculicollis*, Nounoung), crocodiles (*Crocodylus niloticus*, Mfalle), and varans (*Varanus niloticus*) were reported to be caught sporadically by fishermen.

11.3.2 Fishery

11.3.3 Inland Fisheries and Aquaculture in Liberia

Based on an interview of the key responsible in the Bureau of Fisheries, production statistics are scanty (Weefar, pers comm). The best estimate for marine and aquaculture productions respectively stand at 12,000 and 70 tons. No data, even estimates, is available for inland fisheries, and the officer in charge would welcome any result from the current survey. Fisheries staff is currently very limited and with insufficient technical skill. Only 6 extension agents are available nationwide for aquaculture. There are 3 public aquaculture stations at Klay, Zedru, Bount county, and the total number of fish farmers is estimated at 3333 farmers. No data is available for capture fisheries. A Fisheries Development Plan is still under discussion, with support from a regional Fisheries Development Institution (GCLM). Staff national wide comprise 14 staff including 9 inspectors and 5 supporting technicians, to control about 111 landing sites. Forbidden fishing practices, namely with chemicals (DDT) and dynamite, are observed in Liberian waters, but shortage of repressive capability against default fishermen is noticed.

11.3.3.1 Features of Fishermen and Fishing Grounds

All interviewed fishermen are living less than 2 km from the riverside. Location of PRA meetings are provided in Figure 11-1 (white circles).

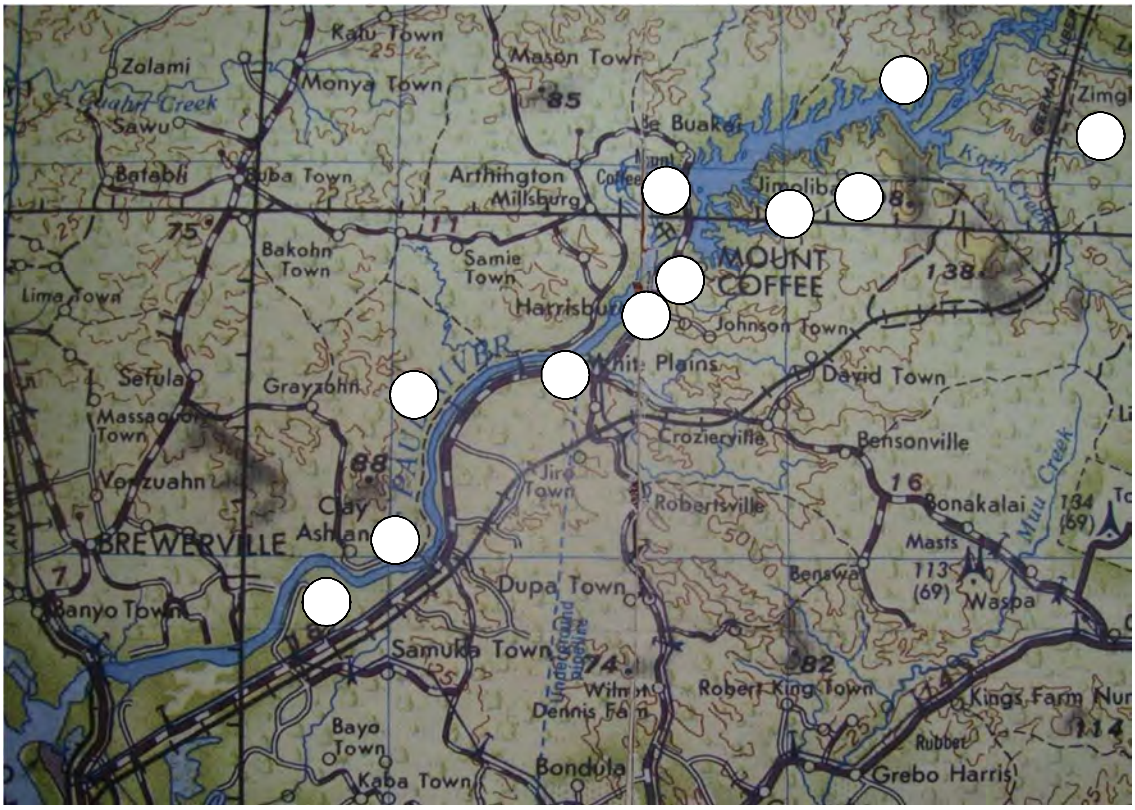


Figure 11-1: Localisation of main fishermen settlements visited during the study

Nearly all people living near the St. Paul river sides practice fishing, usually for self-consumption, since the childhood. The total number of adult fishermen in the project area is estimated at about 566 (see Table 11-2), which constitutes almost one third of the total population of the surveyed sites.

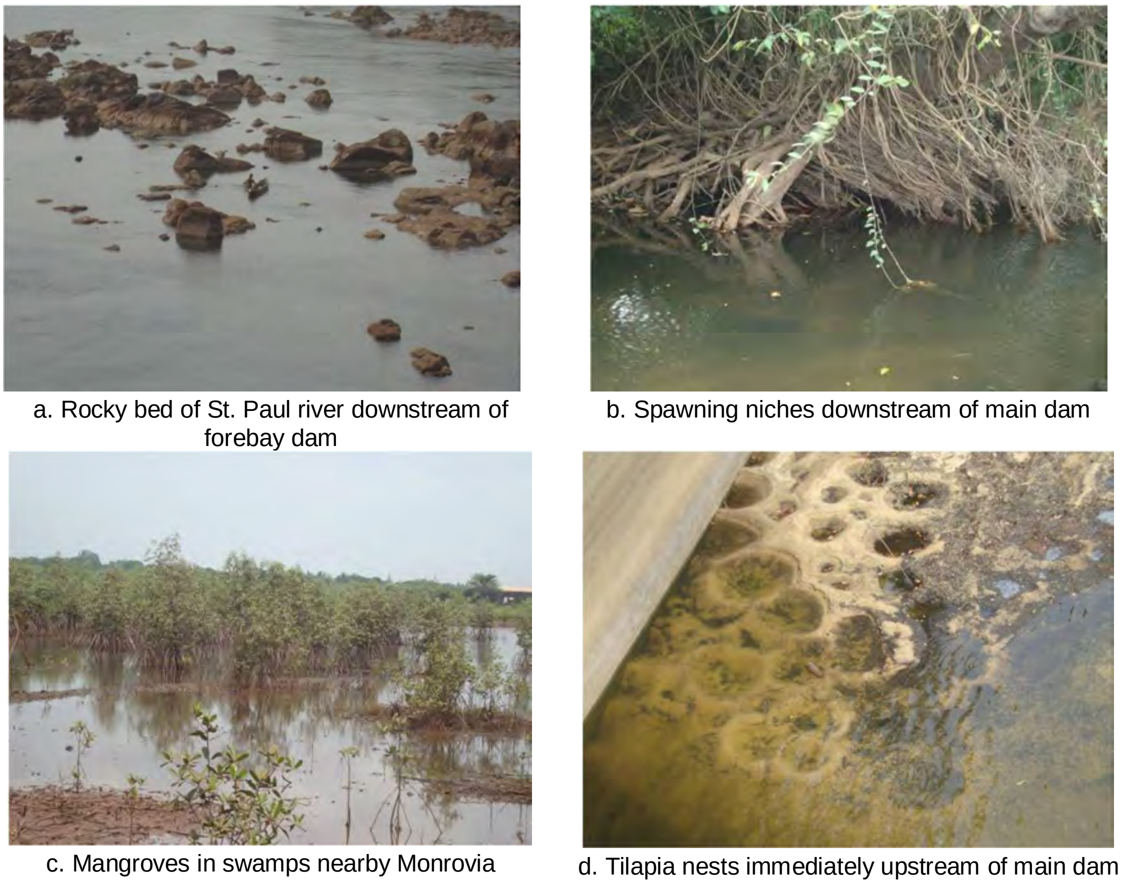
Table 11-2: Number of fishermen surveyed at Mount Coffee in February 2012

Locality	Number
Varnyi Town	40
Mullsbury/Gate	98
Geeto Town	37
Joseph Rick Town	65
Raymond Camp	128
White Plains	31
Fofee Town	53
Banee Town	90
Zanna Town	24
Total	**566**

Differently from many fishing ground in Africa, the percentage of women in active fishing activities is high (close to an average of 40%, and certainly over 60% during group handnet fishing in shallow pools at the end of dry season). Nearly all are married (95%), with an average of 4.2 infants per household. They are aged from 18 to 84 years old, with over 70% between 30 and 50 (18% below 30, and 12% over 50). Education level is from fair to average depending on location: less than 24% upstream fishers (more remoted from the capital city) have reached secondary school, while this percentage goes higher than 84% for downstream fishers (Fofee Town, White Plains and Joseph Ricks). All are crop farm owners (main crops being cassava, sugar cane, rubber, plantain, rice, corn, fruits trees) and charcoal producers. A minority is occupied with hunting, gold mining (by Geeto Town, left side upstream of St-Paul River), and practice more elitist jobs such as teachers, preachers, nurses, bush taxi drivers.

Fishermen usually fish in the section of the river nearby their house. From older fishers' stories, trips to relatively distant sections of the reservoirs upstream could be performed between 1970 and 1990 during the operation of the now damaged dam. As a rule, fishing gears do not allow to go far from the neighbouring area where the fisherman lives. Fish is usually sold more fresh than smoked, even in remote upstream sites (a little more than 25% of catches are kept smoked at Banee Town, at the uppermost limit right side of St. Paul river within the studied area). This is related to a sustainable behaviour of fishers as observed, who do not usually fish more than can be effectively consumed or sold within the local market. Market chains in fish trading are currently short, most often from the fisherman to the consumer via 1 to 2 intermediaries.

Water quality revealed relatively warm water (28.4-30.1°C), relatively neutral (7.2-7.6), and of low conductivity (average 35 µS/cm). These parameters are relatively constant from upstream to downstream, except for conductivity (15 mV upstream to a maximum of 100 mV while descending nearer the sea by Fofee Town). The river bed is very rocky, which is favourable for Cyprinid fishes (Figure 11-2: a).



a. Rocky bed of St. Paul river downstream of forebay dam

b. Spawning niches downstream of main dam

c. Mangroves in swamps nearby Monrovia

d. Tilapia nests immediately upstream of main dam

Figure 11-2: Fish habitats in St Paul River at Mt. Coffee and surroundings

11.3.3.2 Fishing Practices: Gear, Seasonality, Amount, Post Harvest

Fishing activities are done all-year-round, with peaks in January-April. Women are direct involved in fishing activities mostly in the middle of the dry season (February-March), using hand nets and baskets in drying pools. Home consumption in fishermen households is estimated at 25 %. Local fisheries consistently contribute to the nutritional equilibrium of populations, with a strong presence of women in processing and commercialization. Smoked fish constitutes 20% of sales on average, with higher amount in upstream part of Mount Coffee (35%).

Fishing gear

Small wooden hand-made canoes capable of carrying a maximum of 3-4 people are used at Mount Coffee. Gill nets (mesh size of 2.5 cm), casting nets, hooked lines, multi-hooks lines, hoop nets, baskets, hand nets (with small size mesh lower than 1 cm for catching tiny shrimps), river side fish traps, fences across water flow are the most common gear. The state of the fisheries is currently not overexploited, even if training in sustainable management is necessary to prevent destructive fishing gear (namely less than 1 cm mesh net size for most women hand nets, as well as dynamite and chemicals).

Daily fishing schedule and amount

Daily agenda of the fisherman stands as follows: visiting fishing gear left the eve of the day by 7.30 am and by 4.30 pm. Fish collection or catching may last from 1 to 3 hours depending on the number of fishing gear. Fish caught is returned to the river bank or house where they are directly sold or prepared for smoking or cooking, or better kept for more distant market site, Bensonville being the most cited among fishermen.

Estimation of catches amounts

Highly fruitful fishing season lasts from October to March (dry season), with daily capture per fisherman averaging 5 bunches, i.e. 7.5 kg for upstream fishers and 14 kg downstream, for 5 days a week. In the rainy season (April to September), fish harvest reduces to 2.5-4.5 bunches, i.e. 4-7 kg upstream and downstream, respectively, for about 4 days per week given alternate occupations. Dry season lasts for 25 weeks, and rainy season 27 weeks in the year. Total amount can thus be computed as follows:

Upstream, with Raymond Camp, Gate, Banee, Varnyi and Geeto Towns, total of

- 393 fishers x [(7.5 kg x 125 days) +(4.0 kg x 108 days)]= 538’214 kg

Downstream, Joseph Ricks, White Plains, Fofee and Zanna Towns, total of

- 173 fishers x [(14 kg x 125 days) + (7.0 kg x 108 days)]= 433’538 kg

Fishfarming, at Youth Camp by Geeto Town area, and isolated farmers,

- In total about 100 kg

Total current yearly fish production in Mount Coffee then amounts to 971’852 kg, i.e. almost 972 tons.

Post harvest practices

80% of fish is sold fresh at riverside or market, at about 175 LD per bunch, i.e. 120 LD/kg, or smoked (20%) at equivalent fresh basis price. Post capture losses (rotten on gears, or in the household, or through market chains rough or after transformation) are estimated at 15%. Smoking is the most common processing method. Women are the most involved in fish processing and marketing.

11.3.3.3 Fish Farming

Fish culture activities were reported in the area, with a demonstration station at the upstream left side of St. Paul river. This station is attached to a national youth training centre nearby Bensonville, under the Ministry in charge of Youth. The number of private fish farmers in the area remains low, though the potential of the activity is very high given miscellaneous good sites, and the availability of a national equipped aquaculture station at Klay, 30 km Northern direction of Monrovia. Side socio-economic actions of the present project in supporting this activity would be developed in the second part of the report.

11.3.3.4 Socio-economic Importance of Fishing at Mount Coffee

From the total harvest, fishers estimate that about 25% is consumed in the household or shared with relatives, the rest being sold to meet routine needs including school fees, health expenses and other household needs (dress, cooking oil, etc.).

As estimated earlier, 972 tonnes of fish are produced yearly in the study area, with about 15% postharvest losses. This means about 972 x (100-25-15) % = 583.2 tons available for cash earnings. At 120 LD/kg, direct revenues from sold fish is thus estimated at 120 LD x 583,200 = 6,998,400 LD, i.e. close to 100,000 USD per year. Per single fisher, this equates to 172 USD, in addition of nutritional advantage of consuming fresh aquatic products well acknowledged by local public health responsibles as a major contribution to protein balance in the area. Taking into account side revenues up and downstream related to the market chains (boat construction, nets, feeding while fishing, transportation to markets, value added linked to post-harvest improvement) and non fish aquatic catches, the amount of the cash flow generated by fishing and fish farming activities at Mount Coffee is certainly over 150,000 USD/year.

To sum up, fishing offers sustainable employment to over 500 household heads at Mount Coffee, and generates a market chain weighing over 150,000 USD, plus nutritional balance deriving from fresh fish consumed in fishers households.

Main wishes of fishers in relation to the hydropower project included:

- Fishing gear including nets of convenient mesh sizes, hooks, lines,
- Fish smoking area/house with improved smoking materials
- Fishing boat to cross the river in the rainy season to get to the market (specific request from women)
- Sea safety and camping equipments including life jackets, torchess, mosquito nets, matrasses
- Training workshop for sustainable fishing and fishponds
- Promotion initiatives for fish farming (insistance from women)
- Providing drinkable water points and possibly electricity to all villages of the project site.

11.4 Impacts

Impacts identification of Mount Coffee HPP can be approached towards 4 orientations: impact on physical environment, impact on aquatic biodiversity, impacts on fishing activities, and impacts on fishers' communities.

- Dam rehabilitation will generate stagnant water with lower water discharge, and with changes in water quality both upstream and downstream. Mount Coffee reservoir, given its small size and the amount of water flowing through, will be more like a large, slow-flowing river, nevertheless, with more lake-like conditions than the current running waters of St-Paul River. Vegetation within the impoundment area upstream of the dam, including crop farms, planted trees and natural vegetation will be submerged; new trophic webs and feeding niches will develop and provide better development conditions for plankton and aquatic organisms feeding on plankton.
- Fish biodiversity will accordingly be modified, as fishing practices, with transformation of running water system into a more stagnant one, and the existence of an artificial barrier blocking fish movements. Dealing with fish species, most cyprinids for instance are used to migrate upstream for reproductive needs; with the rehabilitation of the dam, they would be handicapped in this natural behaviour, and mitigating measures need to be taken.
- Fishing gears would certainly change upstream, with promotion of more canoes and gill nets in the reservoirs section. Cage culture could opportunately be envisaged in the lake, as pen culture in shallower areas.
- The project will offer employment (even if on a temporary basis) to native and incoming labourers and technicians, and will improve lodging businesses, restauration and trading. Following the closure of the dam to be built, the number of fishers will increase, as will side activities (fish transformation and commercialisation). New infrastructure thus will be required, including housings, schools, health centres, markets, security services.

11.4.1 Impacts on Natural Habitats and Biodiversity

The reservoir will extend over 8.1 km^2 upstream of the dam and will permanently submerge all farms, shrubs and trees currently below contour line 29.08 m above sea level. Impounding would result in decomposition of organic materials and fertilisation of waters for the first years following the termination of the rehabilitation work. Phytoplankton and zooplankton will thus develop massively with light, thus benefitting to fish production. Afterwards, as it has been observed in many man-made lakes with small surfaces, the water will become poorer in its natural feeds, to reach a productivity level lower than before the construction of the dam. Sediments will accumulate in the reservoir, covering rocky niches formerly occupied by fish species of Cyprinidae and Mormyridae families. Again, plankton feeders, namely tilapias alongside with their natural predators (Hemichromis, Clarias) will proliferate in the new environment (Lowe-McConnell, 1975; Lévêque *et al.*, 1988; Pouomogne, 1988).

A further impact on the fish population will be the migration barrier. To allow migrating fish species to cross the almost 20 m height dam, auto-crossing infrastructures such as fish ladders may not be convenient for the current moment. It may be too costly and probably not useful since no previous viable trial has been done elsewhere for tropical fish and the data on size, behaviour, swimming ability are currently lacking to plan an efficient fish pass. However, alternate stock reinforcements of species such as *Labeo sp, Barbus sp., Mormyrus sp.*, etc. may be tried, by practicing alive fishing of these species downstream and transferring them within the reservoirs during spawning period of the year (which usually occur during flooding at the crest of rainy season). A sustainable way of doing this is to involve native fishers in the capture and transferring process, while valorising their knowledge on spawning grounds and seasons.

During the rainy season there will be no impact on the fish related to the operation pattern of the HPP. During the dry season however, if no residual flow is implemented the impact on specific fish species would be very substantial. It is necessary from a biodiversity point of view that the 4 km of original riverbed are kept functioning since this is an important habitat for spawning and rearing of *Barbus, Labeo, Alestes* and *Mormyrops*. Shutting down all flow even just for some hours could also have an impact on some marine/brackish water species namely clupeids (Bonga: *Ethmalosa sp*), Carangidae (*Chloroscumbus sp*) and Polynemidae (*Galeoides sp*) downstream of the dam due to the change in salt content. Therefore a residual flow is essential.

11.4.2 Impacts Related to Construction

During the construction itself the main impact is related to water quality. Increased load in suspended solids stemming from the construction site, contamination with hydrocarbons (fuel, lubricants etc.) and other toxic substances and contamination with concrete, resulting in a higher pH which could potentially be toxic for fish are negative impacts.

11.4.3 Impacts Related to Operation

The number of fishermen, currently estimated at about 600, will probably increase during the first years after dam closure as a result of greater fish production anticipated within the reservoir. Many new fishermen from outside would migrate to Mount Coffee, including side labourers as boats builders, fishing gears traders, and of course merchants. With changes in water flow and fishing conditions (from a river to a lake), some fishermen may abandon the activity for fear of potential danger in the new environment. For each of the different situations evoked, mitigation measures are needed.

As stated earlier, while fish biodiversity, namely some cyprinids and mormyrids, will decrease in the project area, some species will greatly proliferate within the more stagnant new environment, namely catfishes *Clarias sp*, or *Chrisichthys sp.*, and Cichlidae (*Oreochromis sp., Tilapia sp.* and *Hemichromis sp*).

The following formula (after Henderson and Welcomme 1974), cited by Welcomme and Barley (1998) allows to estimate the potential production Y (tons) of a man-made lake extended of surface S (km^2):

$$\mathrm{Log}Y = 3.57 + 0.76 * \mathrm{Log}\ S.$$

Numerical application of this formula with the Mount Coffee Hydropower project at the highest water level in the reservoir (29.08 m asl), i.e. S=8.1 km^2stand as follows:

Log Y = 3,57 + 0,76 x Log 8.1, i.e. Y = $e^{(3,57 + 0,76\mathrm{Log}8.1)}$ = 174 tons.

Another way of calculating is through the Morpho Edaphic Index, MEI= water conductivity / average depth of the reservoir (Handerson and Welcomme, 1974 cited by Welcomme et Barley, 1998); in this case, the formula stands as follows:

$$Y = 23.2\sqrt{MEI}.$$

There is no indication of the average water depth in available documents; this parameter is of course lower than the main dam height at spillway level, i.e. 18.3m. An average hypothetical depth half of this level, i.e. 9 m has been considered. The estimated production would be

$Y=23.2\sqrt{75/9} = 70$ kg/ha; for the 8.1 km^2 reservoir, this equates 70 x 8100 = 567tons.

Results are thus different according to the adopted formula; the actual figure may be in between the two calculated data. Taking the average it would be around 370 tons, i.e. about 1.5 times the production currently registered by upstream fishers at Mount Coffee.

With the afflux of more fishermen to exploit this additional resource, an improved management strategy with the help of the Fisheries Bureau is needed. The average in tropical waters is 2 to 4 fishermen per km^2 for sustainable exploitation. Over the 8 km^2 reservoir, this means a maximum of 20 professional fishermen should be authorised to exercise in Mount Coffee reservoir (in addition to the already recorded native fishers).

The construction of a fish market with cold conservation facilities would be welcome to improve the quality of fresh fish sold and overall nutritional welfare and health.

The Bureau of Fisheries may design production sheets where each fisherman would be encouraged to record catch amounts and species composition. The responsible in charge at the Bureau of Fisheries, M. Georges Weefar, has indicated his full availability to animate community management of the new fishery to come, prevailing reasonable functioning means are provided at start. With time, if all plans are implemented in due form, sustainable management of the resource would not need any subsides. In joint collaboration including LEC, the Bureau of Fisheries and fishermen leaders, minimum needs for fishery resource protection should be realised: protection of restricted access areas (from 1000 m upstream to 500 m downstream of the main dam); periodic transfer of anadromous species from downstream to upstream; participation of fishers to stock assessment and establishment of fishing regulation (permits with provisions on total acceptable capture, periodic fishing closure, etc.).

11.5 Mitigation Measures

11.5.1 Mitigation Measures Related to Natural Habitats and Biodiversity

- Protecting fish biodiversity by securing protected zones with restricted access near the dam (500 m downstream 1000 m upstream of the dam sites) and insuring stock reinforcement of selected fish species adopting a partnership approach involving native fishers.
- Fish transfer from downstream of the dam to the reservoir and vice versa. In general it can be stated that, given the height of less than 20 m which the fish would have to overcome a fish pass facility would be possible to implement, but it should only be recommended based on sound scientific data, which are currently lacking. Fish passes have been developed mainly in North America and Europe for a very limited number of target species, mainly salmonides and clupeids. In

those countries fish passes can be considered as an effective mitigation measure. The situation is different for other areas e.g. South America, Asia and Africa, where biology and migratory behaviour is not well known. Here fish passes have to accommodate species of very different sizes, swimming abilities and migratory behaviour and especially small species with limited swimming abilities. The effectiveness of a fish pass depends strongly on the location of the entrance, attraction flow, step height, pool size etc., to define those parameters more data on fish size, swimming ability and migratory behaviour are essential.

Therefore it is recommended to carry out additional studies related to the above mentioned topics on fish behaviour and physiology, before deciding which kind of fishpass (pool pass, lift, lock, sluice) should be implemented and how the layout should be. Space should be kept at the left bank of the tailrace channel next to the powerhouse for adding such a fish pass in the future. Given the present situation, upstream fish migration across the spillway is not possible. However, fish might be able to use the tailrace channel for such movements. The study will, first of all, have to verify if such migrations actually take place.

It is recommended for the moment to implement a trap and truck system to allow potamo-anadromous species, namely *Labeo spp*. and *Barbus sp.*, to safely cross the dam. Periodic (crest of rainy season) alive fishing and transfer to specific areas upstream are required. Since fish are following the main current the trap needs to be implemented next to the powerhouse in the tailrace channel. From there it can then be transported by truck to the reservoir and released at suitable areas either within the specified protected area or for some species it will be useful to be released at tributaries or even at the upper end of the reservoir. The trapping and transportation would be done with the full participation of experimented fishermen and staff of the Bureau of Fishery. Precise protocols of the operation would be validated after a minimum of 2 years follow-up prior the termination of the project.

During design and construction of the dam, the trap and truck system should be forecast to facilitate fish transfer. Suitable space should be kept in the design for a fishpass.

- Release of a residual flow and implementation of fish transfer is essential for biodiversity and fishery issues up and downstream of the dam.
- Dealing specifically with the CR species of the IUCN red list, develop with Fisheries experts an acclimatation program of *Labeo curriei* in aquaculture, valorising what is currently ongoing in the existing fish breeding program at Klay station.
- Monitoring of fish in general and specifically also on the fish transfer needs to be implemented.

11.5.2 Mitigation Measures Related to Construction

- General precaution measures related to water quality need to be implemented.
- Fishing activities of the workforce needs to be monitored or even forbidden to reduce conflicts between local population and workforce.

11.5.3 Mitigation Measures Related to Operation

- With migration of new fishers coming from outside the Mount Coffee area, actions should be taken to prevent overexploitation of fish stocks.
- Developing a community management approach in the new fisheries involving all stakeholders (LEC, Bureau of Fisheries, fishers leaders) with a minimum of bi-annual meetings in which the concerns of each party would be objectively debated. The number of fishermen authorized in the reservoir should not exceed additional 20 professionals; taking into consideration the 0.5 km^2 (i.e. 400m-crest of the main dam length x 1000m) restricted access area at the immediate upstream of the main dam. All fishers and side activities would participate in regular training workshops organized with the facilitation of the Bureau of Fisheries, with a strong implication of fishers' cooperatives to be sustained.
- Fish and fishing activities need to be monitored in the project area at least until a new equilibrium has been reached.
- Once a sustainable level of fishing will have been reached, the installation of a fish market equipped with handling and storing facilities, e.g. in the vicinity of Raymond Camp, might be considered. Obviously, operating these facilities would require prior electrification of the site.
- As side infrastructures in relation to the dam, reinforce local capacities in housing, health centre, water and sanitation, markets, gendarmeries, school and churches. These initiatives should be conducted in partnership with local responsibles.

11.5.4 Mitigation Measures as Part of Mt. Coffee HPP

The various mitigation measures listed and describes shortly above outline an entire fisheries development program which cannot be implemented in its entirety by Mt. Coffee HPP. It is therefore recommended to set up, under a different financing, a regional fisheries development program which would integrate all the measures outlined.

For the Project as such, the following mitigation measures are recommended to be implemented directly:

- The measures mentioned for the protection of water quality during the construction period.
- The pre-impoundment clearing of the land to be submerged (see Section 8.4.6.4).
- Monitoring of fish and fisheries; for this, specific TOR will have to be developed.
- Setting aside space for a possible installation of a fish ladder at a later stage.
- Implementation of livelihood restoration measures as identified in the RAP.
- coordination of these activities with the Bureau of Fisheries.

12 PROTECTED AREAS

12.1 Prevailing Situation

The focus of this chapter is on National Parks and any other protected areas or habitats important for biodiversity conservation (even if not legally protected) that might be affected by the Project (like the mangroves in the estuary, which is in general an area of high biodiversity used for fish nursery), or that might be used in any way for mitigating impacts, if required.

Liberia has 22 protected areas consisting of 4 National Parks, 3 Nature Conservation Units, and 15 National Forests. 20 of the protected areas are terrestrial and 2 marine.

Table 12-1: Protected areas of Liberia

No.	Protected Area	Type	Area (ha)
1	Cestos Sabkwen	National park	145’000
2	Lofa-Mano	National park	230’000
3	Sapo	National park	129’200
4	Tienpo	National park	19’344
5	Cape Mount	Nature conservation unit	55’400
6	Wologozi	Nature conservation unit	26’130
7	Wonegizi Liberia	Nature conservation unit	20’200
8	Belle	National Forest	65’600
9	East Nimba	National Forest	9’591
10	Gibi	National Forest	60’704
11	Gio	National Forest	32’780
12	Gola	National Forest	20’200
13	Grebo	National Forest	260’326
14	Kpelle	National Forest	174’828
15	Khrahn Bassa	National Forest	513’962
16	Lorma	National Forest	43’505
17	National Forest Name Unknown (LBR) No.1	National Forest	Unknown
18	National Forest Name Unknown (LBR) No.1	National Forest	Unknown
19	North Gio	National Forest	13’172
22	North Lorma	National Forest	71’226
23	Wets Nimba	National Forest	9’146
24	Yomo	National Forest	2’648

Sources: NBSAP 2004, UNEP 2007, Protectedplanet.net

In addition to the terrestrial protected areas Liberia has 8 wetlands. Presently, the first 5 sites in the Table below are designated as wetlands of international importance according to the Ramsar convention.

Table 12-2: Wetlands of international importance

No	Wetlands	Type	Region	Surface area	Coordinates
1	Gbedin	Inland swamp	Nimba	25 ha	07°16'N, 008°48'W
2	Kpatawee	Inland riverine	Bong	835 ha	07°07'N, 009°38'W
3	Lake Piso	Costal lacustrine	Singe	76'091 ha	06°45'N, 011°13'W
4	Marshall	Inland riverine	Margibi	12'168 ha	06°08N, 010°22'W
5	Mesurado	Coastal	Montserrado	6'706 ha	06°18'N, 010°45'W
6	Lake Sheperd	Coastal	Maryland	18'000 ha	
7	Bafu Bay	Coastal	Sinoe	11'900 ha	
8	Cestos- Sankwehn	Inland riverine	Sinoe	15'000	

Source: NBSAP 2004, UNEP 2007

The following map shows the protected areas as well as the areas of high biodiversity. The Mt. Coffee HPP is not located in, or near a protected area or a biodiversity priority site. The closest site is the Mesurado Wetland, which is located near the estuary of St Paul river.

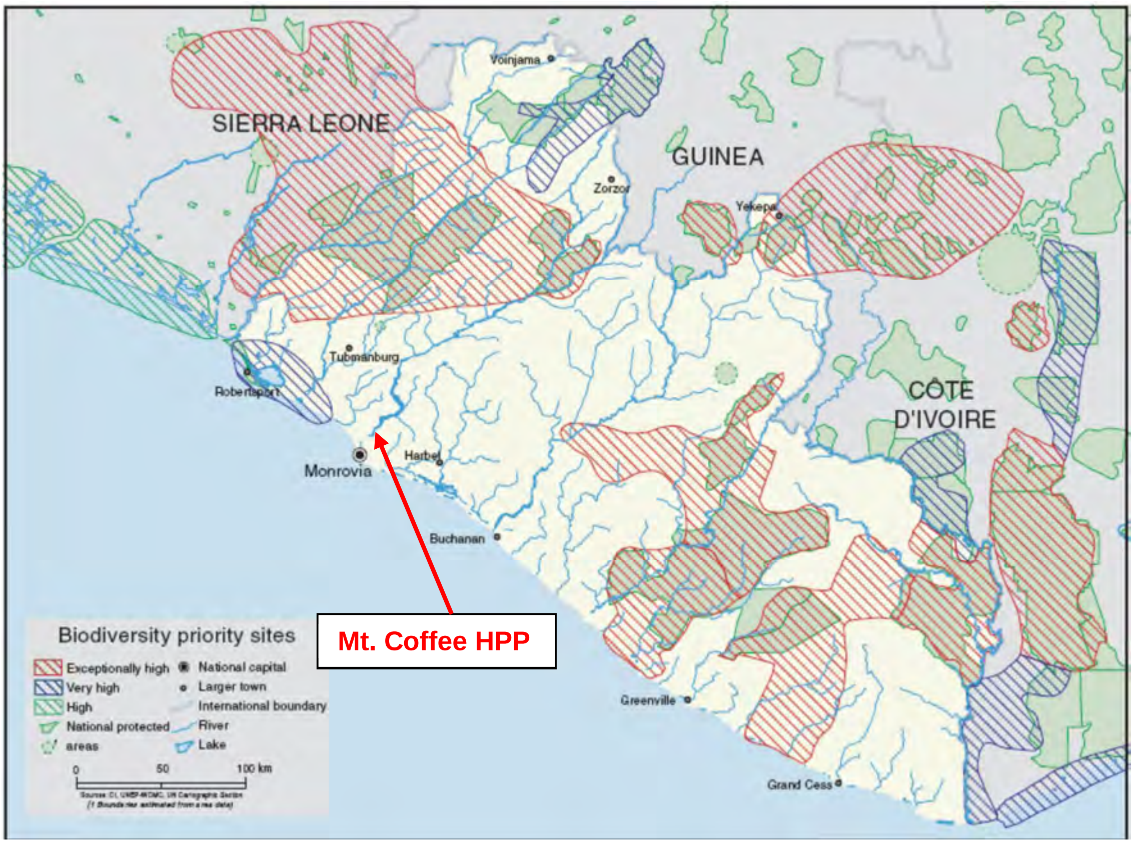


Figure 12-1: Biodiversity priority sites and national protected areas

Source: UNEP, 2004, Desk Study on the Environment in Liberia

12.2 Conclusions

Since the Project will not affect any of the protected areas, no mitigation measures are needed.

III. THE HUMAN ENVIRONMENT

This Section deals with the human population and its activities and living conditions. It will be the basis for the Resettlement Plan.

13 SETTLEMENTS AND POPULATION

13.1 Theoretical Considerations

Involuntary resettlement triggered by development projects has become a topic of increasing importance. While such a resettlement can be caused by different kinds of projects, it is often of special importance in dam projects, due to the fact that reservoirs often occupy a considerable area, and that human populations have a tendency to be concentrated along rivers. The main reasons for these concentrations are the presence of fertile alluvial soils in river valleys, as well as the fact that rivers provide water, food (fisheries), and transportation routes (directly, in case of navigable rivers, or by roads following the valleys). This can create major conflicts between projects and the interests of the local population.

The World Bank played a major role in formulating policies as guidelines for such resettlement efforts. The core point of all such policies consists in the principle of fair compensation for lost assets. The aim of any resettlement program must be to protect project affected persons (PAP) from impoverishment due to the project. As a minimum, after resettlement such persons should be at the same (economic) level as they were before, and if possible their situation should improve (benefit sharing). These principles are by now generally accepted standards.

13.2 Methodology

The method used to gather information for this chapter is a combination of literature, desk study and site visits. Most of the general socio-economic data for the country will be found in Annex 13, showing the country profile data and socio-economic indicators. The World Bank website and the UNDP Human Development Report, 2011 are the main sources. At present there is an ongoing household (HH) survey to collect detailed data on the most likely to be affected households (HHs). Consultation with local leaders and administration to solicit information on settlements has also contributed to information gathered on the project area. Key Informant Survey (KIS) and Emic – story telling have been used to gather information on the village profiles, the methodology combined is the rural rapid assessment for the village profiles.

13.3 Present Situation

The settlements are either villages or towns and for convenience sake, these will be referred to as settlements.

13.3.1 Economy

Locals or residents of the project area are basically involved in fishing, farming, charcoal production and gold mining as their source of livelihood. They transport farm produce to Monrovia markets, which are approximately 25 kilometres away from their respective communities (project site). Local markets which are set up in the settlements are of rudimentary structures with stalls made up of bamboo sticks. The settlements' big market is located in Bensonville, and this market's main operation day is Saturday. For additional produce not sent to Monrovia, Bensonville market remains the main trading site. The basic commodities they produce include: cassava, sugar cane, vegetables and other cash crops like pepper, okra, etc..

The population practising mainly agriculture also grow perennial crops, i.e. tree crops like rubber and palm oil, plantains, cocoa, among others. Rubber trees are the most common and occupy quite a sizeable part of the land in the present reservoir area. A bit of livestock is also kept, though this is not in large numbers.

Though most people practise subsistence farming, petty trade is also common among the population and goods are sold are at the settlement level. In general, the main economy is agricultural-based, with farming, fishing and informal business as the major occupations of the inhabitants.

13.3.2 Ethnic Groups

There are six Liberian ethnic groups that make up the population in the project area which include: Kpelle, Kissi, Lorma, Gola, Bassa and Gio. All of these tribes constitute a total population of about 4’000 people.

The religions practised by the population are Christianity, Islam and indigenous beliefs. The ethnic groups use mostly their vernacular to communicate but most can communicate in Kpelle and Bassa. English is the general language spoken between different ethnic groups that don’t understand each other’s dialect, but this spoken English is a mixture with the vernacular language.

13.3.3 Local Administration

The local administration for a township has a four tier structure as follows:

- Commissioner
- General Town Chief, to whom all village chiefs report. Under this tier there can be Wards in the townships, e.g. Harrisburg has 3 wards. Each ward is controlled by a tribal chief, who deals with the individual tribes, farms and houses. These tribal chiefs would report to the town chief.
- Town Clerk
- Town Chief: This one exists only in townships.

A Commissioner assisted by a Deputy serves as head of the local government in the area. There is also a Town Chief who is an integral part of the local government configuration who directly communicates to the locals. There is a General Town Chief at the fourth level.

Not all townships have a set-up like Harrisburg, which has 1st, 2nd, and 3rd Wards. If there are no wards the village chiefs report to the Town chief. The local administration posts receive a salary, unlike the leadership structure in the settlements.

13.3.3.1 Leadership Structure in the Settlements

At the local level there is the Clan, which can be headed by a Paramount Chief and at lower level there is the Town Chief and then a Village Chief. The Village Chief has a council of Elders, made up of two men and a woman. Below the Council of elders are three groups also known as “koo”, headed by a man, woman and a youth (as there are three groups: men, women and youth). An illustration of the local administration and village leadership structure is shown below. The three groups are also the social network groups, which assist individuals who need help with, for example, house construction, weddings, and funerals. The person being assisted is responsible for providing meals to those helping, while helpers normally come with their tools, equipment, etc to carry out whatever task is at hand.

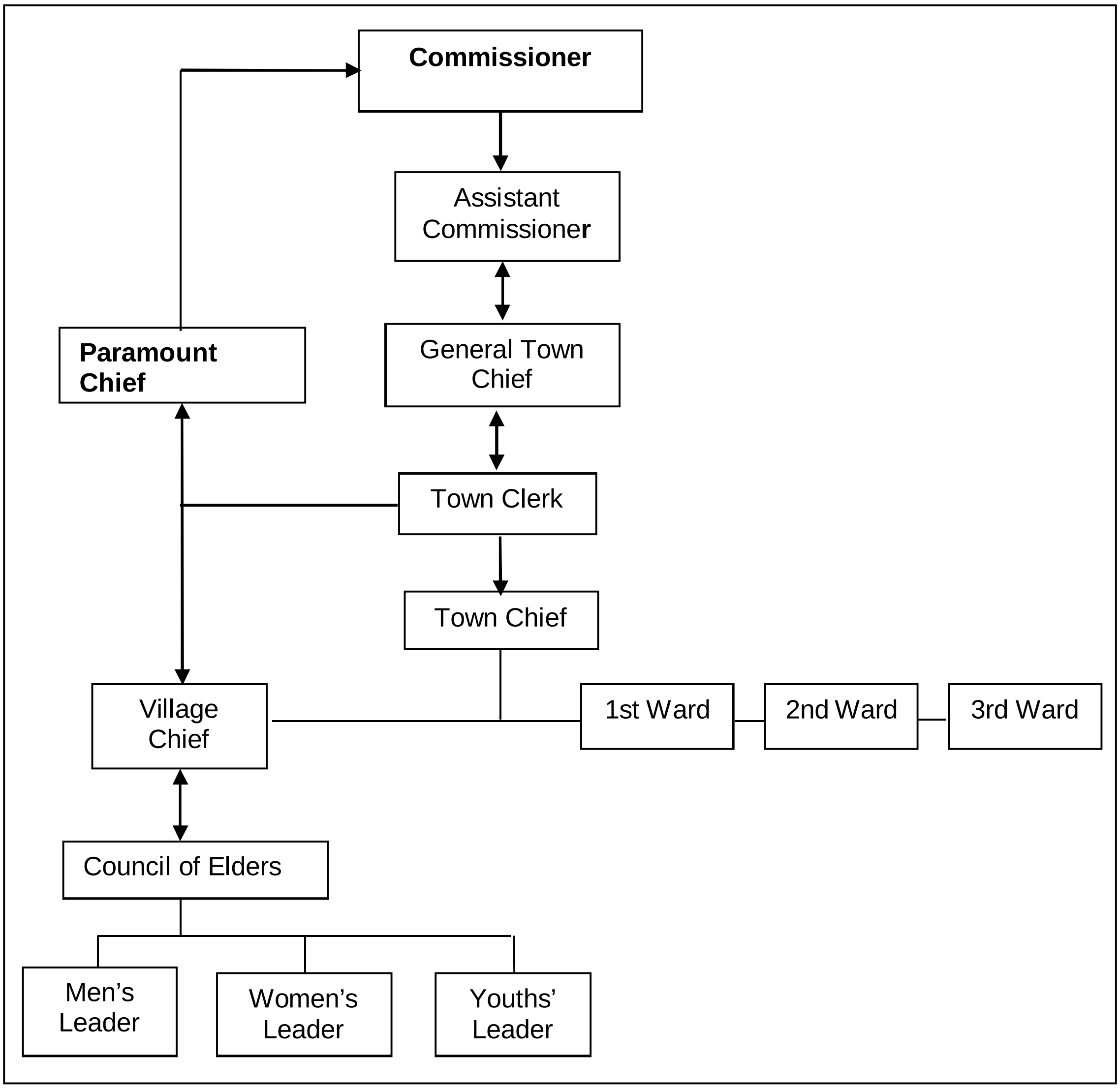


Figure 13-1: Local Administration and Leadership Structure in the Villages

13.3.4 Affected Settlements

Due to the dense vegetation growth, it was apparently not clear that settlements would be affected. However, on further intense investigations in the field settlements have so far been identified that will be affected by the impoundment of the reservoir. The settlements are within the reservoir area and will therefore have to be relocated. The approximate number of structures is put at between 75 – 86 houses plus the kitchen structures, which are built separately from the main house. The ongoing household survey will capture the exact number of these households. This means that there will be physical relocation for these HHs after all. The unit used is the household which may include several families making up the home. However, what is of importance is the number of structures that will be destroyed and hence the need to be relocated.

The ongoing HH survey and other site visits are also identifying settlements surrounding the reservoir area, whose inhabitants are using part of the reservoir area for cultivation or for other purposes. This group of settlements and its population will make up the largest proportion of PAPs.

Local authorities have been contacted prior to starting the HH survey. Viable information on which structures will likely be affected is also being obtained from reliable village/settlement members who are leaders in the community and are known by the villagers.

The following Table shows the settlements and population and number of HHs that will most likely be affected, as the structures are in the reservoir.

Table 13-1: Settlements that will be affected and number of households

District	Township	Settlement Name	Number of HHs	Number of Persons
Careysburg	Harrisburg	Shellen Town	8	37
		Erik	2	10
		Wenekai Village	16	60
St. Paul River	Arthington	Gbally Village	10	60
		Sumo	3	15
Todee	Mount Coffee	Benben Town	68	200
Total			107	382

Source: Study Team

The identified settlements are distanced from each other in the interior and have varied number of built structures. Some settlements like Benben Town have well over 50 structures, which will most likely be affected and thus have to be relocated and compensated. The settlements are interconnected by barely discernible footpaths. Where roads exist these are dirt/secondary roads connecting larger towns. The dirt roads are of poor quality and make some areas inaccessible by ordinary cars (non-4-wheel) during the rainy season. Settlements on the left and right bank of the river can also be reached by canoe from either side of the river. The following satellite picture shows an overview of the location of the settlements.

Figure 13-2: Map showing the villages most likely to be affected

13.3.5 Village Profiles

The general socio-economic situation of the affected villages and the importance of the reservoir area for the livelihood of the population will have to be assessed in detail in the RAP. What is given here is a general picture of what the situation is. A preliminary socio-economic profile of the villages is given in the following sections. More detailed profiles will be given in the RAP.

13.3.5.1 Wenekai Settlement

The settlement Wenekai evolved from a Kpelle word which was translated into English as "*place where we meet friends*." According to the residents, this settlement was established in 1995 as people were returning from displaced camps, settling in big towns that were either burned or completely looted and were fearful to live in. Under this situation, most people were afraid to return to their original town. More so, settling in small settlements could give them some livelihoods such as cutting of wild palm, making of charcoal which would sustain their families for the time being.

Wenekai is about an hour's walk from Raymond Town. It is bounded on the north by St. Paul River, on the southwest by Shellen, and on the east by Eric. The settlement has 16 houses with 60 persons. Since these people are squatters, they could not mention the number of hectares of the settlement. There is no land use category or soil classification.

The main economic activity besides farming is charcoal making. Their main crop is cassava which is harvested only once a year. Production of 50 kg is valued at an average of 1'200 LD. The low production can be attributed to traditional farming techniques under rainfed agriculture. The population also hunts and fishes. In terms of commerce, Wenekai is known for charcoal and cassava production. On the other hand, Wenekai being an open community, goods such as rice, salt, soap, etc. are brought there. Average family income is about 20'000 LD per year. The main market is in Bensonville, which serves all the settlements around, with the big market day on Saturdays.

The settlement has access to farm-to-market road but hardly do cars go into the village. Almost all vehicles that enter the village go to pick up charcoal. The roads are all dirt roads and paths interconnecting the different houses or leading from the settlement are in bad conditions. There are also footbridges leading to the farms, where most people are living. The footbridges are simple, made up of two palm tree trunks lying side by side. Few persons have radios and cell phones. The phone network is poor. There are no sports or recreation grounds.

Most common health problem in this settlement is malaria. Patients walk to Raymond Camp health post for treatment. The source of water is from a nearby creek. Waste is thrown all around while close by bushes are used for toilets.

The settlement's formal social structure is headed by a village chief appointed by the elders of the village. Assisting the village chief are the head of the women wing, the youth wing along with few elders. Wenekai is within Montserrado County, Careysburg District, Township of Harrisburg – which has 1st Ward, 2nd Ward and 3rd Ward. Wenekai is found within the 2nd Ward. In terms of social institutions, there are no churches/mosques nor schools. Kids walk every school day to Raymond Camp.

13.3.5.2 Shellen (Shilling) Settlement

Shellen village was established 1996 by people leaving the displaced center from Todee District. Shellen is said to mean shilling. According to story, Mr. John had a British coin which was so strange to many of the people travelling with him. He then decided that what was written on the coin become the name of the Town.

The main sources of livelihood in Shellen (Shilling) are farming and vegetable gardening. It is noted that rice production is not common. Root crop like cassava is commonly planted and harvested. The vegetables that are usually grown in the area are pepper, beans. However, these vegetables are most likely just enough for their household consumption. Like Wenekai, Shellen (Shilling) does not know the number of hectares on which it sits. There is no soil classification.

The thirty-seven persons (37) of the village live in eight makeshift type of housing. A village chief appointed by the elders heads the village; assisted by the village head of the women wing, the youth wing along with few elders. Shellen is in Montserrado County, Careysburg District, Township of Harrisburg, 2nd Ward and 3rd Ward. In terms of social institutions, there are no churche/mosque nor school. Kids walk every school day to Raymond Camp. There are two community organizations for the male and female – the men Koo and the female Koo. One of the functions of these groups are to assist each member do his/her farm work.

Shellen is limited on the north by St. Paul River, on the west by Raymond Camp, and on the east sharing the creek with Wenekai and south by a large swamp. Commerce is similar to Wenekai.

13.3.5.3 Eric Settlement

Eric is in Montserrado County, Careysburg District, Township of Harrisburg, 2nd Ward and 3rd Ward. There are two makeshift structures in which 10 persons reside. Eric is limited on the north by St. Paul River, on the west by Raymond farms, and on the east sharing creek with Borbor town and south by Wenekai. This settlement has been there since the Second World War.

Eric, Wenekai and Shellen are similar in terms of livelihood activities, leadership structure, commerce and trade. The main economic activities are farming, fishing, and hunting.

The population uses the Raymond Camp health post and serious cases are referred to Bensonville hospital; children also attend school at Raymond Camp. Water for domestic use is from the creek and waste is deposited in the bush, which is also used as toilet. The market used is in Bensonville.

13.3.5.4 Gbally Village Settlement

Gbally settlement is within Gbavia Clan, St. Paul River District, Montserrado County, Township of Arthington. This settlement was established in 1995. The community belongs to Gbfei clan. There are 10 structures, with a total of 60 persons.

There is no motor road; one must walk three to four hours to reach Raymond Camp. School going kids go to in Bandi, normally their parents let them stay with a relative in Bandi for the week in order to attend school and then over the weekend the children go back to their homes in Gbally. Water for domestic use is from the St. Paul River. In terms of telecommunications there is poor cell phone network. There is a mosque. Livelihood activities are mining of gold and farming. No market exists, people have to walk for one and a half hours to get to Gonoghab market.

13.3.5.5 Sumo Settlement

Sumo settlement is within Gbavia Clan, St. Paul River District, Montserrado County, Arthington City. This settlement was established 1989 and the name Sumo is a Kpelle word meaning "*come sooner*". There is no motor road; one must walk three to four hours to reach Raymond Camp. There is poor cell phone network. The water source for domestic use is the river. Livelihood activities are fishing and farming. Sumo is along the St. Paul River, the people have not yet entertained the idea of fish-farming. Fishing for them is just for their immediate consumption. Commercial fish farming could develop into one source of their income and should be established and developed. There are 15 persons living in three makeshift houses. There are no churches or mosques here. Children from this settlement also attend school in Bandi.

13.3.5.6 Benben Settlement

Old folks like 80 years old Tommy Urey Benben recounted that the settlement was relocated in 1962 across the train-track for the construction of the Mount Coffee Hydro. The community returned in 1993.

Benben settlement is within Mount Coffee Township, Todee District, Montserrado County. There is a dirt motor road leading up to the settlement and this is of reasonable quality. There are 200 persons living in 68 makeshift houses. No drinking water, no toilet. The main livelihood activities include mining of gold, rubber taping and farming.

The Nyenh clinic serves the settlement and there is a mosque but no church. A malfunctioning water pump was noted but domestic water is obtained from the creek. The bush is used as toilet and for depositing waste.

13.3.6 Education, Health, Water and Sanitation, Public Services

To date only big townships like Harrisburg and Arthington have a semblance of social infrastructure like primary and junior high schools, clinics, etc. The present schools cover only lower level education and the facilities were heavily affected by the civil war. Water and sanitation facilities in the schools are not ample, with the water present in 26% and latrines in only 35% of the schools surveyed on a national scale in 2004, which implies that education facilities in the project area mirror the same low proportions for water and sanitation facilities. In addition, school equipment like chalkboards, textbooks and furniture (desks for students and tables for teachers) are not sufficient. It is also a problem to get qualified teachers in remote areas.

The 2008 Population and Housing Census found that Careysburg District has 35 schools, while St. Paul district has 252. Most schools are distanced from the settlements forcing children to walk long distances to receive education. Illiteracy among the population aged 10 years and over is high in the project area, especially among the women.

The identified settlements do not have health centres as such, but clinics which cater for primary health care; the clinics are a great walking distance from the rural population's homes. The populations in the settlements use the nearest clinics which are normally found in the townships. All the likely affected settlements use the Raymond Camp clinic. The health facilities are in a sorry state and need qualified medical personnel.

Markets with solid structures are lacking in the settlements. Existing market stalls or structures are rudimentary in the settlements that will be affected. The biggest market serving all the likely affected settlements is in Bensonville.

The Mount Coffee Hydro Electric dam and the White Plains Water Treatment Plan, that are both in Careysburg District, used to ensure a constant supply of water to Montserrado County before the war. The present water provision for the settlements in the project area is mostly from the St. Paul River. No functioning hand pumps have so far been seen in the settlements that are likely to be affected. Household members fetch water from the river or nearby creeks for domestic use, some may have open wells.

Services for sanitation and waste disposal are lacking. Most of the settlements dispose of their garbage in the outskirts of the settlement area or in the bush. Toilets are either open or covered pit latrines in the districts, but the bush is most commonly used as a toilet in the project area. The poor sanitation and hygienic situation exacerbates the health situation. The most common illness among infants whose mortality rates are high, are malaria, diarrhoea, acute respiratory infections, neonatal tetanus, measles and malnutrition which are the major causes of morbidity. It is not clear how high a proportion of adults are infected with human immunodeficiency virus (HIV) but the latest data show a low percentage for both women and men in the age bracket of 14-49 – 1.8% for women and 1.2% for men.

In all the likely affected settlements, no social infrastructure like schools, clinics, will be affected as these are all on higher ground away from the reservoir area. Therefore there will be no need to replace them. An upgrading of the clinics would be called for, however.

13.3.7 Information on Population

Households involved in using, in any way, land that will be lost or otherwise affected by the project are at present being identified. The people who have their produce on this land are the project affected persons (PAP), and this is the most important category of PAP. The type of land use has been identified and is presented in the following Chapter 14. Table 13-1 above shows the most likely settlements that will be affected, indicating numbers. However, for land use most of the settlements along the St. Paul River upstream of Mt. Coffee dam site have their farmlands in the reservoir. An indication of the size of these lands and the crops and trees cultivated is also shown in Chapter 14.

The main part of the RAP will deal with the compensation of the losses incurred. The situation (socio-economic status) of the affected HH will be analysed, and a comprehensive socio-economic survey in settlements that will likely be affected is being carried out at present. So far six settlements, which are indicated in Table 13-1 will have to be relocated. General information on the population is described in the village profiles as regards their socio-economic status derived from occupations as farmers, fishermen, gold-diggers, and hunters.

13.4 Impacts

13.4.1 Impacts of Construction:

From a socio-economic perspective during construction there will be both positive and negative impacts. The negative impacts could include:

- PAPs that have used the reservoir land to grow cash crops will lose these crops and will have to be compensated, albeit the land belongs to LEC.
- Land will be expropriated and as such a resettlement will take place in areas where PAPs have constructed houses in the reservoir.
- PAPs will no longer fish near the construction site but fishing may continue further upstream away from the dam site.
- Access to forest will be curtailed as a lot of vegetation clearance will be done and loss of some forest resources earlier got will also disappear, e.g. collecting sticks for roof construction, herbs, mushrooms, snails, etc.
- Hunting will be restricted in the vicinity of the dam due partly to thin vegetation, but most important to keep the dam site secure.
- Making of charcoal in the nearby forest will be curtailed.
- Increased noise due to construction and should building materials be excavated from quarries nearby. There seems to be potential to start up a quarry near present day Gbally settlement.
- Possibility of increase of disease outbreaks if medical precautions are not taken to screen people coming in for employment from other areas.

- Possible risk of increased crime rate (including abuse and rape of women), due to influx of population if the security precautions are not taken.
- Possibility of less land for cash crops as these have till now been grown in the reservoir. Unless alternative land is identified that will take on cash crop cultivation, as communal land will not support long-term perennial crops/trees.
- Possibility of increased traffic accidents due to high presence of heavy trucks and more vehicles.

Positive impacts include:

- The project, at least during the construction phase, will create a considerable number of jobs, presumably open also to inhabitants of affected villages.
- PAPs could be used to clear the land and thus get temporary employment and earn an income, even if for a short period.
- Possible improvement of commercial activities, due to increase of construction activity in the area.
- Improved roads and an upgraded health centre in Harrisburg Township that should be able to deal with medical issues of workers at the construction site and the people in the surrounding area.

13.4.2 Impacts of Operation:

From a socio-economic perspective impact of operation will mostly be positive. This will include:

- Provision of light and improvement of operation of some social infrastructure by connecting to electricity, e.g. schools, clinics, etc.
- Possibility of starting economic activities other than faming.
- Improvement of security in the area due to lighting.
- Eventual improvement of domestic water with possibility of people now getting piped water.

Generally, all land that is being cultivated now in the reservoir will be lost, inclusive of the built structures that are found in the affected villages.

A negative impact on women related to fishing activities and other water use is not anticipated. Women fish usually with hand nets and hoop baskets in the shallow areas of the river or in ponds, men use mainly canoes. It can be assumed that due to the reservoir the area of shallow ponds will increase and not decrease. Furthermore, processing and marketing of fish is carried out mainly by women, and these activities are likely to increase as a consequence of increasing fish production in the project area. Fetching of drinking water, which is mainly done by women and children, will not be changed due to the project, since the women use the tributaries (small streams have better water quality) and not the St Paul river.

13.5 Proposed Mitigation Measures

The mitigation measures hinge on noise and health. For the land take and crops lost, compensation will have to be paid to the PAPs. The costs will be worked out in the Resettlement Action Plan.

For noise:

- Ensure that the use of heavy machinery is limited to normal working hours, especially if a quarry is to be set up near any of the settlements. Excavation of stones, rocks and other construction materials during the night hours should not take place and during the day this should start when the surrounding population normally start their daily chores.
- Ensure that use of heavy machinery at the site is also during normal working hours so as not to disturb the population unnecessarily.

For health:

- Ensure screening of new workers arriving from other areas so as to contain spread of any communicable diseases such as TB, HIV/AIDs, etc. and provide preventative medicine.
- Ensure general hygiene standards are kept and this might be learnt by the surrounding population.
- Improve the medical facility existing to cater for immediate accidents and other medical issues as hospitals are far from the area and they are also ill-equipped.
- During dry season, sprinkling of dirt roads to cut down on dust that would irritate neighbouring settlements and population.
- Ensure that surrounding population is taught and is aware of increased traffic danger and workers especially the drivers have been trained in traffic safety and look out for the local surrounding population, in particular children and women. Particular attention should be paid to children going and leaving schools. Signs should be put up to indicate where schools are and speeds should be kept at 30 km per hour on the exit road passing through the project area.

For surrounding populations and PAPs:

- Give first priority to people in the project area when employing labourers and other unskilled workers, e.g. vegetation clearance, stone crashing in quarries, guards, etc. Should additional skilled workers also be required, take on workers from the area should they have the skills.
- Carry out some information dissemination and teaching of local population on traffic safety, especially among young people, to curtail traffic accidents.
- Upgrade the public security system to cope with the influx of population coming from outside the area.

13.6 Conclusions and Recommendations

It can be concluded that:

- The project's main negative impact on the surrounding populations is the destruction of their perennial crops/trees and losing this agricultural land, but the project must compensate the persons for their crops.
- A number of settlements located within the future reservoir will have to be relocated. At this present point in time, no resettlement sites have been identified yet.
- The major positive impact is the possibility of employment for the surrounding population, though it is not known how many will be employed and for how long.
- Infrastructure like roads, clinic facility, and water provision may improve as will security due to light presence once operation is complete.

It is recommended that:

1. The PAPs (those losing their crops and houses) be relocated and compensated first before the land is taken into use.

14 LAND USE

14.1 Methodology

A systematic approach was employed and all available literature and survey tools were used to collect relevant data. The field visits were carried out between February 15th and March 14th 2012. Individual household farm sizes within project area were measured. Town hall meetings and focus group discussions were held with communities. During the focus group discussions and town hall meetings with community members, an attempt was made to understand the current perception of the impact the rehabilitation of the MC HPP project will have on the livelihood activities of the people. Furthermore, public consultative meetings were held to give communities in the project area an overview of what the ESIA/RAP is all about.

14.2 Present Situation

14.2.1 Agriculture

14.2.1.1 Communities in the Project Area

There were 17 communities covered during the period of the assessment in the project area (see Table 14-1 and Figure 14-1). Four (4) of these communities are found within and around the hydro facilities, two (2) communities downstream on the left side of the St Paul river close to the White Plain water treatment site and the rest of the eleven (11) communities are found upstream in and around the reservoir area.

Table 14-1: Details on population within the project area

No:	Name of Community	Population	# of HH	# of Houses	Location
1	Raymond Camp	1863	312	125	Power house and construction site
2	Buzzel Quarter	92	11	8	Power house and construction site
3	Voinjama	106	15	7	Spillway area
4	Wenekai /Shellen/Eric	107	26	20	In the reservoir area / right bank
5	Zakama	151	38	26	Forebay area upstream / left bank
6	Borbor Town	72	22	10	Right bank of the reservoir area
7	Varney Town	83	20	10	Right bank of the reservoir area
8	Weaduo	75	11	8	Right bank of the reservoir area
9	James Mulbah Town	425	34	17	Left bank of the reservoir area /
10	James Daniel Town	260	57	63	Down stream
11	Sarah Town	25	8	4	Right bank of the reservoir area /
12	Gbally Village	60	10	10	In the reservoir area / right bank
13	Benben Town	200	68	50	In the reservoir area / left bank
14	Gbandi	75	19	28	Right bank of the reservoir area
15	Sumo Village	15	3	2	Right bank of the reservoir area / maybe in the reservoir area
16	Markai	28	7	6	Right bank of the reservoir area
17	December Town	283	62	52	Downstream
	TOTAL	**3920**	**723**	**446**	

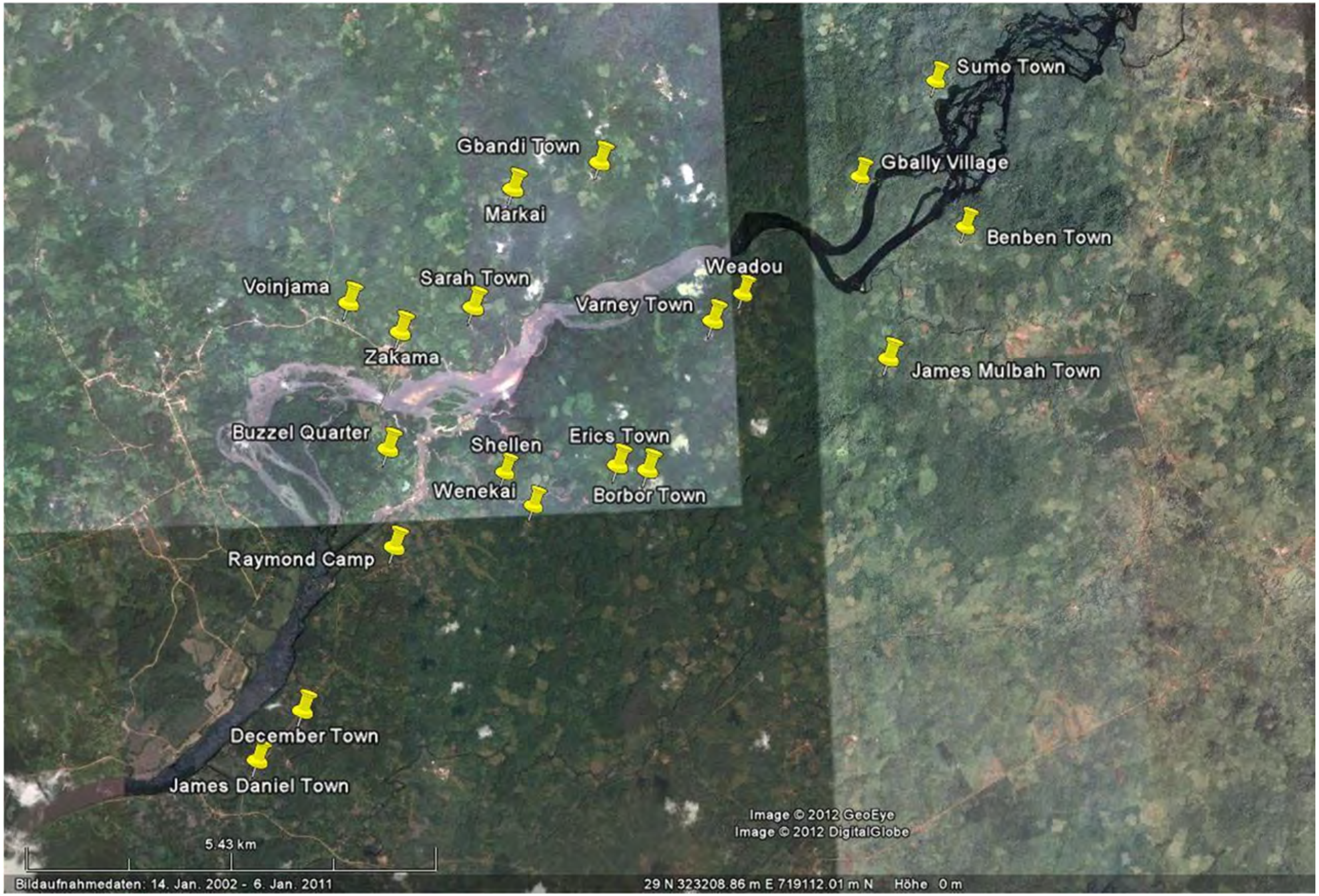


Figure 14-1: Map of settlements visted in the Mount Coffe HPP area

14.2.1.2 Farming Activities

The Mt Coffee Hydropower Project area falls within the Guinea savannah woodland ecological zone under the influence of Sudanese climate characterized by pronounced wet and dry seasons. These conditions dictate the land use pattern within the area.

About 95% of people living in the project area are farmers producing crops such as sugarcane, cassava, rubber, corn, plantain and vegetables. Only a very few farmers, 1% are cultivating rice. The system of farming is predominantly shifting cultivation and land rotation. A piece of land is cultivated for 2 or 3 years and then left fallow to build-up soil fertility for up to 5 years. At times intercropping rubber and sugarcane is common. This practice is mainly carried out by farmers in this area because according to them the straws of sugarcane serve as an important source of nutrients for the growth and development of the young rubber trees.

Most field sizes are less than two hectares. Farms of three hectares or more are rare. There are two systems of cultivation, the permanent compound farming around houses and the shifting cultivation or land rotation away from the villages or towns. Corn and leafy vegetables are mostly grown for HH consumption. Fruit trees such as mangoes, citrus and coconut are around settlements for local consumption.

14.2.1.3 Household Farm Measurement and Assessment of Existing Crops

226 farms with a total size of 257 ha are located in the assumed future reservoir area. The fields measured are not necessarily the only fields of the households, since only fields within the assumed reservoir area have been measured. The distribution of the field size in the reservoir area is shown in Figure 14-2.

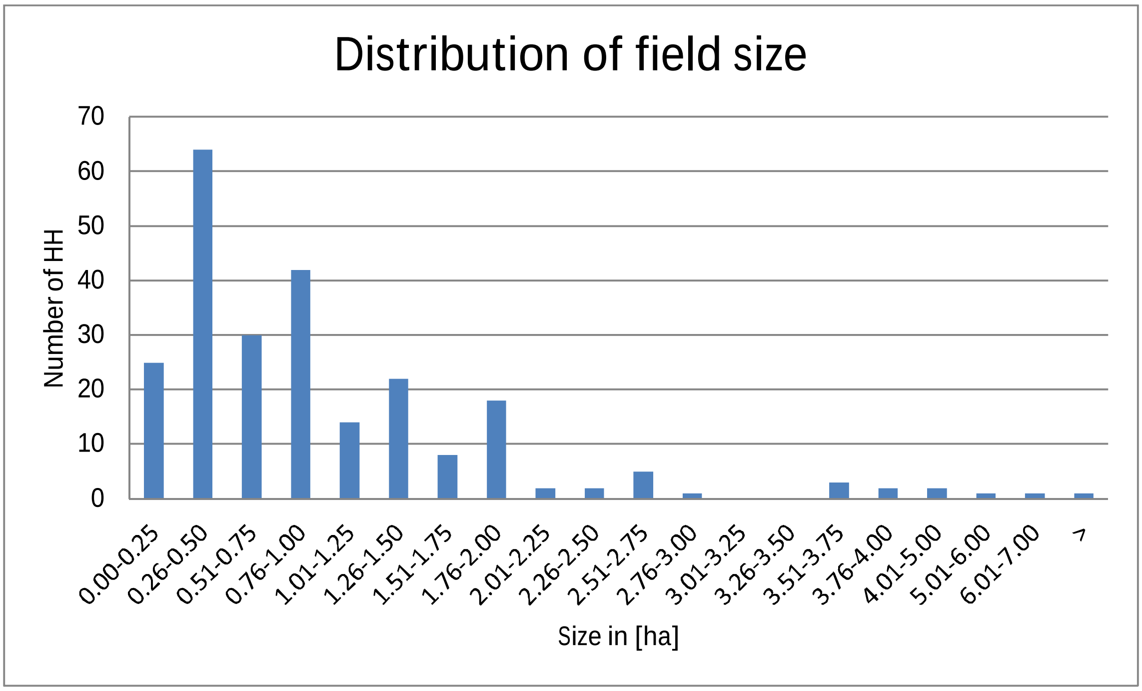


Figure 14-2: Distribution of field size

The crops on these fields are rubber, sugarcane, corn, vegetables (pepper, bitter ball etc.) cassava, pineapple, oil palm, plantain and banana. As can be seen in the Figure 14-3 and 14-4, there are 116 rubber plantations in the reservoir, making rubber the most important cash crop. Cassava, bananas, plantains, and vegetables which are subsistence crops are represented by a rather small number and this can be attributed to the fact that these crops are usually planted near the settlement or housed. Most of the settlements are located outside of the reservoir area.

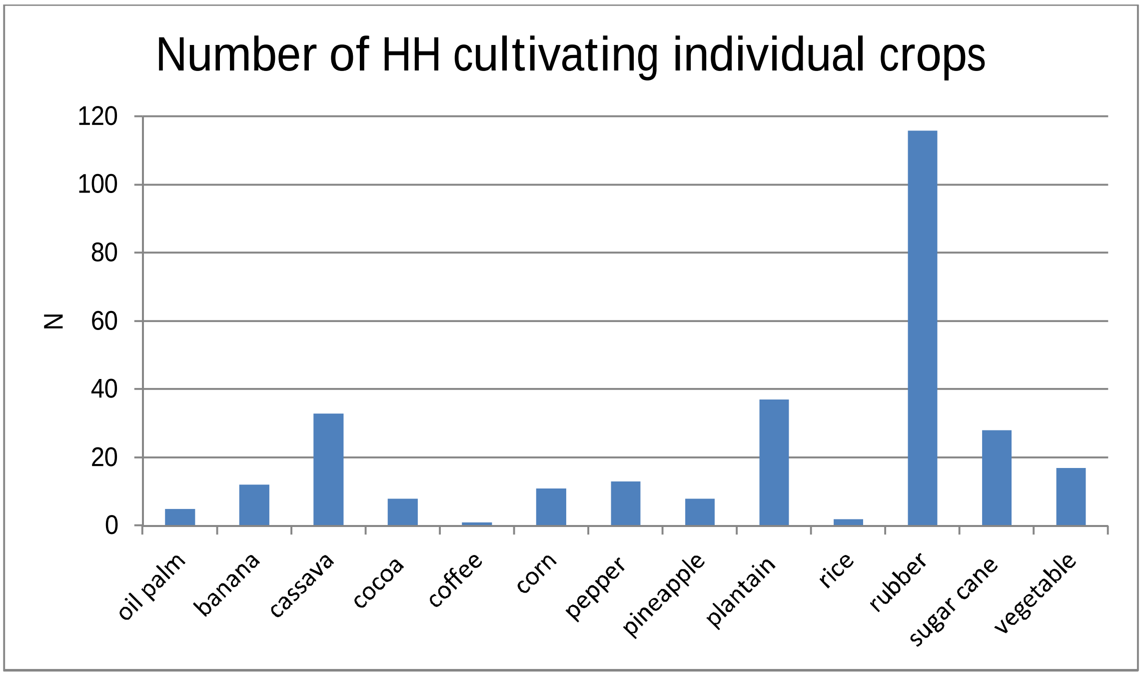


Figure 14-3: Number of HH cultivating individual crops

The Figure below shows the proportion of crops cultivated in the reservoir area, separated into cash crops (60 %) and subsistence crops (40 %).

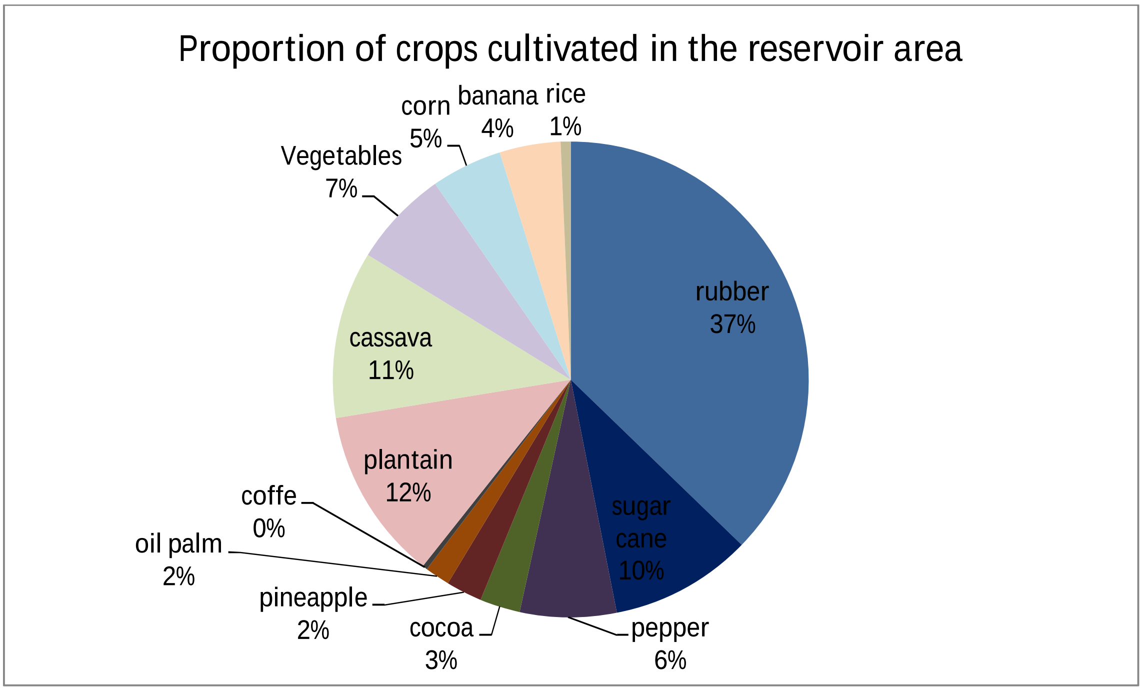


Figure 14-4: Proportion of crops cultivated in the reservoir area

In total, approximately 93'000 rubber trees have been estimated as grown in the plantations in the reservoir area, the rubber plantations cover an area of about 169 ha. In addition around 1'220 oil palms are planted on an area of about 2.11 ha. See Annex 14.1 for detailed data on agriculture per HH in the reservoir area.

14.2.1.4 Inputs

Farming implements used by the farmers are cutlasses, weeding hoes, and scratching hoes.

The farmers rely mainly on rainfed production. A few who practice dry season vegetable farming along the banks of the stream use watering cans to irrigate their crops. There are four big vegetable farmers who are using motorized pump to water their crops.

With regards to inputs the farmers obtain their seeds from previous harvests and from the open market at Bensonville and Monrovia red light. Inorganic fertilizers and insecticides are mainly used by big vegetable farmers.

14.2.1.5 Credit

Farmers' access to credit across the entire communities visited in the project area appears almost impossible. There are no credit opportunities found within these communities, however, there is a system of saving money locally which is referred to as SUSU or CLUB in the Liberian context. This system allows farmers to save and borrow money, but the high interest rate does not encourage farmers in any way to obtain loans. At the same time, obtaining credits from the banks has been frustrating because procedures for obtaining credit are too burdensome. As such farmers are unable to meet their banks' criteria.

14.2.1.6 Market

There is only one regional market available in the project surrounding area which is the Bensonville regional market. The regular market day is on Thursday of every week. About 85% of farmers in the project area use this market, while 15% take their produce to the Monrovia red light market. The main crops farmers trade with are cassava, pepper, bitter ball, corn etc. Sales at the market are predominately done by the women. The produce are transported by own private vehicles. Generally, 75-80% of the produce from the farm are sold, while the rest of the products are consumed.

14.2.1.7 Livestock

Animal husbandry is not commonly practised by communities in the project area. Chickens and ducks were the only livestock identified except for Gbally Village where 15 sheep and 11 goats were seen. Chickens are kept by nearly every family within the project area and are often slaughtered for home consumption during holidays; they are sometimes sold or even used for dowry payment.

14.2.1.8 Land Tenure

During the discussions with farmers in the project area, nobody claimed ownership of any of the land in the area. All they spoke about was that all lands in the project area belong to LEC. Nobody owns land in the area and nobody inherits land. Only crops can be inherited. Settlers consult their landlords who in turn see the chief for the release of land. Settlers only give gifts to the chief and are not allowed to plant tree crops. Consequently the land is basically used for annuals crops.

Land holding in the village is between half (0.5) to five (5) hectares. The average land holding is about 0.5 ha. The minimum land size to support an average family size is between half (0.5) to two (1.5) hectares.

No heavy presence of primary and secondary forest and/or protected area within the project vicinity was observed during this assessment, except for a small piece of secondary forest before reaching the Varney Town community. The major plantation land use within the area is sugarcane and at times cassava.

14.2.2 Forestry

With respect to forestry activities in the project area, majority of the affected community people are engaged in charcoal production, bush meat hunting, NTFPs extraction, fishing, etc. for their livelihood.

The sparsely inhabited lands, mainly of farmland along the tributary rivers and streams, harbour a limited number of game where hunters visit, especially in the nights to poach the games and prepare the carcasses for sale in the local markets or in Monrovia away from the project area. The available game hunted includes monkeys, buffalos, duikers, antelopes, glasscutters, birds, reptiles, etc.

<u>Charcoal production</u>

Production of charcoal and collection of fuel wood for household energy are practised throughout by these communities mostly by men. Some of the charcoal and fuel are heaped in the villages by the major roads for sale. Trees like *Anogeissus leiocarpus Detarium microcarpum, Daniella oliveri, Afzelia Africana and Khaya senegalensis*, *Parkia filicoidia* and *Butyrospermum parkii* are used. These practices have caused extensive deforestation of the vegetation of the project area and have resulted in soil erosion and decline in soil fertility. Charcoal production is one of the livelihood activities of affected communities in and around the Mt. Coffee HPP area.

Table 14-2: Timber species of economic value found during assessment

Botanical Name	Trade Name	Family
Terminalia ivorensis	Framire	Combretaceae
Terminalia superba	Frake	Combretaceae
Chlorophora excelsa	Irko	Moraceae
Canarium schweinfurthii	Aiele	Burseraceae
Nauclea diderichii	Kussia	Rubiaceae
Fagara Macrophylla	Fagara	Rutaceae
Diospira sanzaminika	Ebony	Ceasalpiniaceae
Parinari excelsa	Songue	Rosaceae
Uapaca guinensis	Assam	Euphorbiaceae
Sacoglottis gabonensis	Ozouga	Humiliaceae
Pipdeniastrum africana	Dahoma	Mimosaceae
Erythrophkeum Spp.	Tali	Ceasalpiniaceae

<u>NTFPs collection</u>

Most inhabitants of the project area are engage in livelihood activities like collection of Non-timber Forest Products (NTFPs) such as mushroom, snails, bitter roots, thatches, rattan bamboo, round poles, medicinal plants, etc. from the nearby secondary forest for both commercial and domestic purposes.

NTFP wild edible fruits which are collected in the forest are e.g. monkey apples, walnuts, zalopia seeds (bush pepper), niagon seeds, bush cherries and parkia fruits.

<u>Bush meat hunting</u>

Few Individuals in the affected communities in and adjacent to project areas are involved in bush meat hunting for sustenance in the absence of employment opportunities. During focus group discussions with most villagers, a host of them expressed disappointment for killing some of the endangered animals; but that they were compelled to do so in order to survive.

14.2.3 Employment and Other Income generating Activities

Unemployment rate in rate in Liberia is at 85%, the Government is trying to reduce this high unemployment rate by seeking donor's aids and attracting investors. This situation is even worse in the rural areas and peri-urban areas of Liberia.

For the case of the MC HPP area, only 22 people are formally employed out of the more than 3000 inhabitants. 20 of the 22 people into formal employment are nurses, teachers, and security men from Raymond Camp and working with the clinic, school, and the damaged power house facilities while 2 are workers from surrounding communities.

The town chiefs from various towns in the project area are also considered government workers, but have not been taking salaries.

Other income generating activities are gold mining, oil palm production and charcoal production. Gold mining is only practiced in two communities; Benben town and Gbally village. 90% of the people mining in these two towns are from Monrovia and other parts of Liberia. The local price for a gram of gold is 48-50.00 USD. According to miners in the gold producing area, a group of 5 persons can produce at least 10-15 grams of gold per week. The gold fields are operated by persons or companies who obtain licences from the Ministry of Lands and Mines.

Meanwhile, charcoal production is also one of the income generating activities in the area. 95% of the 15 towns or settlements in the project area upstream of the dam site are involved in these activities, combined with their farming. A bag of charcoal weighing 20-25 kg measured in a 50 kg rice bag costs 150.00 Liberian dollars (LD) or 2.00 USD at farm gate, when transported to Monrovia red light market; cost increases to 300-350.00 LD or 4-5 USD. Transportation per bag of charcoal from the MC HPP area costs 60-80.00 LD.

Oil palm production is practiced by only a few people in the area and specifically men. The palm trees cultivated are grown randomly on available land (mostly fallow from former slash and burn cultivation, and not as plantation. The palm cutters move from one tree to another to gather palm nut bunches to be process into oil. The cost of palm oil per gallon is 3-4 USD during the dry season and 4-5 USD during the rainy season. During the dry season, more oil is produced as compared to the rainy season.

14.3 Impacts

- Loss of farm land and crops
- Loss of forest for charcoal production and collection of NTFP

14.4 Mitigation Measures

Farming is the major livelihood activity of communities residing in and adjacent to the project area, Furthermore NTFPs collection and hunting are important livelihood activities and following measures are recommended:

- Put in place appropriate policies to compensate communities that may be affected by the rehabilitation of MC HPP.
- Identify alternative farm land for affected farmers that are accessible and of comparable productivity.
- Provide farming inputs (fertilizer, seeds, tools) and agricultural extension services to affected farmers to restart farming activities
- Minimize removal or disturbance of vegetation along ROW, around construction camps, etc.
- Provide a relocation or resettlement package for affected community
- Encourage alternative livelihood alternatives such as animal husbandry, cane tree production, rubber farming, provision of vegetable seeds, tree crop farming,

lowland farming outside of the project area, etc. so as to reduce pressure on the current fallow vegetation for environmental stability.

- Identify alternative areas where forest product collection can be restored
- Minimize removal of all disturbance of vegetation around construction area
- Replant native vegetation in disturbed area immediately following construction
- Establish woodlots with fast growing native tree species outside of the project area so as to reduce pressure on the existing natural vegetation where most of the NTFPs are gathered.

15 INFRASTRUCTURE

15.1 Present Situation

The project area is served by a dirt road that connects the bigger towns and settlements. The main road is of reasonable quality but it becomes inaccessible for small cars during the rainy season.

Paths and footbridges connect settlements if there are in the vicinity of each other, and also lead from houses to the farms. These will be affected if they lie in the reservoir. To cross the river, canoes are used and their quality has been found to be wanting.

There are no identified cultural sites that have been found. For the communities with houses in the reservoir, the most likely sites for their secret society practices will either be in the surrounding forests or even in the river. The ongoing HH survey will capture this. In addition, there is a mosque in each of the likely affected settlements of Gbally and Benben.

15.2 Impacts

There are no foreseen impacts on social and economic infrastructure as these mostly do not exist in the likely affected areas. The exceptions are the mosques in Gbally and Benben that will be affected and these may have to be rebuilt in the new sites should they be lacking.

Also secret society sites should these be captured in the ongoing HH survey, will have to be relocated and costs paid for by the project, should the communities wish to have them relocated. Accompanying rituals will also have to organised and paid for. In all likelihood if these sites are in the forests and are

15.3 Conclusion and Recommendation

It is apparent that the present road will need to be upgraded to cater for heavy trucks and vehicles during the construction and implementation stages.

It is recommended that for settlements that have clinics, like Raymond Camp, which is very close to the dam, this be upgraded to a health centre or referral hospital to cater for the population which is likely to increase once other settlements are relocated. The clinic in Raymond Camp is the only one serving the affected settlements in Harrisburg. The upgraded facility would also serve the workers and employees at the construction site, thus avoiding constructing a whole new facility to cater for health.

16 WATER SUPPLY

One specific task of the ESIA for Mt. Coffee HPP is to look at the situation of, and potential positive or negative impacts of the Project on, the drinking water treatment plant downstream of the dam.

16.1 Situation of White Plains Water Treatment Facility

White Plains Water Treatment Facility was inspected by the Consultant on January 19, 2012, together with a representative of the Liberia Electric Company (LEC) and representatives from the Liberia Water and Sewage Company (LWSC).

The facility comprises two treatment plants, the former now derelict plant that received its raw water supply from the Mount Coffee HPP, and the newer plant that draws raw water directly from the St Paul River. The latter was first constructed in 1968 in a joint project between the Republic of Liberia and the USA. The facility was latterly augmented under “Monrovia Water System Phase II” in 1982 cited as a “Joint KL & O Project” with the Republic of Liberia, World Bank and the Republic of Finland.

Although structurally sound, operated well, with a seemingly well-equipped analytical laboratory on site, the plant is clearly suffering from broken or worn out ancillary equipment. Negotiations with consultancy companies are on-going, with a view to engage one of them for engineering services pursuant to rehabilitation of the facility.

Notwithstanding the above, the LWSC are keen to re-establish the raw water pipeline between the Mount Coffee HPP and White Plains Water Treatment Facility. However, the existing capacity of the Mount Coffee Pipeline may be insufficient in terms of capacity and is in need of revision. Its take off may need to be relocated due to water quality issues that may arise from the construction of new reservoirs above the Mount Coffee HPP; this is an issue that will have to be addressed a carefully evaluated in the EIAs that will have to be prepared for these projects.

As mentioned above, the raw water pipeline is presently connected to the Mount Coffee HPP Turbine penstocks; the valve mechanisms are missing, some of the joint clamps are missing, and one of the concrete supporting pedestals has been undermined, the exposed section of the pipe [manifold] is seemingly full of silt. In addition to these issues an approximate 50 metre length (approx. 10 sections) has been washed out of the river embankment some 700 metres downstream of the HPP, reportedly at the same time as the historic breach.

The previous report of saltwater intrusion being drawn into the water treatment facility from the lower estuary has been averted by the construction of a river spanning rock weir across the St Paul river some 200-300 metres downstream of the raw water intake, which has resulted in the effect of creating an artificial pool, and effective barrier against the afore mentioned intrusion due the difference in water levels.

An additional site visit was mad by the Consultant on April 25, 2012. At that day, high tide was at 09.36 h. At that time, at the rock weir d/s of the intake structure a conductivity of 40 µS/cm was measured, no difference between u/s and d/s of this structure. Flow velocity was estimated at about 0.5 m/s. At 08.55 h, a measurement had been taken approximately 10 km downstream. At that site, a conductivity of 170 µS/cm was recorded, and 140 µS/cm at the same place at 16.10 h (low tide had been at 15.15 h).

This downstream site showed no discernible flow velocity or direction. Still, all the values recorded here did not suggest an intrusion of salt water due to tidal movements.

16.2 Saltwater Intrusion

16.2.1 Prevailing Situation

Mt. Coffee dam is located at the point where the river enters the coastal plain. This plain is very flat and only very little above sea level. In fact, the bed of the tailrace channel, or at least its deeper parts, is below sea level (see Stanley 2012, Inspection Report p. 2-28), and this is presumably true also for the entire St. Paul river d/s of the power house. This means that during high tides sea water is likely to flow into this part of the river. This could lead to an increase in salt concentrations in the ground water table in the coastal plain, but mainly it could lead to higher salt content in the water taken into White Plain water treatment plant, potentially making this water unsuitable as drinking water.

The difference between high and low tide in Monrovia is about 1.4 m (see Figure below).

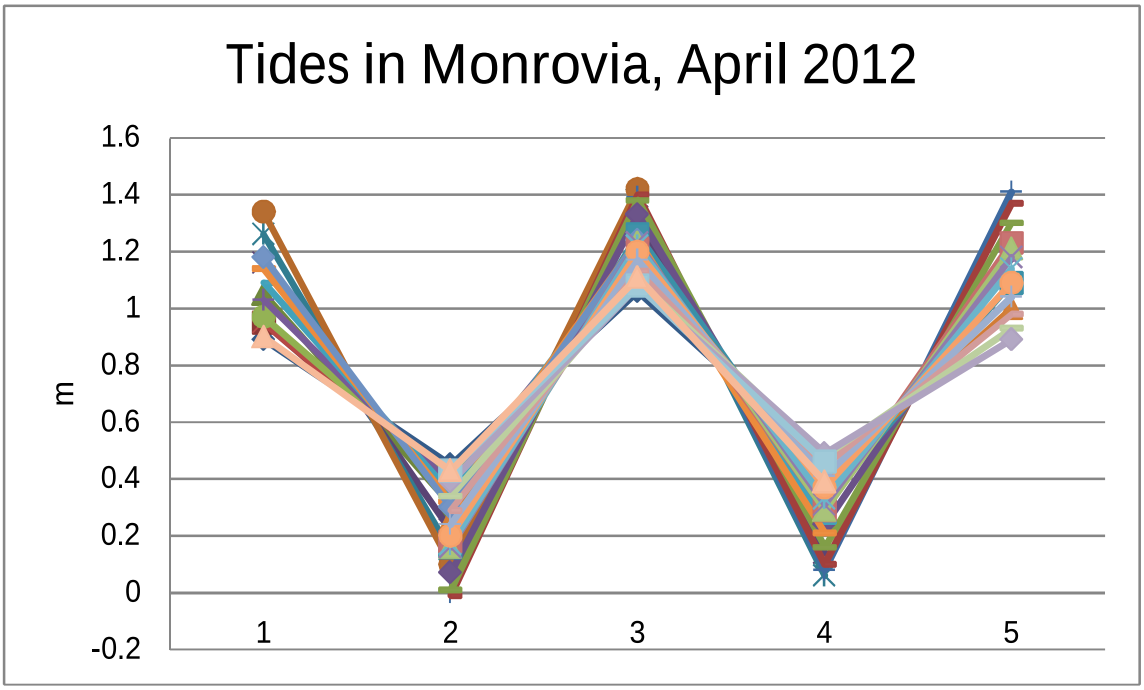


Figure 16-1: Daily tidal fluctuation in Monrovia

Source: http://tides.mobilegeographics.com/calendar/month/3875.html

During periods of high river flow, the pressure of fresh water from the river will be sufficient for preventing salt water intrusion beyond the immediate area of the river mouth. However, during periods of low river flow, i.e. in the dry season, mainly February and March, the backflow from the sea during high tide could actually reach the area of the White Plain water intake.

16.2.2 Water Quality at White Plains Water Treatment Plant

Water quality in the treatment plant is monitored continuously, samples of treated water being analysed every hour during daytime. The analyses are recorded continuously, and the results are kept on record. The Consultant was given the occasion to check the records. Some relevant results can be summarised as follows:

- During the dry season of 2012 (January to March), conductivity (which is a direct measurement of salt content of the water) was always in the range of 28 to 98 µS/cm.
- On the morning of April 25, the most recent recordings showed values of 77 µS/cm; a control measurement taken in the river at the same time resulted in a value of 40 µS/cm.
- The laboratory logbooks showed a period in March 2007 when during about 18 days values of up to 500 µS/cm were recorded.

As a comparison: natural river water can have a conductivity ranging from 0 to 800 µS/cm, brackish water from 1600 to 4800, and sea water has a conductivity of about 50'000 µS/cm (http://www.waterwatch.org.au/publications/module4/electrical.html).

The raw water taken in from the river is treated in three ways in the treatment plant:

- aluminium sulphate ($AlSO_4$) is applied for flocculation (sedimentation of suspended solids);
- hydrated lime (CaOH) is applied for taste adjustment; and
- chlorine is used for disinfection.

No treatment for reducing salt concentrations is being applied.

16.2.3 Mt. Coffee HPP Impact

Project impacts have to be seen in function of plant operation. This is described here shortly.

As long as enough water is available and the power is needed, Mt. Coffee HPP will be operated as pure ROR scheme. However, in times when not enough water is available for operating all four units at full capacity, some load following will be done (i.e. reduced production/water output during some part of the day to enable maximum production during peak hours. This would also mean a certain daily variation of the reservoir level. Mt. Coffee will be operated in a way as to keep the reservoir level constant at 29.1 m asl, or, in case of load following, to restore this level every day. The Volume of the reservoir is too small for doing peak production, it has minimal diurnal load following capabilities.

During the wet season, when the river flow is greater than the hydraulic capacity of the turbines (i.e. river discharge >340 m³/s), there will be no load following. The units will run at their maximum capacity if there is demand to consume the power. Currently, this “too much water” scenario happens about 47% of the time.

In order to be a true load following project, it should follow load 24 hours per day. The average amount of water needed to meet the energy demand of a 100 MW peak system with a 70% load factor (LEC March 2011 Master Plan page 18) is about 880 MWh in a 24 hour day. To generate 880 MWh, the four unit Mt. Coffee plant needs a river flow of about 190 m³/s. Therefore, Mt. Coffee can be a load following plant about 14% of the time. 47% of the time there is too much water and 39% of the time there is not enough water. During the low flow 39%, the plant will operate in some kind of pseudo load following scenario that matches well with bringing individual thermal units on line.

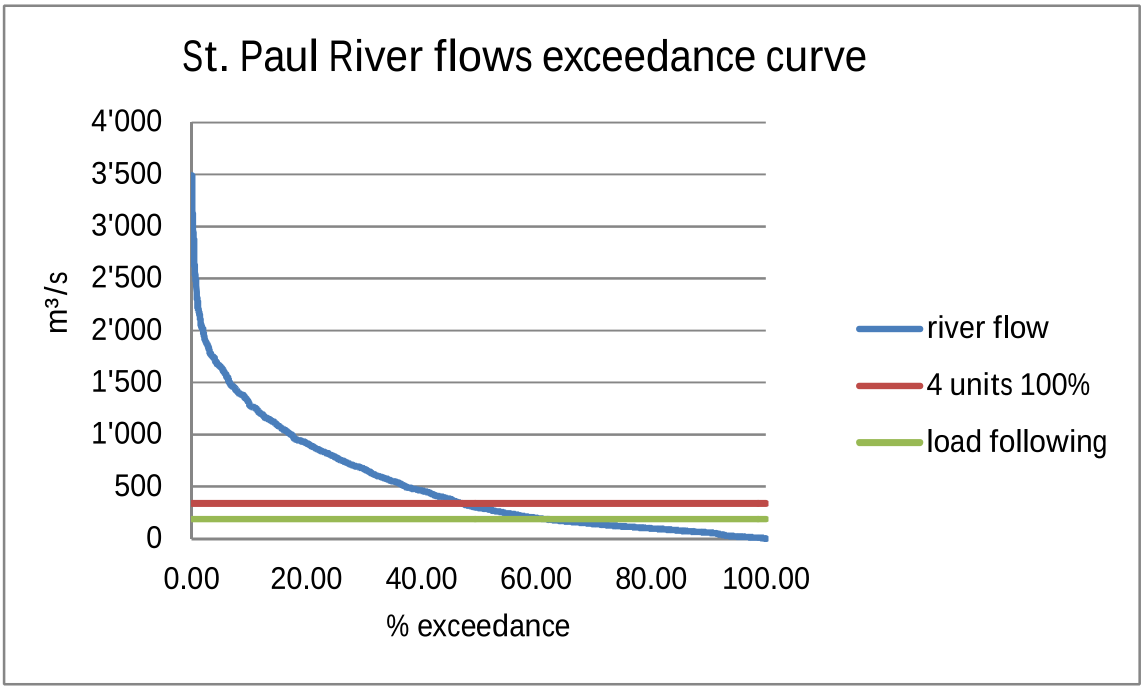


Figure 16-2: River flow and plant operating conditions

The two horizontal lines in the graph indicate the minimum amount of water needed for operating the plant at full capacity (340 m³/s, exceeded 47% of the time) and for load following (190 m³/s, exceeded 61% of the time). During the 14% that load following will happen, there would be no change in the flow from the spillway, and the flow in the tailrace would vary from potentially minimum flow (about 34 m³/s) to nearly maximum (340 m³/s).

The critical situation of plant operation, and therefore for the flow conditions d/s of the power plant, is the low flow period. This is illustrated in the following Figure.

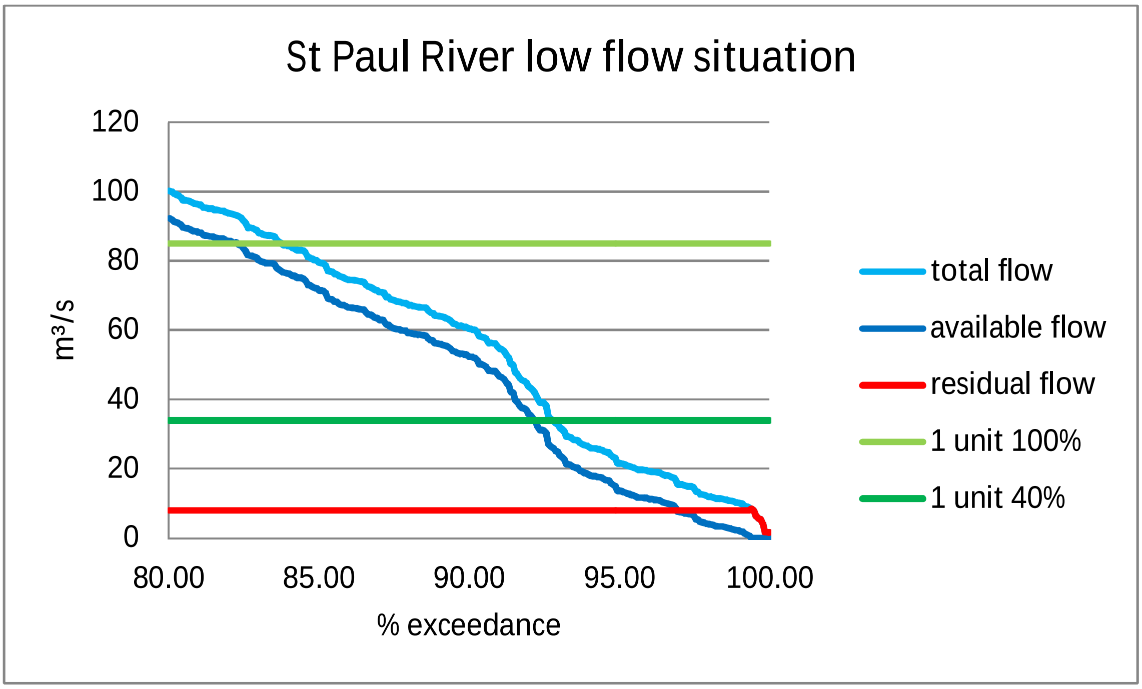


Figure 16-3: River flow and plant operation during low flow conditions

As stated above (Section 8.2.3), a residual flow will have to be released from the spillway in order to maintain river conditions (and mainly fish and other aquatic organisms) in the section of the river between spillway and confluence with tailrace channel), This amount, proposed as 8 m^3/s, is not available for energy production (difference between total and available flow in the Figure). As long as there is a minimum total flow of 42 m^3/s, one unit can be operated at 40% capacity, releasing 34 m^3/s. This situation is exceeded during 92% of the time, which means that on average during 29 days per year there is less water. During such a condition, water could be turbined for a limited time, and in order to fill the reservoir again, the power plant would have to be shut down for about 4 h for each hour of operation.

On days with a flow corresponding to the residual flow, no power production would be possible, since all the water flowing into the reservoir would have to be released as residual flow. This situation will occur on about 1% of the time, i.e. on average on 4 days of the year.

16.2.3.1 Additional Risk Due to Climate Change

Long term measurements of sea level reveal an increase of about 20 cm during the 20th century; this is shown in the following Figure.

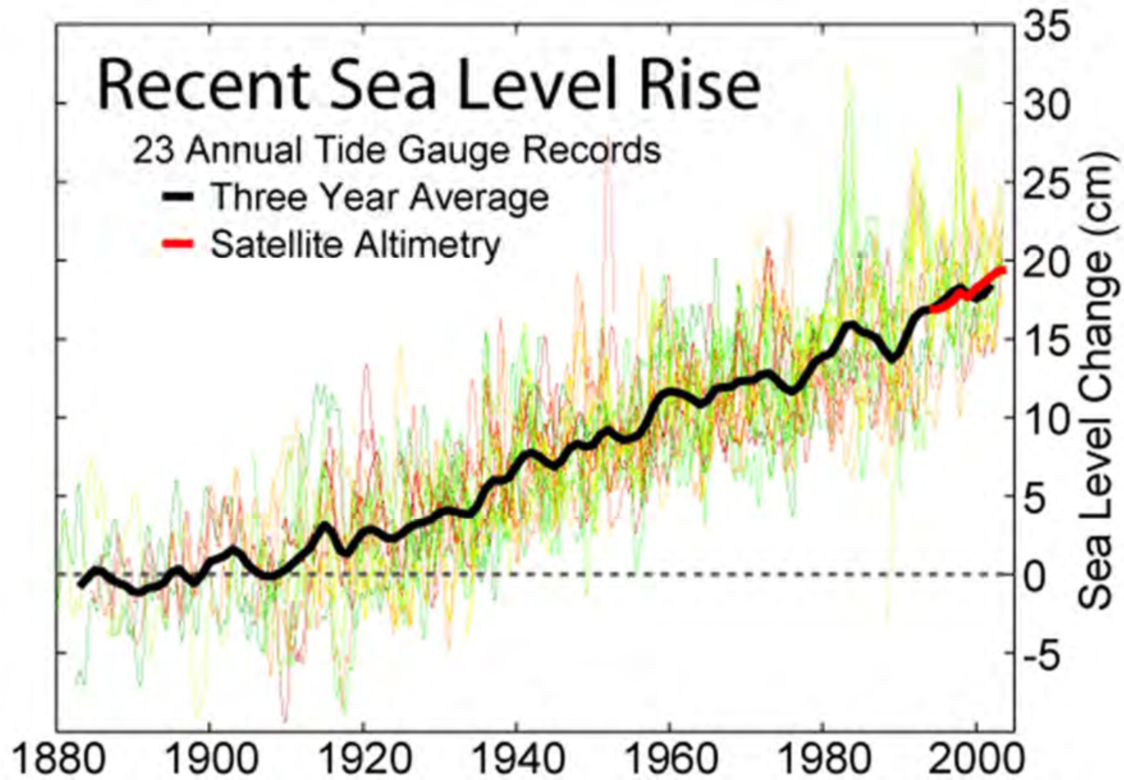


Figure 16-4: Change in sea level during the 20th century

Source: http://en.wikipedia.org/wiki/Sea_level

If this development continues, this could obviously create a risk for White Plain water treatment plant, or further deteriorate the already not very favourable condition. Mt. Coffee HPP does not have any influence on this situation.

16.2.3.2 Conclusions and Recommendations

The analysis of river flow and plant operation leads to the following main conclusions:

- Overall, the influence of Mt. Coffee HPP on river discharge d/s of dam and power house is marginal.
- During high flow conditions, i.e. above 340 m³/s (47% of the time, on average 172 days per year), the plant will be operated as ROR plant; there will be no change in river flow as compared to natural conditions. Under these conditions there will be a considerable amount of spilling
- During periods with flows between 340 and 190 m³/s (14% of the time, 51 days/year) the plant will be operated with load following. During this period, discharge from the power house will fluctuate between 34 and 340 m³/s, and during a 24 h period, flow will correspond to natural flow.
- Under conditions of flows between 34 and 190 m³/s, there are different options for plant operation. It would be possible to operate one unit on a continuous basis at least at the technically feasible minimal rate of 40% (or more as long as more than 34 m³/s are available. The other option would be to operate one or more units for a short time (peak hours) and then closing them down for filling

the reservoir again within the same 24 h period. This could mean that no water would be discharged from the turbines for a minimum of 4 and a maximum of 9 h per hour of operation. Such a situation could arise frequently during the dry season, mainly January to March.

- Under conditions of extremely low flows, all inflow would have to be released, a situation which will occur on about 4 days per year. Here again, there would be no change in comparison to the natural situation.

The quintessence of this is that the reservoir is too small as to have a noticeable effect on downstream river discharge (downstream of the confluence of the original riverbed and the tailrace channel), which would largely remain the same as it is under natural conditions. On the other hand then, it is obviously also too small to allow additional water to be released under conditions of extreme low flow. If this were possible, this would have a positive impact on the water intake in White Plains, and would actually contribute to prevent salt water intrusion. In order to reach this situation, however, Via reservoir would need to be in place, as was shown in Chapter 27 (CIA for Cascade).

Given this situation, and the lack of impact of Mt. Coffee HPP on the water intake at White Plains, the following recommendations are made:

- A monitoring program of water quality, and especially of conductivity as a direct measure of salt content of water, should be implemented. The monitoring carried out presently and described shortly above must be maintained. However, it is recommended that conductivity is also measured in the raw water, in addition to the measurements made in treated water. Water intake should be stopped at moments of too high salt content (presumably at high tides during conditions of extremely low flows).
- It might be advisable to operate Mt. Coffee HPP in a way that closing down the turbines completely during high tide conditions would be avoided.
- It is recommended to evaluate the possibility for rehabilitating the pipe line from the reservoir in order to have a water intake for White Plains treatment plant which is outside of the reach of salt water intrusion. As reported above, LWSC is undertaking efforts in this direction.
- If this is being implemented, water quality monitoring should be extended to water taken in from the reservoir; this could be done either at the intake (i.e. in Mt. Coffee) or at the water treatment plant. In any case, there should not be two monitoring programs carrying out the same analyses; synergies should be used.

17 PUBLIC HEALTH

Given the expected changes in the hydrological pattern and thus the local ecosystem due to the introduction of the dam and its hydraulic organs, and the population influx at the project site during the construction phase, one would expect the development of certain waterborne diseases especially those related to cumulative risks. This might lead to the proliferation or reduction of vectors associated with the modification of the corresponding microenvironments conducive to systemic change in the biotic interactions of its immediate catchment (water level increase).

Most of these factors are related to diseases development either because they are part of the conditions influencing vectors’ dynamics or because they are linked to the pathogens' life cycle. Therefore it is necessary to take into account the contribution of these factors while describing vulnerabilities in order to better deal with them.

The health aspect of the Environmental and Social Impact Assessment (ESIA) hereby discussed was conducted solely for the purpose of making an inventory of the health profile in a 20 km radius around the Saint Paul River, to: (i) monitor the impact of the reconstruction/rehabilitation of the dam on the prevailing diseases (especially waterborne diseases) and (ii) identify risks related to the construction and the exploitation phases. We therefore oriented our investigations on the most relevant conditions in order to measure the expected impacts and propose corrective / mitigation measures.

Concretely, the analyses of public Health are based on both supply and demand sides of the health system, the major causes of mortality and morbidity (epidemics and endemic diseases): (i) the epidemiological profile through the description of major water-related diseases in the catchment area, (ii) the analysis of socio-cultural factors and structural determinants of morbidity and mortality, and (iii) the health supply apprehended through the health infrastructures in order to highlight the disequilibrium between health supply and demand. Furthermore, impacts analysis (positive and negative) on public health was consistent with the anticipated changes foreseen.

17.1 Data Collection and Methods

The field work was a broad sequencing of data collection, beginning with the documents review followed by qualitative interviews at institutional and community levels. To ensure that the subject was adequately covered, all information were double-checked and a number of institutional consultations were undertaken prior to the report writing to exfiltrate subjective information yielded from group discussions on the ground. Quantitative data were obtained mainly from statistics as recorded by health facilities on site.

The aim was to determine the potential effects for human health most likely to occur, and to estimate their likelihood, be they positive or negative. After a prediction of scenarios in relation with the dam reconstruction, a list of relevant impacts was made-up by distinguishing 2 different phases: the construction phase and after operation, the exploitation phase. Each impact was ranked according to its characteristics: the significance (beneficial or detrimental), the magnitude (the scale of the impact) and the likelihood (probability of occurrence) as stated by Ahmad and Sammy [1985]. Finally, a couple of measures were proposed in order to mitigate and control the identified health risks.

17.1.1 Qualitative Data Collection

The qualitative data collection involved formal and informal interviews with key informants (see Annex 17). These also include Ministry of Health and Social Welfare (MoHSW) officials, traditional leaders and local population. Interviews to identify constraints to the hydroelectric installation as well as the main waterborne and wastewater diseases affecting the population at the project's catchment area, especially the most vulnerable have been carried out. These were supplemented with content analysis of secondary data, information from official publications and other related official literature. Groups' participants were selected on convenient basis by the principal investigator. Transcripts of interviews, field notes, and relevant literature were analysed on the basis of themes that addressed the health assessment objectives.

17.1.2 Quantitative Data Collection

Quantitative data were drawn from a variety of sources. The two most important are: (i) statistics recorded from each health facility (county hospital, health centres and clinics), and (ii) the health administration at the MoHSW in charge of the compilation and follow-up on health indicators towards national health objectives. Data from facility records collected by the interviewers included information on the number of new outpatient visits to the facility in the preceding year (from 1st January 2011 to 31st December 2011). Returning patients were excluded from the analysis to avoid double counting.

17.2 Present Situation

17.2.1 Health Policy, System and National Challenges

The Government of Liberia issued its National Health Policy in 2000 as a result of the health sector reform. The document which is the operational frame of the health system sets targets for the period 2000-2024 and emphasizes the importance of achieving access to basic primary health care services for all segments of the population. The health policy specifies that the health services should include preventive, curative and promotional components. In order to achieve the goals of the health policy and make health care delivery services throughout the country more effective and efficient, a twenty four-year health sector development strategy was formulated, being implemented through a series of five-year plans with corresponding milestone indicators for each interval.

The Ministry of Health and Social Welfare (MoHSW) is responsible for health care delivery at the policy level. Under the decentralized approach adopted in the delivery of health care by the country, the Ministry's primary responsibility is to provide policy guidelines and direction for the health and social welfare sector. Other responsibilities include macro-planning, resource mobilization, broad programming, monitoring and evaluation, technical oversight of service delivery, and major research and development initiatives.

At the operational level of the health care delivery system, there are County Health Teams (CHTs). These teams supervise all dimensions of public health care at both primary and secondary levels in the counties and operate under the supervision of the MoHSW. The Liberian health system is characterized by a three-tier system with a Primary Health Care unit (PHCU) which comprises one Clinic for every 2,500 persons, one Health Center (HC) for every 25, 000 persons, and one Hospital (DH) in each county [MoHSW, 2008].

There are three levels in the structure:

- **Primary Level** care services are front line health services and constitute the bottom of the pyramidal hierarchy. Health care services are provided through clinics in local communities predominantly offering primary health care (PHC) activities.
- **Secondary level** is made up of intermediate services and includes services provided by health centers and hospitals. Health Centers are administered by the CHTs.
- **Tertiary Level** is represented by the only tertiary facility in the country, The JFK Medical Center. Although it is government owned, it is an autonomous institution managed jointly by a General Administrator and a Chief Medical Officer; both are supervised by a Board of Directors.

The overall health service coverage has improved throughout the years. However, this varies substantially among the regions depending on their topographic and demographic characteristics. Geographical distance from a health facility and socio-economic factors are the major obstacles for people to get access to health care. Traditional medicine has always been part of Liberia's health care delivery system (either traditional self-medication or traditional consultation). This is so because an estimated two-thirds of the population resides in rural communities and practise their culture. Cultural beliefs lead them first to herbalists and traditional healers, and when the outcomes are not successful, do they seek modern medical treatment [MoHSW, 2007].

Despite some improvements, the country faces major problems such as: shortage of skilled health care professionals, limited resources, poorly equipped health facilities and lack of infrastructures. The ratio between service-providers to the population continues to be very low.

On the other hand, Liberia is making great strides in reducing child mortality, but has demonstrated slower progress in reducing neonatal deaths. In order to meet Millennium Development Goal (MDG) 4 for child survival, newborn deaths must be considerably reduced. The MDGs represent the broadest commitment in history to address global poverty and ill health. MDG 4 commits the international community to reducing mortality in children aged younger than five years by two-thirds between 1990 and 2015. Concerted efforts to vaccinate pregnant women in the remaining high risk areas would allow the country to Accelerate Reduction of Maternal, Newborn and Child Deaths as developed in the actual National Health Policy and Plan.

17.2.2 Health Status of the Project Site

17.2.2.1 Demographic and Environmental Profile

<u>Demographic weight</u>

The scope of influence along the Saint Paul river using health facilities catchment population have been analysed. Therefore, the demographic weight presented does not represent the people directly affected by the project. It represents people living in the crossed site of the project, which covers 15 health facilities. This population is estimated at end 2010 to 132,921 inhabitants.

Limited access to safe drinking water

Pipe-borne water facilities are severely limited in the 2 health districts like other rural districts of the Country. The direct consequence is an inadequate provision of safe and secured water to the population with effects on health, productivity and quality of life which lead to negative trends in terms of socio-economic development. This lack of clean/potable water supply services has serious implications on the development of water borne diseases. It is also important to note that the limited hygiene of drinking water in the study area is highly dominated by the diversity of sources, the conditions of transportation and storage and the relatively low level of knowledge on water-related diseases.

The population, especially women and children, spend considerable time every day in fetching water. This is further complicated during periods of drought when communities are forced to cover long distances for getting water for themselves and their livestock. Almost the whole population in the area is sourcing drinking water from traditional dwellers, tube wells and creeks. Hence, the current supply was found to be both inadequate and far less than the demand.

Poor sanitation status

Due to the shortage of reliable and up-to-date data, it was not possible for the team to assess the sanitation and even the water supply coverage in the 2 districts. However, we noted that the average number of households that have access to improved sanitation is very low. This is a matter of public health concern as it is actually known that 60% of the overall disease burden is related to poor sanitation and hygiene. The main reasons for limited access to sanitation service are low implementation rate and lack of awareness of the people to sanitation services. The majority of the population is not accustomed to hand washing and proper management of human wastes and garbage disposal. In all villages, more than half of people explain the non-use of soap by economic constraints. However, the benefits of hand washing with soap to prevent diseases are well known by them.

Some of the reasons for this low level of sanitation include: lack of awareness of communities on sanitation service, lack of linkage between water and sanitation, and limited resource allocated for its development, etc. The constraints on the use of latrines are mainly economic. From the group discussions, awareness of the benefits to owning and using a latrine is expressed by three arguments: avoid illness, provide comfort to family members, and avoid shame in case one has visitors.

17.2.2.2 Health Infrastructures and Services

As a reminder, health districts ensure the implementation of integrated basic health care at the operational level of the health pyramid. The project’s zone of influence mainly includes 2 health districts, which are Careysburg and Saint Paul River. These health districts include 15 health facilities of which a District Hospital (Bensonville Hospital), one health center (Nyehn Health Center) and 12 clinics. The health care supply is therefore mainly public (13 health facilities) with only 3 private clinics (2 private for-profit and 1 non-profit).

The technical capacity remains poor in almost all of the health facilities. Bensonville Hospital is the most furnished in terms of number of functional beds (20) and staff (54 among which 32 volunteers) followed by Nyehn Health Center (13 beds and 19 staff respectively) in Careysburg District. In Saint Paul River District, Wonjah Smith and Saint Peters Clinics are the ones beating the records of number of bed (10) and staff (15 and 10 staff respectively). Most of the clinics do not offer hospitalization services and are therefore having few beds dedicated to short stays while waiting for referral in the event the situation is stable or getting worst. This means that even in those clinics with few beds, the occupancy rates are still very low compared to the population size.

From table 17-1 figures, one realizes that the number of functional beds, even though they are fully mobilized to the delivery room, still falls under the number of delivery expected each year. This severe shortage of essential equipment is a likely contributor to low basic health care coverage. It leads directly or indirectly to the promotion of practices which are to be discouraged such as self-medication (traditional and modern), traditional consultation or inappropriate therapeutic resorts.

17.2.2.3 Quality and Availability of Services

The minimum package of activities found in health centers and clinics are those of the first line health care delivery. They include: (i) curative consultations, (ii) minor surgery, (iii) antenatal care, (iv) delivery, (v) immunization, (vi) pharmacy, (vii) management of first line emergencies (first aid and short stay). Also, in almost all clinics, outreach activities are carried out to address both health education and promotion, but also to improve immunization coverage. Hospitalization services are offered only at the Bensonville Hospital which is the referral center (even though some clinics are referring directly to JFK Hospital). Out of these services, major programs against life-threatening diseases like malaria (MCP - Malaria Control Program), tuberculosis and HIV/AIDS are being implemented with support from NGOs and donors.

The first-level care package in the 15 facilities includes: maternal health, immunization (routine and outreach), preventive and curative consultation, management of major endemic diseases, management of epidemics, minor surgery, reference, resource management, data collection and analysis. The health information system does exist, but still weak as it is very difficult to have reliable data without going through counting. The unavailability of a guide for diagnosis and treatment in the facilities is an indicator of non-harmonization in terms of quality of services and benefits delivered in the districts. With the absence/rarity of advanced training courses, such guide can be helpful to maintain standards and keep the staff abreast of new developments.

Even in Bensonville hospital, the technical equipment to offer a complete health care package is still incomplete and its optimal use is actually suffering from lack of electricity. Health facilities are much unprepared to receive severely injured persons, which is harmful due to their position on main roads. The services offered at the first reference level (Bensonville) in addition to the activities of the first level are: outpatient consultation, emergency clinics, surgery, laboratory, medical and surgical specialties (ORL, ophthalmology, radiology, pediatrics, gynaecology, etc.).

Table 17-1: Technical capacity of health facilities

Health facility	Type	Status	Nb. of functional beds	No. of staff
Careysburg District				
Careysburg clinic	Clinic	Public	7	13
Bensonville hospital	Hospital	Public	20	22 (+32v)
Crozierville clinic	Clinic	Public	2	6
Harrisburg clinic	Clinic	Public	6	9
Kingsville clinic	Clinic	Public	9	7 (2v)
Goba town clinic	Clinic	Public	4	8v
White Plains clinic	Clinic	Public	2	6 (+2)
Peaceland Medical and Laboratory clinic	Clinic	Private	3	6
Nyehn health center	Health center	Public	13	19
Saint Paul River District				
Blamacee clinic	Clinic	Public	4	6 (+1v)
Bromely Community clinic	Clinic	Public	2	6 (+2)
Wonjah Smith Clinic	Clinic	Non profit	10	15
Saint Peters Clinic	Clinic	Private	10	10
AF Russell Clinic	Clinic	Public	3	6 (+1)
Arthington clinic	Clinic	Public	6	6 (+4)

Immunization

Even though socio-economic inequalities remain in the distribution of basic immunization across SES-groups and regions, it is important to note that this service exists in all health facilities and immunization data are the most organized. Almost three in four children received BCG and the first DPT before one year. However, coverage for the third dose of DPT (DPT3) falls to half. The inoculation of the first polio dose before age one and the measles vaccine are a bit higher than the DPT3 (averaging 3 in 4 children).

Maternal health

Maternal health care coverage measures the number and timing of antenatal visits, booked deliveries, postnatal care, and family planning. Despite some achievements of the 1st National Health Plan (2007-2011), the services utilization is still low. Similarly, utilization of family planning services is very low as evidenced by the fact that few deliveries were recorded last year. While coverage of one ANC visit is high in 4 out of the 15 facilities (Bensonville, Goba Town, Nyehn and Wonjah Smith), there is a significant decrease in the number of women who receive the recommended 4 or more visits.

Prevention of Mother-to-Child Transmission of HIV

PMTCT services include pre- and post-test voluntary counselling and HIV testing for pregnant women (VCT), counselling on infant feeding practices, family planning counselling and/or referral, and providing prophylactic ARV drugs to HIV-positive women and their newborn babies.

According to OiCs posted in the 2 districts, none offer a complete PMTCT services; only Bensonville and Wonjah Smith have necessary items to offer the minimum PMTCT package. The number of women in need of treatment may be underestimated due to inadequate coverage of VCT.

Sexually Transmitted Infections

No facility has medicines to treat each of the 4 main STIs: syphilis, gonorrhoea, chlamydia, and trichomoniasis. The 2 district surveys found that health workers who provided antenatal care at the reproductive and child health clinics of the district hospitals and health centers were not all trained in midwifery skills. Mothers are seen by nurses and auxiliary nurses. It was also observed that screenings for blood pressure, haemoglobin levels, syphilis and urinalysis for asymptomatic bacteriuria were not routinely conducted at the referral Hospital. Even when counselling is provided, it rarely addressed important newborn health issues such as cord hygiene, temperature control or detection of danger signs.

Table 17-2: Services offered in different health facilities

Health facility	Consultations	ANC	Deliveries	Minor Surgery	Vaccinations	Pharmacy	Out-reach	Education for Health	Hospitalisations
Careysburg District									
Careysburg clinic	√	√		√	√	√	√		
Bensonville hospital	√	√	√	√	√	√	√	√	√
Crozierville clinic	√	√		√	√	√	√		
Harrisburg clinic	√	√		√	√	√	√	√	
Kingsville clinic	√	√		√	√	√	√	√	
Goba town clinic	√	√		√	√	√	√	√	
White Plains clinic	√	√		√	√	√	√		
Peaceland Medical and Laboratory clinic	√	√		√	√	√	√		
Nyehn health center	√	√		√	√	√	√	√	
Saint Paul River District									
Blamacee clinic	√	√		√	√	√	√	√	
Bromely Community clinic	√	√		√	√	√	√	√	
Wonjah Smith Clinic	√	√	√	√	√	√	√	√	
Saint Peters Clinic	√	√		√	√	√	√	√	
AF Russell Clinic	√	√		√	√	√	√	√	
Arthington clinic	√	√		√	√	√	√	√	

17.2.2.4 Epidemiological Profile: Morbidity Analysis

Weight of waterborne diseases

Key elements were used to assess the morbidity and its determinants (parasites, vectors, physical environment), as well as the leading causes of death. Waterborne diseases are highly correlated with poor individual and environmental hygiene. This poor sanitation and hygiene is itself due to limited capacities in waste management and garbage disposal which in turn contribute to an unsafe environment conducive to bloody diarrhoea, typhoid and intestinal infections. Very few cases of cholera were recorded in 2011.

Improved access to water and sanitation is emerging as a key strategy to reverse the rising trend of child mortality and waterborne diseases such as amoebiasis, schistosomiasis, intestinal parasites and bloody diarrhoea. Based on information collected and acknowledging the fact that reliability cannot be guaranteed at this stage, the prevalence of these diseases from EPI statistics are approximately 40% for diarrhoea and 55% for intestinal parasites. Cholera would represent 7% of consultations in emergency.

Main diseases, potential vectors and determinants

Table 17-3: Main diseases, potential vectors and determinants

Diseases	**Potential parasite species**	**Vectors/substrates**
Malaria	*Plasmodium sp. (> 90% falciparum)*	Anopheles
Filariasis	*W. bancrofti* *Loa loa* *Onchocerca volvulus* *Mansonella perstans*	*Aedes africanus* *Chrysops* *Simulium damnosum* *Culicoïdes*
Typhoid	*Salmonella sp.*	Food substrates, drinking water
Scabies		Waste water
Acute Respiratory Infections	*(Staphylococcus Mycoplasma, Streptococcus Bordetella?)*	Ambient air, flourishing vegetation
STD/AIDS	*HIV: Trichomonas, Ureaplasma, Mycoplasma, (Treponema?)*	Blood, human sexual secretions (sperm and vaginal secretions)
Diarrhoea	*(Salmonella, Entamoeba, Escherichia, Vibrio, Campylobacter Staphylococcus)*	Food substrates, drinking water
Gastroenteritis		Food substrates, organic wastes, excreta
Amoebiasis	*Entamoeba (coli, histolitica ?)*	Food substrates, organic wastes, excreta
Tuberculosis	*Mycobacterium tuberculosis*	Ambient air, physical substrates
Worm infections	(Ascaris, whipworms, hookworms, nematodes, pinworms, tapeworms)	Food substrates, organic wastes, excreta

Leading causes of morbidity and mortality

Several conditions maintain a high level of mortality. Among these diseases, malaria and anaemia are by far the first leading causes. We do not assess differences among health facilities since almost no deaths were recorded in 2011 as they do not hospitalized and are only performing on manageable cases on a short stay.

Table 17-4: Leading causes of mortality and morbidity

3 leading causes of mortality (in emergency)	Malaria
	Severe anaemia
	HBP
3 leading causes of mortality (in hospitalization)	Malaria
	ARI
	Traumas
3 leading causes of morbidity	Malaria
	ARI
	Severe anaemia

17.2.2.5 Synthesis of the Project's Site Health Profile

Table 17-5: Synthesis of the project's site health profile

#	Public health issues	Major aspects / constraints	Conclusions/observations
1	Morbidity and other related-health problems	• Malaria: major public health problem with high prevalence (44.3% overall outpatients consultations and 57% in children under 5 years) rate of to health facilities compared to the national average (36.5%)	• Low use of ITNs at the household level and propensity to self-medication against malaria
		• Risky pregnancies exacerbated by low utilization of ANC services	• Availability obstetric care package at the referral center (Bensonville); But few pregnant women complete the recommended 4 ANC and many deliveries remain unbooked
		• Filariasis: no clinical cases found but onchocerciasis declared as one of the major disease at the dam's vicinity (Arthington, White Plains); predominance of onchocerciasis dermatitis?	• The regular Onchocerciasis Control Program campaign to kill body worms and prevent blindness is organized through ivermectin mass treatment
		• Tuberculosis and Acute Respiratory Infection: prevalence of pneumonia, acute bacterial bronchitis, flu syndrome, pertussis. Possible association with HIV infection	• Ongoing screening campaign, but high –speed transmission due to sexual behaviours and sexual exploitation
		• HIV / AIDS: high prevalence, but highly disseminated ("poison ", "bad luck", "witchcraft")	• Persistence of chronic malnutrition and vulnerability to diseases
		• Intestinal parasites: prevalence of nematode infections with some cases of polyparasitism. No documented cases of schistosomiasis (both urinary and faecal)	• Poor individual and environmental hygiene causing multiple infestations
		• Other waterborne diseases: several cases of bloody diarrhoea (acute gastroenteritis of varying severity), salmonellosis, staphylococcal intoxication, gastroenteritis, typhoid, amoebic dysentery) and dermatitis.	• Cholera is in a manageable proportion. No outbreak reported

2	Health infrastructures	• Insufficient skilled staff (quantitatively and qualitatively) • Lack of equipment to provide quality health care • Shortage in essential drugs, • Incomplete technical platform in all facilities. Significant imbalance between health demand and health supply	• Insufficient health coverage due to the fact that current population has inadequate health provision. • Predominance of self-medication, consultation of herbalists and traditional healers
3	Main vectors of diseases and enhancing factors	• Colonization of houses by anopheles, bugs and rodents • Risk for emergence of vector-borne diseases associated with arthropods	• People (especially men) use to spend the night out in the open because they want to air themselves, a behaviour that increase malaria transmission
4	Water, hygiene, sanitation and nutritional status	• Use of unsecured water from rain (due to unsafe water collectors), springs, dwellers and creeks ; • Poor hygiene practices at both community and individual level • Poor waste management and garbage disposal • Poor food hygiene practices	• High risk of food poisoning and intoxication ➔ high exposition to diarrhoea and cholera • Absence of community programs against waterborne diseases • Nutritional problems associated with chronic parasitic infections in young children

17.3 Impacts

To evaluate the morbidity at the population level, several indicators are generally used:

1. The **incidence** that relates to the number of new cases occurred during the observation period (last 2 weeks preceding the survey) over the total number of people;
2. The **prevalence** which focuses on the number of patients observed in a population during a period;
3. The **lethality** that relates to the severity of the disease and which expresses the frequency of deaths among patients.

Data from this study have not allowed us to track these indicators as we did not undergo a household survey. However, we perceived morbidity from data recorded at different health facilities (this concerns people attending health facilities as their main therapeutic resort). In many sub-Saharan African countries, the percentage of people who have formal medical consultation as a first resort appeals to an average 40% of the total population [WHO, 2006].

17.3.1 Impacts Identification

Health impacts were identified following the methodology and classification as described in the inception report. Only major impacts were assessed according to their significance, magnitude and likelihood which of course require some knowledge of the situation that goes beyond the limits of the area under direct influence.

Table 17-6: Identified impacts and categorization

Identified impacts	Significance (+/-)	Magnitude (-3 to +3)	Likelihood (High or Low)	Assessibility (Yes or No)
Communicable diseases				
Malaria	-	-3	H	Y
Filariasis	+	+1	H	N
Typhoid	-	-2	H	Y
Sepsis and pneumonia	-	-2	H	Y
Diarrheal / dysentery	+	+2	H	Y
Tuberculosis	-	-2	H	Y
STD/HIV/AIDS	-	-2	H	Y
Amoebiasis	-	-1	H	N
Scabies	-	-1	H	N
Non communicable diseases and conditions				
Alcohol / drug abuse	-	+1	H	N
Hazardous chemical	-	-2	H	Y
Injuries	-	-2	H	Y
Noises	-	+1	L	N
Odour	-	-1	L	N
Dust / visibility	-	-1	L	N
Worms infections	+	+1	H	N

Significance: beneficial (+) or detrimental (-)

Assessibility: possibility for predicting the risk based on significance, magnitude and likelihood

17.3.2 Impacts Associated with the Construction Phase: Risks for the Labour Force

Risks analyses for the labour force are two-fold and cover two main aspects from a public health perspective: the risk of importing new diseases and risk of exposure to hazards during the construction phase. Thus, three main risks are targeted for this category:

- The introduction of new parasite strains or new conditions on the project site, leading to the emergence of diseases in case the ecological conditions are favourable for their development and the vectors / substrates are suitable as well;
- Proliferation of vectors, changing patterns of disease transmission such as mosquitoes and blackflies, respectively vectors of malaria and onchocerciasis due to changing microenvironments favourable for their propagation;
- Increase health risk behaviours especially for HIV / AIDS infection, tuberculosis and other uncontrolled viral diseases.

Positive impacts

Positive impacts on the labour force are essentially socio-economic and organizational. The aspects related to public health are: a light reduction of filariasis as the establishment of hydroelectric organs will certainly lead to the destruction of some blackflies breeding-grounds; and the reduction of diarrheal / dysentery due to an alternative water supply and communication for behavioural change at the workplace.

From a socio-economic perspective, the project will generate social and economic benefits not only for the immediate community of workers, but also for the local population. At an individual level, the project will give opportunity for workers to free medical examinations and treatments which they might not afford in normal times.

From a socio-organizational perspective, the social links between workers are going to be strengthened with regard to the participatory experience gained. In a context strongly influenced by individualism and non-participation in community services, the project will also promote dialogue among communities and provide windows of opportunity to solve common problems, and raise awareness on cross-cutting issues like HIV/AIDS, gender, fight against rape, use of latrines, chlorination of wells, etc.

Negative impacts

This section deals primarily with exposure of the labour force to major risks on the dam site. It assesses the environmental changes and vectors proliferation and the concomitant effects on the prevailing diseases development.

- **Introduction / emergence of new diseases and conditions in the dam site.** At the construction phase, we can expect an influx of people from different background and morality on the project site. The direct consequence is the development of sexual networks (prostitution), sexual misconduct with young petty traders and others small-scaled job seekers. HIV/AIDS will therefore be an issue during this phase. Health checks of workers, consultation (especially regarding prevention) and treatment will have to be part of the contractor's health services. It is also important to mention the possible introduction of new parasite strains (difficult to prevent), criminality and traumas (road accidents, falls, drowning, burns, etc.).
- **Exposure to major prevailing diseases:**
  The main diseases that pose a risk to the labour force and the catchment population are particularly close to the quality of water, sanitation and hygiene, as well as some uncomfortable conditions due to environmental pollution. Here we are addressing only diseases and conditions related to the labour force. The other diseases will be analysed in the section dedicated to the exploitation phase.

Exposure to solid wastes

During the construction phase, three types of solid wastes will be generated: debris from demolitions, spoils and domestic refuse. The extent of impact will depend on the location of discharge points and the possible treatment of drinking water. Uncontrolled discharge of waste would have a moderate adverse effect on water quality but this would be mitigated by adequate provision for treatment of on-site wastes and wastewater from camps during construction, reducing the magnitude of these impacts to minor.

Risk of injuries and other traumas

The workers will be exposed to hazards which could lead to road accidents, burns, electrocution, drowning, inhalation of toxic fumes, etc. People collecting rubbish may be injured by sharp objects including glasses, metals and woods. These may lead to puncture wounds and lacerations which may become infected and cause serious morbidity. Composted solid waste can cause injury to farmers as sharp objects are not always properly removed. Building awareness and providing good safety and security measures (EHS) to them are necessary to mitigate these risks.

Exposure to waterborne diseases and poor sanitation

In general, the physical environment at the project site is unhealthy due to inadequate access to safe water and sanitation services. Regarding the water supply, the prevalence of diarrheal diseases (and their consequences as cholera and dysentery) and intestinal parasites prevalence can increase. Also, groundwater requires protection from potential pollutants. Improving water supply also helps to reduce the impact of other infectious diseases, thereby limiting the proliferation of many skin infections (scabies) and eyes, including trachoma (second cause of blindness) and schistosomiasis - faecal and urinary - (contracted when in direct contact with infected water).

Exposure to environmentally hazardous chemicals

The pollution of the ambient air due to the transportation of construction materials and emissions from vehicles and other engines could occur: the emanation of dust and anarchic rejection of hazardous waste during construction which will be handled by the Contractor. Non-compliance materials should either be destroyed at the border or may need to be taken back to their place of origin. Incineration of wastes may pollute the air with particulates, and sulphur oxides and nitrogen. The slag and ashes from incinerators may result in leachates that are rich in heavy metals and other potentially toxic substances.

Noise and Vibrations

The main sources of noise during the construction phase will include blasting, heavy equipment, transportation vehicles and the demolition of existing infrastructures, which are within the project catchment area.

17.3.3 Impacts Associated with the Exploitation Phase: Risks for the Population

Water supply

The construction of drinking water points in villages closest to the reservoir would be a possibility to reduce both the risks of consuming unsuitable water and person-vector contacts. This would contribute to the reduction in the incidence of waterborne diseases (amebiasis, schistosomiasis, helminthiasis). Whether such measures will be adequate and required in the framework of Mt. Coffee HPP will have to be evaluated in the RAP.

Increase in health coverage

Health coverage would certainly be improved by reinforcing the technical capacity of health centers (provision of minimum equipment, essential drugs, skilled staff and means of transportation for reference, etc.). The project, i.e. the contactor, will have to provide health services for its labour force. It will have to be decided to what extent these services could also be made available for the population of nearby villages. Other potential improvements in regional health services will be discussed in the RAP.

Improvement in hygienic conditions and nutritional status

Indeed the predominant causes of waterborne diseases are parasites, bacteria and viruses. Infection occurs through consumption of contaminated water sources by humans in daily activities (bathing, leaching, defecation and various grooming) and also by straying animals. Artisanal fisheries will provide fisheries resources, especially fish that will complement the traditional diet generally poor in calories and animal proteins.

Possible reduction of the River Blindness disease

During the reservoir filling, large blackfly breeding sites will be submerged and replaced with virtually stagnant surface water, reducing blackflies population and in fine, the transmission of onchocerciasis. The effect of the project on blackfly breeding sites in the downstream area (reduction of river flow between main dam/spillway and outlet of the tailrace channel should be monitored.

Negative impacts

Possible increase in malaria prevalence

The two districts are mosquito-infested that require regular malaria prevention and control measures, especially during the malaria transmission period running from May through October (seasonal fluctuations with a peak around August). The Reservoir will cause the elevation of groundwater level and flood terrestrial fauna and flora. Subsequently, the aquatic environment will gradually move from an oligotrophic state, characterized by a low concentration of organics to a trophic status marked by the abundance of organic elements. This will have direct and indirect impacts on local population by creating breeding sites for arthropods and snails.

Introduction of new diseases

As noted above, the transformations due the dam may induce changes of the micro-environments. The modification of the groundwater may create favourable conditions for development of some parasites and/or their vectors. As a component of the pathogen complex (pathogen, host and vector), we can expect not only the development of existing diseases, but also the emergence of new ones favoured by modifications in ecological niches due to the imbalance between environmental and population pressures (yellow fever, trypanosomiasis, schistosomiasis).

17.4 Mitigation Measures

Health coverage

The rehabilitation and/or equipment of one of the most closed clinics like Arthington or White Plains clinics and the provision of minimum equipment is necessary to take care of emergency (that might arise during the construction phase) before referring to JFK Hospital. It is not important to install a medical center in the camp, but to improve one of the existing clinics that will benefit to the local population after the dam construction. This takes into account: the provision of basic supplies, the supply of essential drugs, the establishment of electric power, the provision of a motorcycle for outreach and an ambulance for references.

Hygiene and sanitation

It is necessary to improve the quality of water. Huge amounts of substrates, dust with heavy metals can affect aquatic life and substantially increase the quantities of heavy metals ingested by people. The promotion of health should not be considered as a unique measure for water supply and sanitation, but as a complementary measure. Indeed, the supply of water and latrines are prerequisites to the adoption of good hygiene behaviours.

The installation of such commodities must be accompanied by measures to promote hygiene and sanitation. Otherwise, the expected health benefits will be realized only partially. A campaign on hygiene and sanitation must be maintained regularly to promote healthy behaviours. Similarly, it is important to develop devices for household waste collection, disposal and wastewater treatment and latrines maintenance. This approach aims to eliminate faeces of young children in latrines which contain more pathogens than those of adults. Although they are less harmful, diseases included in the faeces of children could easily proliferate in the wild. It will be of great interest in reducing faecal pollution and therefore the development of faecal-related diseases.

Vector control

Given this particular situation, it is conceivable that vector control operations, limited to periods of high transmission, would be effective, at relatively low cost. Regular epidemiological monitoring should be conducted through surveys to determine the transmission dynamics of vectors and their seasonality. Vector control should not only be done at the individual level (use of mosquito nets, repellents, etc.), but also at the community level e.g. by the destruction of breeding sites for mosquitoes etc. Given the situation in the project area, the focus will have to be on malaria. A survey should be carried out during the first year of operation in the rainy as well as in the dry season to identify breeding sites for mosquitoes along the shorelines of the reservoir (like pools forming in the drawdown area, marshy areas at the edge of the reservoir) and to destroy them where possible or to shade them by planting suitable trees.

18 CULTURAL HERITAGE

It will be investigated whether in the area to be affected there are any objects of cultural or historical importance, like e.g. archaeological sites. If yes, these would obviously have been affected by the first impoundment of the Mt. Coffee reservoir; this, however, does not necessarily mean that they would have been destroyed, and in such a case one might get a "second chance" to investigate and document them properly before the renewed impoundment.

Of course, it cannot be excluded that in the 20 years since the breaching of the dam graves would have been located in this area, which would have to be relocated. This issue will be addressed with the local population.

18.1 Archaeological and Historical Sites

There is no indication for the presence of any archaeological or historical sites within the area of the former reservoir, i.e. the area which will again be covered by water after the rehabilitation of Mt. Coffee HPP.

18.2 Sites of Cultural Importance

18.2.1 Churches

There are two churches along the access road near the reservoir, both of them badly damaged during the war and presently not in use. However, they are outside the area affected by the Project, and will not in any way be influenced by it. Mt. Coffee HPP does not have to include any mitigating measures for these churches.

18.2.2 Mosques

Two mosques were found during the initial survey. One is in Gbally and the other in Benben town. Both of these will be lost. No churches were found in the reservoir area. The mosques will have to be replaced during the RAP.

18.2.3 Sacred Sites

The populations in the reservoir were asked about the sacred sites and they were reluctant to divulge any information on these. It is therefore assumed that no sacred sites exist in the reservoir area. However, the ongoing HH survey should capture these if they exist. If they do, the necessary rituals will have to be performed if they are to be relocated and the project will bear the costs for this during the implementation of RAP.

PART C SYNOPSIS

In this Section, the impacts and mitigation measures identified in the previous Chapters are analysed and finally defined, and the required plans or framework plans are developed.

19 MAIN IMPACTS

19.1 Impact Categories

Project impacts are shown in a summarised way in the matrix on the following page. This matrix shows project components and activities in the left hand column and the affected environmental parameters in the top row. Impacts are then shown in the form of a number of categories in the table itself.

It has to be emphasised that a matrix of this form is a simplified way of looking at the issues at hand. Therefore, it is important that the value and the limitations of the matrix are clearly understood. In a first step, the categories used need to be explained.

In a general way, there are three main groups of impacts: positive, negative or uncertain. The scale as explained in the following Table was applied in the matrix.

Table 19-1: Impact categories used in matrix

	Definition of Impact
+3	**Strongly positive:** highly beneficial effect, permanent or at least of long duration, affecting a wide area and/or an important parameter.
+2	**Positive:** beneficial effect, of long duration or permanent.
+1	**Small positive:** beneficial effect of lesser importance, either of short duration, limited in space, and/or affecting a parameter of little importance.
0	**None:** no or negligible impact, limited in time and space, and not requiring any measures, or environmental category not present.
-1	**Small negative:** negative impact of limited duration, affecting a small area, and/or affecting environmental parameters of less importance. Note that in spite of the small effect mitigation measures may still be proposed or even required.
-2	**Negative:** undesirable or harmful effect of limited concern, either temporary, limited in space or affecting parameters of medium importance.
-3	**Strongly negative, mitigation possible:** strongly negative or detrimental effects (permanent, of high intensity, affecting important environmental parameters), for which mitigation measures can (and have to) be taken in order to reduce them to an acceptable level.
-4	**Strongly negative, mitigation not possible:** strongly negative or detrimental effects (permanent, of high intensity, affecting important environmental parameters), for which mitigation or compensation is not possible. Such effects could be no-goes for a project.
±	**Ambivalent:** effect can be positive or negative, or a combination of positive and negative effects is possible.
?	**Questionable:** it is unclear (possibly due to project stage) whether the aspect will be of any relevance and/or an effect will result.

Without any doubt, the entries in the matrix, to a certain degree, have a subjective character. Nevertheless, given the information provided in the previous chapters should enable the reader of the report to check the items and to draw his own conclusions.

Table 19-2: Impact matrix for Mount Coffee hydropower plant

(See following page)

		Abiotic												Biological													Human															
		atmosphere	climate	air quality	noise	**hydrosphere**	hydrology	hydrogeology	water quality	**lithosphere**	erosion	geology, mineral deposits	soils	**vegetation and flora**	vegetation	flora	**terrestrial fauna**	mammals	birds	reptiles and amphibians	**aquatic fauna**	fish	benthic	**landscape**	landscape	protected areas	**population**	demography	socio-economy	settlements	ethnicity, culture	**land use**	fishery	agriculture	forestry	pasture	**other aspects**	tourism	archaeology, culture	health	occupational health	infrastructure
No	**Project Features**																																									
1	**Main structures**																																									
	reservoir	±	±			-1	-1	-1	-1	-1	-1			-1	-1	-1	-1	-1	-1	-1	-2	-2	-1	-1	-1		-2	-1	±	-2	-1	±	(+)2	-2	-1	-1	-1	-1	-1	-1		-1
	dam					-1	-1														-2	-2	-1	-1	-1																	
	power house																																				-2				-2	
	turbines																																				-2				-2	
	transformer																																				-2				-2	
	access road									-1	-1						-1	-1	-1	-1				-1	-1		(+)1		(+)1								-2				-2	
	switchyard																							-1	-1																	
	transmission line																							-1	-1																	
	construction site	-1		-1		-2			-2	-2	-1		-2	-1	-1	-1	-1	-1	-1		-1	-1		-1	-1		(+)3		(+)3								-2			-2	-2	
	dumping sites					-2			-2	-1	-1			-1	-1	-1	-1	-1	-1		-1	-1		-1	-1																	
	borrow areas	-1		-1		-1			-1	-2	-2		-2	-1	-1	-1	-1	-1	-1		-1	-1		-1	-1		-1			-1		-1	-1	-1		-1						
	camps					-2			-2				-1	-1	-1	-1	-1	-1	-1		-1	-1		-1	-1		(+)2		(+)2								-2			-2	-2	
2	**Construction activities**																																									
	work force	-1		-1	-1	-2			-2	-2			-2	-1	-1		-2	-2	-1	-1	-2	-2		-1	-1		(+)1	-1	(+)2			-1	-1	-1	-1	-1						
	waste	-2		-2		-2			-2	-2			-2	-1	-1	-1	-1	-1	-1	-1	-1	-1		-2	-2							-1				-1	-2	-1		-2	-2	
	waste water					-2			-2	-2			-2	-1	-1	-1	-1	-1	-1	-1	-2	-2	-1	-1													-1	-1		-1	-1	
	traffic to site	-2		-2	-2								-1				-1	-1	-1	-1																	-2			-2		
	traffic on site	-2		-2	-2						-1		-1																								-2				-2	
	construction machines	-2		-2	-2	-2			-2	-2	-2		-2				-1	-1	-1	-1																	-2				-2	
	works:																																									
	dam construction	-2		-2	-1	-2			-2	-2	-2		-2	-1	-1	-1	-1	-1	-1	-1	-1	-1		-1	-1		(+)2		(+)2								-2	-1			-2	
	other construction	-2		-2	-1	-2			-2	-2	-2		-2	-1	-1	-1	-1	-1	-1	-1	-1	-1		-1	-1		(+)2		(+)2								-2	-1			-2	
	deposits			-1	-1	-2			-2	-2	-2		-2	-1	-1	-1	-1	-1	-1		-1	-1		-1	-1		(+)2		(+)2								-2	-1			-2	
	electro mechanical																										(+)2		(+)2								-2	-1			-2	
	reservoir clearing/filling					-1	-1	-1	-1	-1	-1		-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	0	(+)1		(+)1			-1		-1			-1		-1			-1
3	**Operation**																																									
	work force					-1			-1								-1	-1	-1	-1	-1	-1					(+)2		(+)2	(+)1		-1	-1	-1	-1	-1						
	waste	-2		-2		-2			-2	-2			-2								-1	-1		-1	-1												-2			-2	-2	
	waste water								-1												-1	-1		-1	-1		-1		-1	-1							-1			-1	-1	
	plant operation					-2	-2														-2	-2		0		0																

Impact scale:

(+)3	strongly positive
(+)2	positive
(+)1	small positiv
0	none
-1	small negative:temporary and local effect;specific mitigation measures might be required
-2	negative; mitigation measures required, if feasible
-3	strongly negative; mitigation possible
-4	strongly negative;mitigation not possible
±	effects can be possitive or negative

19.2 Main Impacts

The impacts identified and listed in the matrix are described and characterised shortly here. It should be noted that in every group of environmental parameters the first column is a kind of "summary": it is considered as affected when one or several of its components are affected.

When talking about effects, a distinction needs to be made between structures and activities: it is possible that a structure has little or no impact on the environment, while its construction does have an impact.

Below, the entries in the matrix are discussed briefly. This should also contribute to clarifying the definitions provided above.

19.2.1 Assessment of the Impacts Caused by Structures

The main structure in terms of environmental impacts is the **reservoir**, the main impact is on land use, fauna and flora and settlements; the impact is considered as relatively small for fauna and flora and medium for the human population, since the size of the reservoir is rather small and since the entire area to be affected already was a reservoir 20 years ago. It causes the following impacts:

- Climate: reduction of temperature amplitude, increase in humidity; negligible due to the small area which will be additionally submerged.
- Water: small influence on hydrology since Mount Coffee HPP will be operated as run-of-river scheme with a very limited regulation capacity; the main negative impact will be on the 4 km of river between spillway and confluence with the tailrace channel. Negligible influence on hydrogeology. It could have a small impact on water quality, which could be partly reduced by reservoir clearing. The water quality depends also on the contamination of the water due to activities upstream of the HPP like mining activities, agriculture, etc. The water quality data show currently a generally good quality in most parameters reaching drinking water standards.
- Vegetation and terrestrial fauna: plants and animals are affected negatively through loss of habitat. Small impact, since the reservoir was already existent and no exceptionally valuable habitats have developed in the short time, especially given the fact that the wider area is strongly influenced by human activities (charcoal production and crop plantations).
- Aquatic fauna: medium impact since the migration pattern of some fish species could be interrupted due to the dam, the part of the river between spillway and tailrace channel confluence will be affected, and a change in species composition will occur.
- Landscape: ambiguous effect: the reservoir will be clearly visible and change the aspect of the landscape. This can be considered as positive (lake) or negative (change of natural aspect, drawdown). No protected areas affected.
- Human population: medium negative impact through the submersion of six settlements and of 219 ha of agricultural fields. This can and has to be mitigated.

- Land use: the submerged area due to the reservoir will be relatively small, therefore the impact on forest (although not much valuable forest left) and on pasture is considered as small.

The **transmission line** corridor will follow the access road and will be clearly visible in the landscape.

Quarry, **burrow areas** and **dumping sites** also have an impact on the landscape and on geomorphology. However, the Mount Coffee HPP is a rehabilitation, the main dam and the main parts of the forebay dams are still existing and can partly be reused; the amount of material will be smaller than for the construction of a new project. Presently there is not enough information on needed material to evaluate this accurately.

All the **other structures** are comparatively small, or will be built on the former foundation or replace already existing remnants of structures. They are not occupying larger additional areas. For these reasons, their environmental impact is considered as negligible to small. Currently there is not yet enough information on all these locations.

19.2.2 Impacts Caused by Construction Activities

The presence of the **work force** causes a number of impacts: on water quality (waste water), potentially on animals (hunting, fishing) and on the local population; these latter can be positive (by generating income in the area) or negative (by competing for jobs at the construction site).

The **construction activities** as such (including transports etc.) are an important cause of environmental impacts. Problems with air quality and noise are all related to these activities, and so fare most impacts on water quality. The construction activities have a considerable (positive) impact on the local economy. However, all these impacts are limited, restricted to the construction site (and, given the difficult terrain, without much risk of spreading) and to the construction period.

The construction period is also the period causing most impacts, some of which are limited to this period; such impacts are, e.g.:

- temporary occupation of areas for construction site installations; risk of increased erosion on surfaces where vegetation was cleared;
- risk of soil and water contamination due to storage and use of fuels, lubricants and other potentially toxic substances, and by activities like maintenance of vehicles and machines;
- risk of water contamination with concrete, which can increase pH to a level which is toxic to fish and other aquatic organisms;
- noise and vibrations stemming from traffic and the operation of machines (e.g. breakers); dust from the same sources;
- generation of solid waste of different types and waste water;
- social and health impacts due to the large work force coming from other areas of the country or even abroad.

Given this number of effects specific to the construction period, the ESMP also has to foresee a number of measures specifically for this period. These measures are listed and described in the provisional ESMP (see Chapter 20 and 21). They will form the basis for the specific EHS Management Plans, which will have to be developed jointly by the project proponent and the contractor.

19.2.3 Impacts Caused by Plant Operation

These are important, since they will be permanent (at least for the life span of the power plant, which is supposed to be 50 years, but will probably be much longer)..

Reservoir operation, effects on the downstream area of Mount Coffee reservoir by water level fluctuations could lead to river bank erosion, but as long as the natural cover of vegetation is kept on the river banks this effect will be negligible. Furthermore, since the topography is in some areas of the reservoir rather flat, even a small drawdown will have an effect on the banks of the reservoir by exposing a large drawdown area. But since the Mount Coffee HPP is planned as a run-of river scheme the effects will be rather small.

19.3 Overall Impact Evaluation

The conclusions of the discussion in the previous section are the following:

- There are no "category -3 and -4" impacts, i.e. strongly and very strongly negative impacts without the possibility of mitigation, caused by the project.
- The most important negative impact is the one on the local population. This aspect can be mitigated, by means of adequate compensation for the used land and houses.
- The other environmental impacts are the ones that could be termed as the "usual" or "normal" impacts caused by any dam project. Since MC HPP was existent 20 years ago and the area which will be submerged additionally is rather small, they are all of limited magnitude, none of them being considered as strongly negative, and most rated as small. The ones rated as -2 can be mitigated by best practise and environmental management.

20 MITIGATION MEASURES

20.1 Basic Approach to Mitigation

Mitigation measures, where necessary, were identified with the following priorities:

- Avoidance: if possible, e.g. by modifications of the Project, measures will have to be sought which can avoid relevant impacts altogether; such measures have to be checked with the Technical Consultant in order to ensure that they are feasible, acceptable for the Project, and actually integrated in the planning.
- Minimisation: measures to reduce impacts to an acceptable level (e.g. noise reduction measures to ensure that legally defined noise levels are respected).
- Compensation: if avoidance and minimisation is not possible, then adequate compensation will have to be provided; this will be the case mainly for the human population presently using the area to be submerged (compensation for field and other uses).

20.2 List of Mitigation Measures

In the Tables on the following pages, a summary overview of the proposed mitigation measures and related monitoring activities is provided.

Table 20-1: Preliminary main project impacts and corresponding mitigation measures

Issue	Project component	Impact	Mitigation measures	Related Sub Monitoring and Management Plans (S-MMP)
Physical Environment				
Geology	Dam and reservoir		Not required	No S-MMP
Soils	Construction area, quarries, burrows and dumping areas	Soil erosion and land sliding	Good engineering practices will help controlling soil erosion both at construction sites and in peripheral areas, particularly in borrow and dumping areas and along access roads. Following measures have been mentioned: • Install sediment traps • Drainage channels where necessary • Prevent steep slopes, define optimum height of work evaluating the instability of the rock, soil etc. • Stabilise, compact and strengthen steep slopes • Adequate selection of road tracks, taking into account the landscape, technical environmental and social aspects • Construct drainage ditches at roads if there are pasing through mountainious area If the slope is more that 16 % they have to be paved • install culverts with enough capacity for strong rains, drainage pipes and channels have to be of an adequate size and should be equipped with screens at entrance and exit points to reduce the risk of clogging • Re-vegetation	EH&S Management and Monitoring of the Contractor Erosion Management Plan

Issue	Project component	Impact	Mitigation measures	Related Sub Monitoring and Management Plans (S-MMP)
	Construction area, quarries, burrows and dumping areas	Contamination of soil	The maintenance of machinery and lorries has to be done in work-shops, liquids including cleaning water should be collected in tanks. Storage of fuel and lubricants has to be in tight containers placed on sealed surfaces undernice a roof. The storage has to be equiped with all safety measures to prevent oil spilling including fire fighting equipment. The area needs to be marked. In the case of an oil spill sufficient quantities of oil absorbent have to be stocked. The contaminated absorbent has to be disposed of properly. Hazardous waste has to be stored in designated closed tanks or areas. Solid waste generated during construction and at campsites will be properly treated and safely disposed of only in demarcated waste disposal sites. All activities which could contaminate the soil have to be carried on a sealed surface and if accidental spillage occurs that the contaminated soil has to be excavated and disposed properly. Awareness has to be raised within the workforce to properly dispose of the waste.	EH&S Management and Monitoring of the Contractor Equipment Maintenance Management Plan Wastewater Management Plan Waste Management Plan Pollutant Spill Contingency Plan
Climate	Reservoir		Not required	No S-MMP
Hydrology	Dam, reservoir, turbine operation; reservoir filling	Small impact due to change of water discharge pattern	A minimum of 8 m^3/s should be released from the spillway structure as the required residual flow. The possibility of installing a small unit at the spillway for turbining this water should be investigated (for technical and economic feasibility). This would reduce the loss in energy production due to allocating this residual flow, and it might be possible to use the energy generated there for electrification of the surrounding villages. A preliminary analysis shows that this would have an overall positive effect.	

Issue	**Project component**	**Impact**	**Mitigation measures**	**Related Sub Monitoring and Management Plans (S-MMP)**
Water quality	Reservoir	Change from river to lake ecosystem. Possible greenhouse gas emission	Cutting of trees which can be used, either for timber or for producing charcoal. The local population should be encouraged to use all timber resources within the reservoir to the extent possible. Cutting and burning of all trees which cannot be used, before impoundment to reduce obstacles and dangers for boats and fishing gear. Shortly before impounding cutting of as much vegetation as possible, and burning it.	Water Quality Management Plan during operation Waste Water Management Plan during operation Waste Management Plan during Operation
Water quality	Construction activities	Increased load in suspended solids stemming from the construction site. Contamination with concrete, resulting in a higher pH which could potentially be toxic for fish. Contamination with hydrocarbons (fuel, lubricants etc.) and other toxic substances used on site. Contamination with human waste from the worker's camp.	In general all equipment, machinery, trucks and camp installations have to be located in a distance of more than 250 m to water used for human consumption and at least 150 m to any body of surface water. Strict measures must be taken to prevent oil pollution of the river. The most important are: • Storage of fuel and lubricants away from the river, in tight containers placed on sealed surfaces. • Storage areas shall be designed such that they will contain 110 % of the largest container/ vessel stored in the storage area and waterproof; have available on site equipment and materials to execute clean-up (sufficient absorband). • Good maintenance of vehicles and machines to prevent oil losses. • No cleaning or maintenance of vehicles or machines in close proximity to the river. This must be done on specially prepared places (workshops) equipped with oil skimmers. Unnecessary dangerous chemicals and/or toxic substances are forbidden to use. Do not install a deposit even for uncontaminated gravel from the quarry near any body of surface water All the water draining down from the quarry needs to be lead to sedimentation and neutralisation tanks and has to be treated before releasing it to the river. All the waters from the batching plants, the concrete mixer washing facilities and the crusher plants needs to be collected and treated before releasing to the environment. Waste water from the camp site must be collected in portable latrines or septic tanks and has to be treated before releasing into a river.	EH&S Management and Monitoring of the Contractor Equipment Maintenance Management Plan Wastewater Management Plan Waste Management Plan Pollutant Spill Contingency Plan

Issue	**Project component**	**Impact**	**Mitigation measures**	**Related Sub Monitoring and Management Plans (S-MMP)**
Biological Environment				
Vegetation and flora	Construction area, reservoir,	Loss of habitat: up to 8.1 km^2 of land will be submerged including the vegetation. Possible greenhouse gas emission In the absence of vegetation cover the soil will become more susceptible to erosion.	Damage to the natural vegetation should be minimized. Use material inside of the future reservoir and dump unused, uncontaminated material in the future reservoir. Keep additional sites as small as possible. The useful wood in the future reservoir area should be made available to the local population. Local population should be advised to use during construction period, timber in the future reservoir area for charcoal production. The full supply level should be market in the field so that the people are aware where they should go for harvesting, this would reduce the pressure on the surrounding forest for this period and it would already clear parts of the reservoir area. Do not disturb vegetation especially trees at the riverbank downstream of the construction site Re-vegetated as far as possible the reservoir banks with native shrubs and trees in an appropriate manner. The clearing of forest should be monitored by the Forest Development Agency. Do not use any herbicides for vegetation clearing (manual cleaning rather than herbicides). To counterbalance increasing pressure on forests due to the loss of trees growing in the reservoir area and presently used for charcoal production, it is recommended to carry out a plantation program of fast growing tree species which are suitable for charcoal production. This activity should be developed as a community based program, developed, managed and used by the local population, with support of the Forestry Development Agency.	Reservoir Clearing Management Plan Re-vegetation Management Plan Erosion Management Plan
	Road		Use existing facilities and roads where possible for access roads and keep vegetation clearing as small as possible. Do not use any herbicides for vegetation clearing (manual cleaning rather than mechanical or herbicides) Re-vegetation of disturbed areas with native species	Erosion Management Plan Re-vegetation Management Plan

Issue	Project component	Impact	Mitigation measures	Related Sub Monitoring and Management Plans (S-MMP)
	Work force	Overexploitation of the forest resources for charcoal, fire wood and construction wood due to influx of people to the project area	Any illegal logging of the work force must be forbidden Strengthen the awareness of the workforce for the environment (protected areas, plants and wildlife) to avoid logging, hunting etc. at project site and in the surrounding	needs to be part of the employees contract and of the Human Resources Policy
Terrestrial Fauna	Reservoir	Up to 8.1 km^2 of habitat will be submerged.	Reservoir clearing before impoundment needs to be carried out	Re-cultivation Management Plan will improve habitats for terrestrial fauna.
	Construction area, roads and all temporary structures		Damage to the natural habitat should be minimized where possible.	Re-vegetation Management Plan will improve habitats for terrestrial fauna.
	Work force	Disturbance caused by the presence of a high number of people. Risk of illegal hunting.	Hunting by members of the work force must be forbidden. Strengthen the awareness of the workforce for the environment (protected areas, plants and wildlife) to avoid logging, hunting etc. at project site and in the surrounding	needs to be part of the employees contract and of the Human Resources Policy
Fish and Fishing	Dam	Disruption of river continuum. Habitat fragmentation	Not required	Fish Monitoring Management Plan
	Reservoir	Will change from a lotic ecosystem more to a lentic ecosystem, which results in a change of fish species composition.	It is recommended to create a Fisheries bureau connected to a market upstream of the dam, with a staff capable of insuring a sound management of the fishery resources. Preparation of a fish breed management program	Fish Monitoring Management Plan
	Reservoir filling phase		A minimum discharge of 8 m^3/s has to be released.	
	Construction activities	Risk of water contamination	See mitigation measures of water quality	EH&S Management and Monitoring of the Contractor Equipment Maintenance Management Plan Wastewater Management Plan Waste Management Plan Pollutant Spill Contingency Plan
Protected Areas	Operation	No impacts	Not required	----

Issue	Project component	Impact	Mitigation measures	Related Sub Monitoring and Management Plans (S-MMP)
Human Environment				
Human population	Reservoir, construction area, work force and construction activities, and operation	**Negative Impacts:** Land expropriation and resettlement. Restricted fishing in the construction area and near the dam during operation. Loss of forest area for NTFP collection, charcoal production and hunting. Hunting will be restricted in the vicinity of the dam to keep the dam site secure. Increased noise due to construction activities Possibility of increased traffic accidents. **Positive impacts** Generation of jobs, although limited to construction period Possible improvement of commercial activities. Provision of light and improvement of operation of some social infrastructure by connecting to electricity, e.g. schools, clinics, etc. Possibility of starting other economic activities than faming. Improvement of security in the area due to lighting. Eventual improvement of domestic water with possibility of people now getting piped water.	The PAPs (those losing their crops and houses) be relocated and compensated first before the land is taken into use. **For noise:** Ensure that the use of heavy machinery during normal working hours, especially if a quarry is to be set up near any of the settlements. Excavation of stones, rocks and other construction materials during the night hours should not take place and during the day this should start when the surrounding population normally start their daily chores. Ensure that use of heavy machinery at the site is also during normal working hours so as not to disturb the population unnecessarily. **For health:** Ensure screening of new workers arriving from other areas so as to contain spread of any contaminable diseases such as TB, HIV/AIDs, etc. and provide preventative medicine. Ensure general hygiene standards are kept and this might be learnt by the surrounding population. Improve the medical facility existing to cater for immediate accidents and other medical issues as hospitals are far from the area and they are also ill-equipped. During dry season, wet dirt roads to cut down on dust that would irritate neighbouring settlements and population. **For surrounding populations and PAPs:** Give first priority to people in the project area when employing labourers and other unskilled workers, e.g. vegetation clearance, stone crashing in quarries, guards, etc. Should additional skilled workers also be required, take on workers from the area should they have the skills. Carry out some information dissemination and teaching of local population on traffic safety, especially among young people, to curtail traffic accidents.	Resettlement Action Plan

Issue	**Project component**	**Impact**	**Mitigation measures**	**Related Sub Monitoring and Management Plans (S-MMP)**
Land use	Reservoir	Loss of agricultural land Loss of crops in the reservoir area Possibility of less land for cash crops as these have till now been grown in the reservoir. Unless alternative land is identified that will take on cash crop cultivation, as communal land will not support long-term perennial crops/trees. Loss of forest	Put in place appropriate policies to compensate communities that may be affected by the rehabilitation of MC HPP. Identify alternative farm land for affected farmers that are accessible and of comparable productivity. Provide farming inputs (fertilizer, seeds, tools) and agricultural extension services to affected farmers to restart farming activities Minimize removal or disturbance of vegetation along ROW, around construction camps, etc. Provide a relocation or resettlement package for affected community Encourage alternative livelihood alternatives such as animal husbandry, cane tree production, rubber farming, provision of vegetable seeds, tree crop farming, lowland farming outside of the project area, etc. so as to reduce pressure on the current fallow vegetation for environmental stability. Identify alternative areas where forest product collection can be restored Minimize removal of all disturbance of vegetation around construction area Replant native vegetation in disturbed area immediately following construction Establish woodlots with fast growing native tree species outside of the project area so as to reduce pressure on the existing natural vegetation where most of the NTFPs are gathered.	Re-vegetation Management Plan Resettlement Action Plan
Infrastructure	Reservoir	Loss of mosques	Any lost infrastructure will have to relocated or compensated	Resettlement Action Plan

Issue	**Project component**	**Impact**	**Mitigation measures**	**Related Sub Monitoring and Management Plans (S-MMP)**
Public Health		Potential negative effect on health (diseases brought from outside by workers) Risk of STD (Sexual transmitted Diseases) / HIV / AIDS Introduction of new diseases Possible increase in malaria prevalence Exposure to acute respiratory infections Exposure to wastes and other pollutants Increased risk of accidents	All workers should attend a work shop on communicable diseases (TBC, HIV/AIDS and STDs (Sexual transmitted Diseases). How to get infected, how to recognise symptoms, what should be done and on prevention measures. Every worker has to have the necessary vaccination (Hepatitis A and B, Tetanus, etc.) Overall good housekeeping contributes to maintain hygienic and safe conditions on the construction site. Do not create additional breeding places at the construction site for arthropods and snails e.g. unnecessary ponds, tires etc. Vector control at the individual level (use of mosquito nets, repellents, etc.), and at the Community level by the destruction of breeding sites using biological simulicides to avoid additional environmental pollution. Regular epidemiological monitoring should be conducted through surveys to determine the transmission dynamics of vectors and their seasonality. Rehabilitation and/or equipment of one of the most closed clinics, and the provision of minimum equipment is necessary to take care of emergency. It is not necessary to install a medical center in the camp, but to improve one of the existing clinics that will benefit to the local population after the dam construction. This takes into account: the provision of basic supplies, the supply of essential drugs, the establishment of electric power, the provision of a motorcycle for outreach and an ambulance for references. A campaign on hygiene and sanitation must be maintained regularly to promote healthy behaviours. Similarly, it is important to develop devices for household waste collection, disposal and wastewater treatment and latrines maintenance Install Project Information Center and prepare a Community Relation Plan and inform the population about the Project. Speed limits and a safety driving training should be implemented Improve infrastructure in the area directly affected by the project (maintenance of access roads) Control activities affecting waters and landscape.	Community Relation Management Plan Health and Safety Management Plan Traffic Management Plan

Issue	**Project component**	**Impact**	**Mitigation measures**	**Related Sub Monitoring and Management Plans (S-MMP)**
Cultural Heritage	Reservoir	Destruction of any cultural sites within the reservoir area	Mosques will have to be replaced	Resettlement Action Plan
Emergency preparedness			For the activity of emptying the reservoir in case of alarm or hurricane or flooding, the proponent must inform nearby communities downstream that may be affected in case of release of high flows from the reservoir of the project. Develop an Emergency Preparedness Plan (fire, flooding, hurricanes, earthquakes)	Emergency Preparedness Plan
General construction related issues				
Air quality	Quarries, construction activities and transportation activities	Air pollution mainly to nitrogen oxides (NOx) and Particulate Matter (PM10) • Emission related to construction activities • Emission related to transport of material. • Emission related to borrow areas. Impact restricted to construction site (including quarries and access roads) and phase.	Use adequate and well maintained construction and transportation equipment and the contractor has to develop a maintenance program to ensure this. Take good measures for dust suppression: • this includes among others good housekeeping, • Instruct workforce on appropriate measures to minimize air pollutants. • optimization of storage on-site of materials that are known to be whirled up by wind • water sprinkling especially on unpaved roads during dry season, if necessary. • Truck which transport construction material for longer distances (quarry to construction site) should be covered. • Do not exceed speed limits • Do not burn waste Organize the sequences of construction activities in a way that the use of equipment powered by diesel fuel is optimized and duration is minimized (switch-off the engine during parking periods).	EH&S Management and Monitoring of the contractor Equipment Maintenance Management Plan Traffic Management Plan Waste Management Plan Air Quality Management Plan.

Issue	**Project component**	**Impact**	**Mitigation measures**	**Related Sub Monitoring and Management Plans (S-MMP)**
Noise	Quarries, construction activities and transportation activities	Mainly on the Workforce	Use adequate and well maintained construction and transportation equipment including state-of-the-art built in systems (muffler) to reduce the noise. The contractor has to develop a maintenance program to ensure this. Instruct the workforce to avoid unnecessary noise. Use adequate and state of the art techniques for blasting, which do not exceed the exposition time to the noise. Workers exposed to excessive noise have to wear ear protectors and the exposition time has to be limited. The quarry must be located in a sufficient distance to any populated area. Separate installation areas, for example mechanical workshops etc. from that are used by people for temporary housing and recreation distance should be at least 10 m. Noise and vibration associated with the use of explosives needs to be monitored. Max 136db Avoid any noise intensive works such as metalworking, blasting (in quarries) etc. during night time. Avoid transporting of material (rock, concrete, etc.) during night, if they have to pass villages.	EH&S Management and Monitoring of the contractor Traffic Management Plan Equipment Maintenance Management Plan Explosives Management Plan Health and Safety Management Plan
Vibration	Construction activities and quarries		Use best practice to reduce the dispersion of material and vibrations near any physical structures. Install a monitoring system at sensitive sites and monitor and record vibrations during blasting events. Use state of the art techniques Restrict access during blasting events.	EH&S Management and Monitoring of the contractor Explosives Management Plan Health and Safety Management Plan

Issue	Project component	Impact	Mitigation measures	Related Sub Monitoring and Management Plans (S-MMP)
Waste, hazardous waste and storage of hazardous materials		Contamination of soil, water, health risk.	Develop a waste management system Install garbage cans for temporary waste disposal of domestic waste. Those have to be collected and disposed according to the regulation of solid waste management and approved by the local authorities. No waste shall be disposed of or buried on the site. Illegal dumping, either at the construction camp, along the roads or in the surrounding areas, or into the river shall not be allowed. Solid waste generated during construction and at campsites will be properly treated and safely disposed of only in demarcated waste disposal sites. In general waste should be reduced, re-used, recycled and the disposal should be controlled. Hazardous waste (oil, chemicals, etc.) has to be stored in a designated closed tank and/or area. Until it will be delivered to companies specialised on the proper disposal or recycling of those hazardous wastes. Containers have to be available at the workshops for the disposal of used filters, gaskets and other spare parts. A full clean-up of the site has to be carried out before main construction starts. A full clean-up of the site has to be carried out after construction. All wastes accumulated during construction and all demolishment wastes from temporary structures have to be disposed properly. A continuous monitoring of the proper waste handling by the contractor and by the Owner is indispensable to ensure that problems are identified and addressed early Instruct workforce on appropriate measures to minimize waste and raise the awareness of the workforce. Implement a waste management for the population upstream of the dam so that the mixture of plastic and tree branches will not block the racks of the HPP	Waste Management Plan Hazardous Material Management Plan

Issue	Project component	Impact	Mitigation measures	Related Sub Monitoring and Management Plans (S-MMP)
Use, transport and storage of explosives			Take into account the procedures established by the responsible authorities of Liberia and/or any international standards accepted by Liberia Do not use explosives in areas not authorized for this purpose. Explosive material should be stored in a state of the art storage (solid structure, fire resisted material, ventilation for heat control, electrically grounded, clean and dry, exclusively for Explosives) it has to be labelled with the necessary warnings, and needs to be closed and lockable. The storage needs to have an area open surrounding of 10 m and no other combustible material is allowed to be stored in a distance less than 20 meter. Detonators should be stored in a different storage or at least in a different compartment of the storage. Blasting agents should be stored separate from explosives, safety fuses and detonating cords. Just persons authorised should be allowed to store, handle, use and transport explosive material. The authorisation has to be maintained if required by the Liberian legislation and the certificate should be kept on site. For transport of explosives use designated closed containers with insulation. Use separate containers for the detonators Do not allow people, workers and animals in a distance of less than 500 m Implement suitable warning system (banners, mobiles, sirens etc.) Activate an auditable alarm 15 minutes before blasting	Explosives Management Plan

Issue	Project component	Impact	Mitigation measures	Related Sub Monitoring and Management Plans (S-MMP)
Occupational Health and Safety	General		Develop occupational health and safety procedures like to wear protective equipment, proper handling of hazardous substances, working near water, etc. All workers have to use the relevant protective equipment (helmet, gloves, goggles, work boots, masks, ear plugs, etc.) All restricted plant facilities have to be labelled with caution signs, especially those with potential risk for workers All construction areas shall be marked and fenced to avoid accident from unauthorised people. Fence off all areas like excavation pits, quarries etc. to prevent accidents First aid kits need to be available at the construction site for fast action if an accident occurs. Accessible consultation sheets for review in case of contingency or emergency situations. These should have phone numbers for police, fire-fighters, Red Cross, personal supervisor or project leader. Prepare a scheme of the evacuation routes and where the fire extinguishers are located within the plant and place them at on conspicuous places. maintenance of machinery (preventive and corrective; during construction and operation) Provide sufficient portable water. Assign during construction a special area for the food intake. Separate installation areas, for example mechanical workshops etc. from that are used by people for temporary housing and recreation distance should be at least 10 m. Install portable toilets for the disposal of manure generated by the builders in a distance of at least 15 m to the river. They should be regular maintained and disinfected. The number of latrines is correlated with the number of employees and there should be one toilet for every ten (10) workers. Workshops and camp site must have acceptable conditions of light, ventilation and safety for workers. Label T&D Line poles indicating danger, high voltage	Health and Safety Management Plan Emergency Preparedness Plan

Issue	**Project component**	**Impact**	**Mitigation measures**	**Related Sub Monitoring and Management Plans (S-MMP)**
Traffic and roads	Offsite transportation routes	Medium impact. Additional traffic passing through villages.	A Traffic Management plan will have to be developed, which has to be compulsory for all contractors and subcontractors on roads within the project area as well as on all public roads. Regular maintenance of the vehicles (brakes, wheels, lights, brakes and power lines, etc.) The driver has to adapt his driving style to type of charge and the weight of the charge (braking distance increases with the weight), special caution has to be taken in front of schools where children suddenly cross the street. Where possible traffic should avoid populated areas. In the villages animals and pedestrians have the right of way. Procedures if an accident occurs (whom to call, which is the next hospital, etc.) including reporting procedures. Actions to be taken if the driver does not comply with the set guidelines. Adequate signing, warnings and controls have to be implemented like speed limits. Enforce maximum load restriction Implement a maintenance program for access roads carried out before rainy season (cleaning gutters, improvement of the road if necessary, etc.) Develop procedures for parking and on-site traffic movement Use if feasible project buses to transport workers to the site.	Traffic Management Plan Equipment Maintenance Plan

21 PROVISIONAL ENVIRONMENTAL AND SOCIAL MANAGEMENT PLAN

Based on the results of the two preceding Chapter, the Environmental and Social Management Plan (ESMP) will be developed.

All the relevant measures will be included in the ESMP. This will define:

- The impact.
- The proposed mitigation measure (detailed description).
- Responsibility for implementation (note: this can include the necessity for further specifying certain measures at later stages of the Project).
- Means required for implementation (staff, infrastructure, equipment, funds).
- Costs (as far as they can be identified or estimated at this point; it also has to be noted that some measures might be included in the technical project, and that these costs will be considered there.
- Monitoring process.

21.1 Objectives of Environmental and Social Management Plan

The ESMP will help Mount Coffee HPP to address the adverse environmental impact of the project, enhance project benefits, and introduce standards of good environmental practice. The primary objectives of the plan are to:

a) Define the responsibilities of project proponents, contractors and other role players, and effectively communicate environmental issues among them.

b) Facilitate the implementation of the mitigation measures identified in Chapter 20 by providing the instructions on how to handle the issues, and providing an implementation schedule

c) Define a monitoring mechanism and identify monitoring parameters to ensure that all mitigation measures are completely and effectively implemented.

d) Identify training requirements at various levels and provide a plan for implementation.

e) Identify the resources required to implement the ESMP and outline corresponding financing arrangements.

21.2 Institutional Requirements

21.2.1 Project Owner

The Project Owner, i.e. LEC, will have the overall responsibility for the project and for its implementation according to the plans and conditions agreed upon; these conditions, obviously also contain the requirements for environmental management described in the final ESMP. In order to be able to comply with these requirements as far as environmental management is concerned, he will therefore need to have the required capacity and know how. For this purpose, it will be required that LEC hires a person, a qualified environmental engineer or somebody with a similar background, who will be in charge of carrying out the necessary supervisions, control and monitoring work.

Furthermore, a person needs to been employed, covering all the social issues. The requirements needed for social issues will be part of the Resettlement Action Plan.

The following will be the main duties of the person responsible for the environmental issues:

- To check regularly the monitoring and progress reports to be provided by the Contractor (and to make sure that these reports are being produced according to schedule).
- To carry out regular inspection visits on the construction site.
- To organise and coordinate activities of external monitoring (see below).
- To carry out some direct monitoring work of his own (most important: Water quality monitoring, waste management, etc.). To this end, the specialist must be provided a corresponding measuring device.
- To prepare reports for the attention of LEC management and the burrowers (at a frequency to be determined by the Bank); the Environmental Consultant proposed Quarterly Reports.
- To report regularly to LEC management on the state of the work and compliance with environmental rules.
- To assist in proposing corrective measures in case non-compliance has been observed with any of the conditions.
- To report immediately to the contractor's as well as to LEC’s management in case a serious non-compliance, which presents considerable risks to the environment and/or to workers' health, has been observed.
- To alert LEC and contractor's management immediately in case of an emergency.

This should be a full time position during the entire construction period.

21.2.2 Contractor

The contractor will have his own staff for dealing with the requirements of the contract, and specifically for compliance with environmental management measures.

The following personnel are required:

- A safety and security manager: responsible for security (access control to the construction site and for safety on site (availability of all required safety devices, including health protection equipment for workers; marking of restricted areas; control of implementation of these measures).
- Medical personnel: nurse or similar, with special training in first aid and capable of giving instructions to workers. In order to make sure that one person is on duty whenever work is in progress, and can be reached in cases of emergency also during off-hours, a team of two seems to be the minimum.
- An environmental specialist (environmental engineer or similar). His main duties will be the formulation of detailed environmental management plans (most of which have to be in place before construction work actually starts!), supervision of implementation of all the measures (internal monitoring),

participation in implementation of measures, and reporting (preparation of the required monitoring reports). Given the size of the construction site, it might be required that this specialist has an assistant (technician), mainly for carrying out routine supervision and monitoring activities.

The contractor will have to include costs for these specialists in his proposal.

21.2.3 Internal Monitoring

21.2.3.1 Contractor's Monitoring

The first level of monitoring has to be carried out by the contractor. This is part of the duty of the personnel described in Section 21.4.2

21.2.3.2 Equipment

For an efficient monitoring, a number of measuring devices are required, which allow to make fast and precise measures on site at the required places and intervals. The Environmental Consultant proposes to use modern hand-held equipment for this purpose. A list of these devices will be developed for the final ESMP Report.

21.2.3.3 Monitoring by LEC

LEC, as the project owner, will need supervision and monitoring of its own in order to make sure that the contractor keeps to his obligations. This will be the main duty of the position described shortly under 21.4.1.

This monitoring will be done by checking the regular monitoring reports to be provided by the contractor, and by carrying out regular site visits.

21.2.4 External Monitoring

External monitoring is usually required in such projects. This can be done in two - not necessarily mutually exclusive - ways as described below.

21.2.4.1 Institutions

The Environmental Protection Agency plus other relevant agencies as maybe required will have the following obligations:

- Check the reports received from LEC; this latter will have to make sure that regular monitoring reports are being delivered to EPA and or other Agencies.
- Carry out some inspections by its own (as e.g. on the type and condition of vehicles and machines used in the construction; on waste management and waste disposal; and on water quality.

21.2.4.2 External Experts

As a part of its normal procedures, for large Category A project, the World Bank normally uses Panels of Experts for checking on compliance with environmental and social safeguards. Such a PoE regularly (usually twice a year) visits and inspects the construction site and reports on its observations.

If this is deemed necessary (to be decided by the financial institution) given the size and the type of impacts caused by the Project, this could be done by one experienced environmental expert; given the social impacts, and especially given the fact that resettlement is required for this project, a social specialist will need to be part of this PoE.

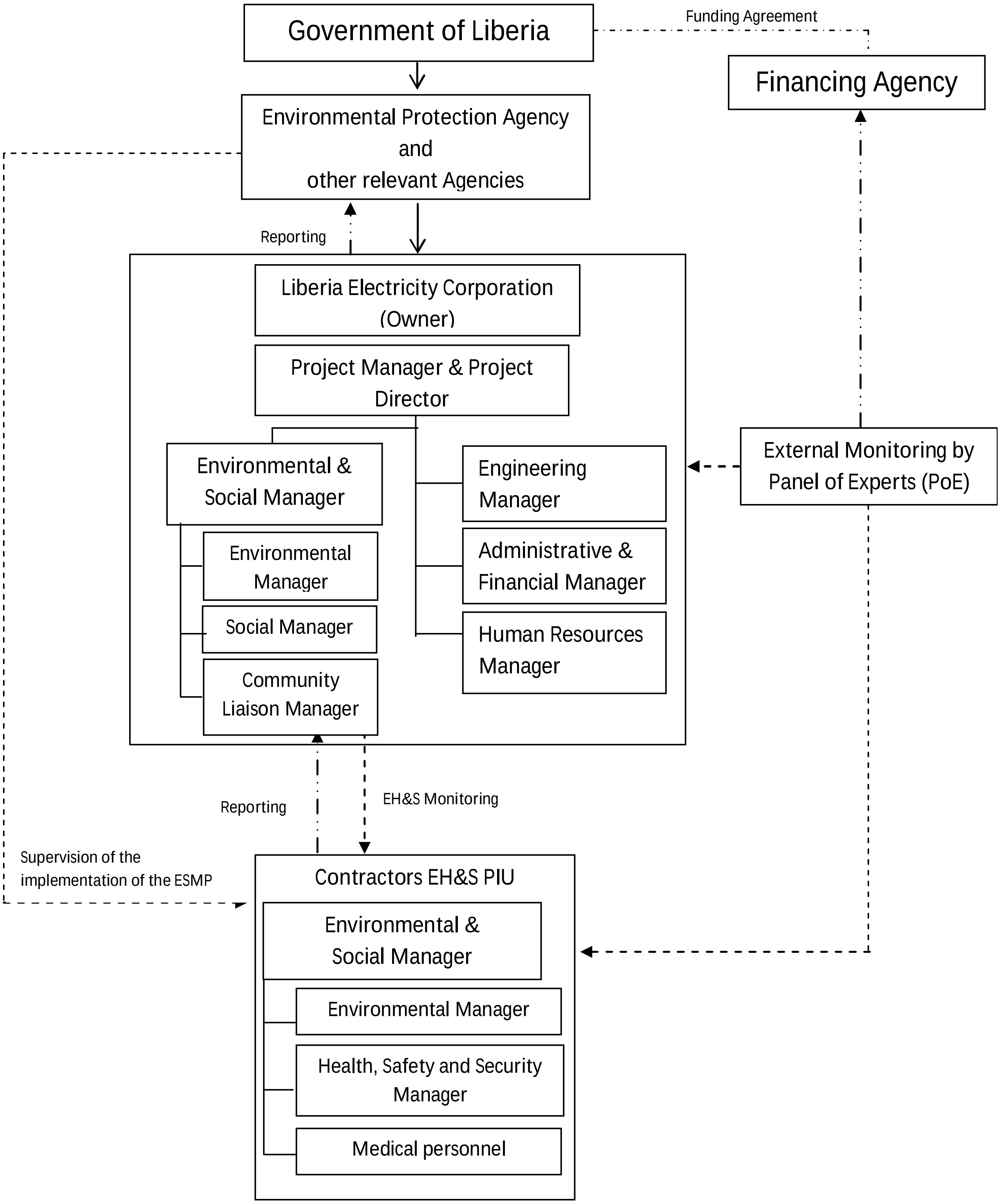


Figure 21-1: Project Mangement Organisation Chart

21.3 Reporting

Reporting is essential. The following monitoring reports seem required for this project:

- Monthly Progress and Monitoring Report: to be prepared by the Contractor's specialist, providing a (short) statement on all monitoring activities, and on any specific events, as the case may be. Internal reports, to be made available to LEC (routinely) and EPA (at their request).
- Quarterly Reports: to be prepared by the Contractor, summarising all observations of the period. Report for LEC and EPA.
- Quarterly Report by LEC: based on the contractor's reports and on own activities, for EPA and the burrowers.
- Additional reports according to specific conditions. Most importantly: if a PoE should be put in place, this would have to prepare a short report after every site visit, on behalf of LEC and the Financing Agency.

21.4 Sub ESMPs

The Owner will be committed to the creation and implementation of programmes to reduce the probability of occurrence of deleterious environmental incidents. Contingency plans will be developed for dealing with such adverse incidents, if they occur.

The Owner will expect the same level of environmental performance from its contractors, sub-contractors and suppliers and needs to stipulate this in any legally binding agreements it enters with these parties. The Owner should include following umbrella obligation into the contract of any main and sub-contractors:

The Contractor shall take all responsible steps to protect the environment (both on and off the Site) and to limit damage and nuisance to people and property resulting from pollution, noise and other results of his operation.

The Contractor shall ensure that emissions, surface discharge and effluents from the contractor's activities shall not exceed the values indicated in the Employer's requirements, and shall not exceed the values prescribed by applicable Laws.

This Clause shall take precedence over all Environmental-related clauses elsewhere in the Contract.

In addition a similar umbrella obligation should be included into each contract related to Social, Health and Safety requirements

Furthermore, the Contractor will be under contractual obligation to the Owner to implement the aspects of the ESMP that apply to it, and to ensure compliance by its own subcontractors. The Owner and the Contractor will ensure that appropriate corporate resources, personnel and reporting and accountability systems, are in place for the successful implementation of the ESMP. They will, on a continuing basis, review the objectives of the ESMP as well as the company's success in achieving them. Where objectives are not being achieved, corrective action will be taken. The ESMP objectives will also be modified over the life of the project, as appropriate, to reflect changing environmental laws, regulations, standards, and technologies.

The ESMP is an umbrella plan that is comprised of several components that are to be integrated and implemented by the Owner and the Contractor with regard to the Mount Coffee Hydropower Project. These components are shown in Figure 21-2 below:

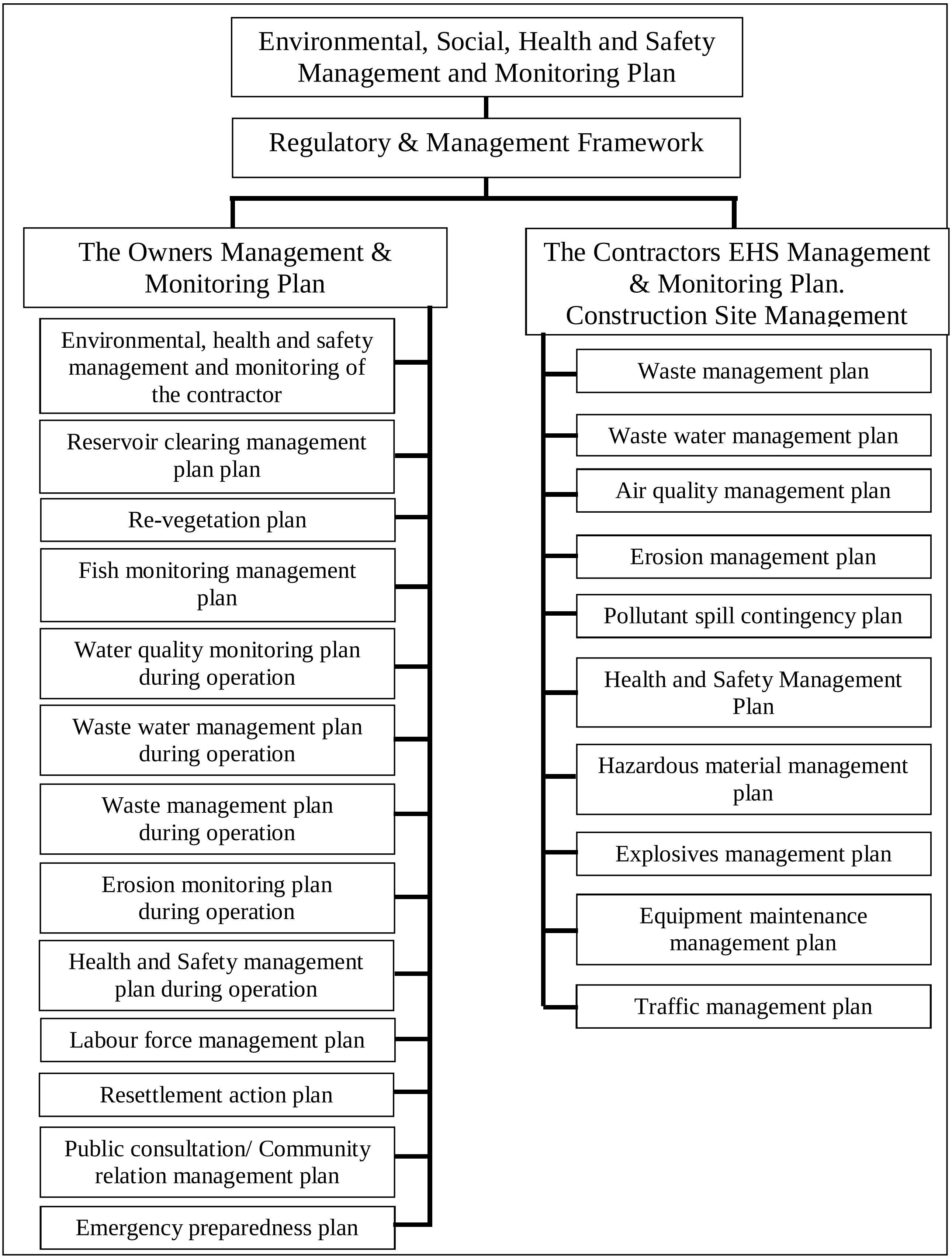


Figure 21-2: ESMMP and Sub-ESMMPs

The Content of each Sub ESMP should include the following.

- The Purpose
- Reference and Relevant Documents (Legislation of Liberia and other applicable International Standards and other documents used)
- Roles and Responsibilities
- The management process
    - Emission standards and requirements
    - The project emission sources
    - Prevention and Control
- Surveillance
    - Inspections
    - Monitoring (Measurements)
    - Reporting
- Actions to be taken in the case of Non- compliance
- Awareness and Training
- Documentation and Communication

The Final ESMP will contain the main issues which each Sub EMMP has to cover.

21.5 Training

According to the TOR, the Consultant, in addition to the preparation of the ESIA and the ESMP, also has to carry out a training program for selected staff of LEC and other entities involved in environmental and social management of the Project.

21.5.1 Choice of Topics

The following broad topics are proposed for this training:

- EH&S management of large construction sites.
- RAP implementation.
- EH&S management of HPPs during operation.

These three topics are outlined shortly.

21.5.1.1 EH&S Management of Large Construction Sites

Dam and power plant construction require large construction sites, usually in operation for several years, depending on the size of the project. These construction sites create a number of problems related to health, environment and safety, which have to be managed properly. This requires the necessary means (infrastructure, material, budget), but first of all personnel properly trained in and aware of these issues, who can manage them.

Main contents of this module on Environment, Health and Safety (EH&S) will be:

- Organisation: structure, distribution of tasks (mainly distribution between project proponent and contractor), required human resources.
- Preparation of detailed plans: for each of the main activities (like e.g. health provision for the work force; waste management; water and waste water; noise and vibrations; etc.), separate management plans have to be prepared, which take into account the legal requirements, but also the specific conditions presented by the site and the project. These individual plans will have to be prepared, either by the project proponent, by the contractor or by both of them, depending on the subject, before or at the beginning of the construction phase. The module will not aim at preparing a full set of such detailed plans, but some examples will be presented, discussed and/or prepared by the participants.
- Role of the different actors: the responsibility for the implementation of the EH&S system on the construction site will be mainly the contactor's. However, the project proponent will have to define the conditions and regulations to be respected, and will be responsible for supervising the activities of the contractor. Other entities, e.g. EPA, might be involved as well.
- Aspects of the daily work of personnel responsible for EH&S management.
- Environmental measures not related to construction activities: depending on the project and on the impacts caused by it, there can be a need for more or less far ranging environmental management or mitigation measures which are not related to the construction site and construction activities. Implementation of these measures is in the responsibility of the project proponent (or of another entity mandated for this purpose; this can, but does not have to be, the main contractor, depending on the nature of the activity.
- Monitoring: internal monitoring (carried out by the entities in charge of the measures), and external monitoring (carried out by third parties, independent of the project and directly involved organisations).
- Reporting: purpose, form, main contents, etc.

21.5.1.2 RAP Implementation

Resettlement is a major aspect of most large hydropower projects, and a proper implementation of the RAP is crucial for its outcome. Topics to be covered by this module:

- Organisation: Resettlement Implementation Unit, village resettlement committees, other entities involved; tasks, responsibilities and requirements.
- From RAP (Resettlement Action Plan) to RIP (Resettlement Implementation Plan).
- Procedural questions: finalisation of compensation packages, agreements with PAPs; dealing with grievances; etc.
- Integration of affected persons in the process: public consultation and participation, relationship with communities and individuals.
- Coordination of resettlement activities with the project schedule.

- Monitoring (see above).
- Reporting (see above).

21.5.1.3 EH&S Management of HPPs during operation

A number of EH&S issues will also have to be dealt with during normal operation of an HPP. This will be the subject of this module. Some important aspects to be covered:

- Occupational health of plant staff.
- Managing of the transition phase from construction to operation: these concerns, e.g., on-going monitoring programs, if any, as might be required for a final assessment of project impacts and the definition of follow-up measures (e.g. monitoring of fish populations and, based on results, definition and implementation of a reservoir fisheries management program).
- Environmental consequences of plant operation: residual flow, water quality in the reservoir, water quality and river discharge issues in the downstream area, etc.
- Monitoring and reporting.

21.5.2 Training Courses

The topics will be addressed in a general manner, i.e. pointing out issues to be dealt with in any such project, but special emphasis will be put on the specific situation and conditions presented by Mt. Coffee HPP. For illustration purposes and possibly for some specific group work, examples from other projects will be used as well.

Each of the chosen topics will be treated in a two day workshop. The following methods will be applied:

- Lectures, formal (classroom) teaching.
- Discussions with/among participants.
- Group work, including presentation of results by participants.

It is important that participants will also be able to contribute their own experience with these topics.

21.5.3 Participants

LEC and the other entities involved will have to identify the persons who will participate in these training courses. The Consultant would like to make following suggestions:

- LEC:
    - Person responsible for environmental issues at LEC (environmental engineer or any other equivalent scientific education)
    - Hydrologist, with knowledge on water quality
    - Person responsible for health and safety issues at LEC
    - Person responsible for social issues at LEC (socio-economist or equivalent education)

- Other institutions:
    - Responsible person from the EPA for the monitoring of the Environmental Issues on construction sites (environmental engineer or any other equivalent scientific education).
    - Responsible person from the bureau of fishery for inland fishery
    - Person responsible for the monitoring of health and safety issues from the governmental side (Ministry of Labour or Ministry of Health)
    - Person responsible for reforestation of the forestry development agency (Ministry of Agriculture)
    - Person from the agricultural research institute and/or university.

21.5.4 Required Input

For finalising the training program, the Consultant needs to get the following input from LEC and the other institutions involved, like e.g. EPA, other Ministries:

- Choice of topics: from the ones proposed, or, if required, other subjects which they deem as important.
- Designation of participants: number, qualifications, specific training needs (if identified).

Once this information is available, it will then be possible to plan the workshops in detail.

21.5.5 Expected Outcome

The aim of this training program will consist mainly in raising the awareness of the participants (who presumably will be in charge of such issues during project implementation and operation) for problems related to EH&S, and to provide a number of instruments (sample management plans, monitoring procedures etc.) for dealing with the issues at hand.

A possible outcome could also be that additional training needs will be identified. It is obvious, however, that in such a case alternative possibilities for additional training would have to be evaluated.

22 RESETTLEMENT PLANNING

The ESIA only outlines the requirements for resettlement (which basically includes physical displacement, i.e. resettlement in the narrower sense of the term, and economic displacement). The details of this, i.e. mainly necessity of and conditions for compensation of lost assets, will be dealt with in the RAP.

The present chapter presents the basics of what will be done in resettlement planning.

22.1 The Present Situation

A number of structures have been identified in the reservoir area and the ongoing HH survey is gathering data on the owners of the structures regarding their socio-economic status. The settlements identified are so far are seven as shown in Table 13-1 in chapter 13, and these will definitely have to be relocated. The exact number of structures and the number of households and people will be confirmed with the ongoing survey. Therefore there will be need for a Resettlement Action Plan. The questionnaire for the ongoing HH survey is found in Annex 22.

Up to now investigations have revealed that land that is in the reservoir that is being used for agriculture will all be lost. This implies that the crops, both perennial and annual, will have to be compensated. The reservoir land is mostly cultivated with cash crops and this has implications for the PAPs in terms of their livelihood.

Based on loss of structures, livelihood, etc. resettlement planning will follow the World Bank’s Operational Policy 4.12 (OP 4.12) on involuntary resettlement, a policy that is internationally accepted and whose basic elements are the following:

1. Involuntary displacement should be avoided or minimized whenever feasible, because of its disruptive and impoverishing effects.
2. Where displacement is unavoidable, the objective of Bank policy is to assist displaced persons in their efforts to improve, or at least restore, former living standards and earning capacity. The means to achieve this objective consist of the preparation and execution by the borrower of resettlement plans as development programs. These resettlement plans are integral parts of project designs.
3. Displaced persons should be: (i) compensated for their losses at replacement costs, (ii) given opportunities to share in the project benefits, and (iii) assisted in the transfer and in the transition period at the relocation site.
4. Moving people in groups can cushion disruptions. Minimizing the distance between departure and relocation sites can facilitate the resettlers' adaptation to the new socio-cultural and natural environments. The tradeoffs between distance and economic opportunities must be balanced carefully.
5. Resettlers' and hosts' participation in planning resettlement should be promoted. The existing social and cultural institutions of resettlers and their hosts should be relied upon in conducting the transfer and reestablishment process.
6. New communities of resettlers should be designed as viable settlement systems equipped with infrastructure and services, able to integrate in the regional socio-economic context.
7. Host communities that receive resettlers should be assisted to overcome possible adverse social and environmental effects from increased population density.

8. Indigenous people, ethnic minorities, pastoralists, and other groups that may have informal customary rights to the land or other resources taken for the project, must be provided with adequate land, infrastructure, and other compensation. The absence of legal title to land should not be grounds for denying such groups compensation and rehabilitation.

These basic rules have then been integrated into the presently applicable WB guidelines, the World Bank Operational Policy on Involuntary Resettlement (OP 4.12), which will apply for the involuntary resettlement of owners and users of the project lands. OP 4.12 requires that planning for resettlement be an integral part of the project design, and should be initiated as early in the project planning as possible. The policy sets out the following policy statement for consideration during resettlement planning:

1. Involuntary resettlement should be avoided or minimized where feasible, exploring all viable alternative project designs.
2. Where displacement is unavoidable, resettlement plans should be developed. All involuntary resettlement should be conceived and executed as development progress with re-settlers provided sufficient investment resources and opportunities to share in project benefits. Displaced persons should be (i) compensated for their losses at full replacement cost prior to the actual move; (ii) assisted with the move and supported during the transition period in the resettlement site; (iii) assisted in their efforts to improve their former living standards, income earning capacity, and production levels, or at least to restore them. Particular attention should be paid to the needs of the poorest groups to be resettled.
3. Community participation in planning and implementing resettlement should be encouraged. Appropriate patterns of social organisation should be established, and existing social and cultural institutions of re-settlers and their hosts should be supported and used to the greatest extent possible.
4. Re-settlers should be integrated socially and economically into host communities so that adverse impacts on host communities are minimised. The best way of achieving this integration is for resettlement to be planned in areas benefiting from the project and through consultation with future hosts.
5. Land, housing infrastructure, and other compensation should be provided to the adversely affected population, indigenous groups, ethnic minorities, and pastoralists who may have usufruct or customary rights to the land or other resources taken for the project. The absence of legal title to land by such groups should not be a bar to compensation.

The World Bank Group's OP 4.12 on Involuntary Resettlement provides that land-for-land resettlement is generally the preferred option. This fits into the Liberia's set up where all land belongs to the Government and resettled persons are given land for land acquired by the project. Therefore, land based resettlement will be carried out where possible, but a major emphasis of the RAP will be to develop a Livelihood Augmentation and Income Restoration (LAIR) Plan to ensure that affected households are able to restore and sustain incomes previously gained from agriculture (to at least equivalent levels). Interim compensation payments for loss of assets and general disturbance will also be made to assist with the transitional period.

22.2 What Needs to be Done

Contrary to what was assumed that no settlements would be affected, the few settlements found so far though they were squatters on LEC land, will still have to be settled elsewhere. Also crops and trees lost will have to be compensated. It is therefore imperative that with the planning:

- HH survey data is analysed and Focus Group Discussions held with the PAPs
- Land is identified for resettlement
- PAPs are involved in identifying where they want to relocate
- PAPs are identified and confirmed and their structures are noted
- PAPs whose crops and trees are affected are also noted and crops and trees noted
- Modalities of compensation have to be worked out
- PAPs are involved in identifying alternative livelihood strategies should land not be available for cash crop farming and planning for these strategies.
- Host communities are involved in the planning as they take on new settlers and to ensure that conflicts are avoided.
- Infrastructure in host communities is upgraded to avoid pressure from increased use due to additional people.
- Carry out public consultations. The consultations with all stakeholders (involved) will be open, transparent and continuously ongoing in order to plan and implement a successful programme.
- Institutions that will deal with resettlement are identified and their roles spelt out.
- Eventual cut-off date will be set by the project (LEC) to avoid new people moving into the project area
- Eventual implementation plan will be drawn up
- Eventual budget for the whole resettlement will be drawn up.

22.3 Resettlement Policy Framework

Since Liberia has no National Resettlement Policy, the Consultant will draft a resettlement policy. The framework will be based on the WB OP 4.12 and the legislations of the country that deal with land acquisition and expropriation. These laws are shown in Chapter 2 of this report. The Resettlement Policy Framework (RPF) will be written under separate cover.

22.4 Resettlement Plan Outline

The outline of the RAP will follow the points shown in section 22.2. A summary follows:

- A complete survey of all affected settlements is carried out and data analysed. Each and every individual affected has to be interviewed.
- A detailed survey of the farm land i.e. counting valuable trees, measuring the land and valuing this.
- Creating a comprehensive databank indicating name, gender of affected and what they will lose. The data bank should be made with the possibility of adding new information when collected. Data should be disaggregated to capture which gender has ownership, income and other socio-economic aspects in the HH.
- Establishing a cut-off-data once the survey is concluded. It is crucial that people are informed as early as possible if they have farm land in the reservoir.
- Drafting of livelihood strategies and income restoration.

- Selecting of an NGO or an established entity to carry out livelihood and income restoration plan.

A Resettlement Unit has to be in place in order to implement the RAP. The responsibility lies mainly with the project and detailed planning from the onset must include the participation of all stakeholders, especially the would-be affected people.

23 PUBLIC PARTICIPATION

23.1 Main Aims

The ESIA process, and even more so the preparation of a RAP, foresee a communication with the public (all stakeholders and PAPs). The purpose of such a communication is two-fold, namely

- providing information on the Project, its impacts and the proposed measures, to the interested public, and
- obtaining input in form of suggestions, queries, etc. from the public, and, especially for the RAP, from the directly project affected persons (PAPs).

23.2 Access to Information

Locals are able to get first-hand information on events in the country through news broadcasts on radio. They receive daily radio broadcasts from three radio stations beaming broadcast signals from Monrovia. A local community radio that broadcast community oriented programs to residents in the project area also has a presence in that vicinity. Other means through which information is shared to and from the communities in the project area is through a GSM (Celcom) telephone network. Residents are able through telecommunication facilities of this GSM service provider to communicate freely to any part of the country and abroad.

23.3 Preliminary Public Participation Plan

In the Screening Report, a broad range of potential ways and means of public information were identified. Some of those, like e.g. providing information to the wider public (population of the wider project area, or the country as a whole) on the project as such, on the different planning steps (technical, schedule of implementation, envisaged start of operation) and on its role for the economy of the country (by providing electricity at reasonable costs, etc.), and providing this information via generally available mass media, mainly TV and radio, are clearly not in the responsibility of the ESIA Consultant. If such an information campaign is envisaged, this would have to be done by the GOL, and more specifically probably by the Ministry of Energy or LEC.

However, the ESIA Consultant clearly has a role to play in the public participation required as part of the ESIA process.

23.4 Stakeholder Identification

Stakeholders can basically be grouped as follows:

- **Directly interested parties:** persons and (mainly) institutions who have a direct interest in the project, and who also have a more or less decisive influence on project outcome. This is, first of all, GOL represented by the Ministry of Energy and LEC, i.e. the project proponent, but then also other organisations like WAPP, and obviously also the financing institutions which will or might be involved in project financing.

- **Indirectly interested parties:** this is, in a very general way, the entire population of Liberia, or, in the short and medium term, at least the part of the population which expects to have electricity supply, and with it general living and economic conditions, improved by the project; this also includes enterprises and workers who hope to get contracts and jobs in the course of project implementation. This group, while certainly in favour of the project, has little or no direct influence on project outcome.
- **Involved parties:** these are mainly state organisations that, in their immediate function (and not in their role as electricity consumers!) have no direct interest in the project as such, but are involved *ex officio* in the project preparation and implementation process. This is e.g. EPA, the entity responsible for conducting the ESIA process and of issuing the environmental licence to the project, but also other entities whose interests may be affected by the project (e.g. those responsible for agriculture, forestry, fisheries and public health). They have a direct influence on project outcome.
- **Affected parties:** this is the population directly and physically affected by the project as such, i.e. the population living in the area where the project is located, and which will be changed by construction activities, project implementation and operation. The most direct impact on this group is loss of land and potentially housing, aspect mentioned in this report in a preliminary way and to be dealt with in detail in the RAP. To some extent, this group is obviously also an "interested party" insofar as they expect jobs and other economic advantages from the project. While this group is the one most directly affected by the project, it is also the one with the least influence on project outcome.

The focus of the participatory process in the ESIA and RAP development lies clearly on this latter group. While at least some of the directly interested stakeholders (like LEC and WAPP as Clients for the ESIA) and some of the involved parties (mainly EPA as the institution finally deciding on issues related to environmental impacts) are involved in any way, and also automatically receive (and have to comment) the reports, it is important that the main stakeholders, the affected parties (PAPs, project affected persons) receive adequate information on the project and are also enabled to voice their concerns and suggestions.

23.5 Stakeholder Involvement So Far

Stakeholder involvement, including most of the parties listed above, has been done by the Consultant in a number of ways, including formal and informal approaches. The main steps are listed shortly hereunder.

- Official project announcements: the Consultant published a Notice of Intent in two Liberian newspapers for three days (the Inquirer and the New Dawn 2nd, 5th and 6th March, 2012), see Annex 23.2.
- Reporting: the Reports prepared so far (Monthly Reports and Scoping Report) were submitted to the parties as identified in the contract. A further distribution of these Reports, if any, is then entirely the decision of the Client, i.e. WAPP and LEC.
- Meetings with various agencies: a number of meetings were held with various institutions and key persons (see list of meetings in Annex 23.1). Usually, these

meetings had two main objectives, namely, (i) to provide information on the project and the EISA/RAP process, and (ii) to obtain information of relevance for the project (e.g. on land use, public health, agriculture and/or procedural issues).

- Meetings with village authorities: the leaders of affected villages were visited by members of the consultant's staff on various occasions, again with the double aim of providing information (on the project as such and its likely impacts, on work undertaken for impacts assessment, etc.) and receiving information (on the situation of the affected villages, concerns related to the project, etc.).
- Field work: during field work of the various specialists involved in the preparation of the ESIA Report, contact with stakeholders, i.e. with the local population, was actively sought. A large number of discussions were held either in a formal way (structured interviews, group discussions) or in and informal way ("dropping by", "road side encounters"). So far, every house suspected to be located in the reservoir area, and therefore having to be removed, was visited, although in some cases the inhabitants have not been met on these occasions, since they were in the fields.
- Mass meetings: two mass meetings (palaver hut discussions) were carried out in the affected area to discuss the project and obtain preliminary feedback and concerns of the PAPs, the first one in Raymond Camp on 23rd of February and the second one in Arthington, Gbandi, on 5th of March, 2012 (see Annex 23.3 and 23.4). Since not everybody in the project area could participate, comments and suggestion forms have been distributed so that the people which were not able to participate had the chance to deliver their opinion in written form (see Annex 23.5).

With these meetings, encounters and discussions it was assured that by now all the people living in the area affected by the project are aware of it and know that they are, and will continue to be, involved in the process.

23.6 Next Steps

The public participation process is on-going. Most importantly, besides of continuing contacts to institutions, the contact to the PAPs is carried on in two main ways:

- direct contacts to affected communities and HH in the on-going preparatory work for the RAP (socio-economic survey of affected HH);
- upcoming public meetings in the project area for discussing the ESIA and related issues, as part of the official ESIA procedure.

This latter needs to be coordinated with and approved by EPA. Discussions in this respect are under way.

24 PROJECT ALTERNATIVES

24.1 Main Considerations

When considering pros and cons of the different alternatives, the following points have to be taken into account:

- The country needs electricity in order to cover present demand and to enable economic development in the future.
- Covering the demand, or at least a considerable part of it, by means of small diesel generators is expensive and not very environmentally friendly.
- Some of the structures of the former Mount Coffee Power Plant can be used (presumably power house, spillway and embankment dam or parts thereof).
- Environmental and social impacts of the Project are rather small, as is shown in this Report.

24.2 Alternatives

24.2.1 No Project

One option would obviously be not to rehabilitate Mt. Coffee HPP, i.e. to keep the present situation and/or to develop alternative energy supplies. Effects of this alternative are discussed briefly below.

24.2.1.1 Environmental Effects

The environmental impact of rehabilitating Mt. Coffee HPP are discussed and described in detail in this Report. Overall, it can be said that negative, i.e. undesirable impact of the Project are rather small, mainly due to the fact that the reservoir is quite small, that it does not have the capacity to modify river discharge pattern, and that it will only restore a situation that has been there already until 20 years ago. Furthermore, the impacts are rather easily manageable, if the proposed mitigation measures are implemented.

Conclusion: the environmental advantages of not implementing the project would be marginal.

24.2.1.2 Socio-economic Effects

Without recreating the reservoir, the people living presently in the area going to be submerged would not have to be resettled, and no compensation for fields lost to impoundment would have to be made.

As for the environment, the negative socio-economic impact is rather small. Only quite a small number of HH (approximately 107, to be confirmed), who moved into the reservoir area, or who moved back from their resettlement sites to their original places after the breaching of the dam, will have to be relocated. Cultivated land will be lost, and so will the other natural resources used on this 8 km² by the local population (mainly wood for charcoal production).

The details of compensation will be described in the RAP. However, it is already possible to say that resettlement and compensation can be done without any major problems. Enough land is available in the area surrounding the reservoir for enabling the local population to continue with their present life style. The RAP will define in detail the measures to be applied for preventing impoverishment of local HH in the short, medium and long term.

On the other hand, the project will bring considerable advantages to the project area and the local population, as e.g.

- improved access through upgrading of existing roads;
- creating jobs, mainly during the construction period;
- general boost of the local economy due to activities related to project implementation and operation;
- possibility of rural electrification.

Overall, from a socio-economic point of view, the advantages outweigh the negative impacts.

24.2.1.3 Effects on the Country as a Whole

Liberia is suffering from a severe power shortage. This does not only have a negative impact on the overall standard of living of the Liberian population, it is also a severe hindrance of development. Improvement in this respect is urgently needed.

The negative effects of this lack in energy can be seen mostly in three respects, namely:

- Deficiency of grid coverage. Presently, outside of Monrovia and a few small local grids there is no electricity supply at all. According to LESSP (2012), less than 12% of the population in Monrovia, and less than 2% of Liberia's rural population, presently has access to electricity. This, obviously, is a question of transmission and distribution and cannot be influenced or changed directly and immediately be Mt. Coffee HPP.
- Insufficient power supply: power cuts are frequent, and overall power supply is not sufficient. Here, Mt. Coffee will lead to a very considerable improvement of the situation, provided, of course, that transmission and distribution will be improved.
- Exorbitant costs for electricity. Presently, power tariffs are very high (reportedly as high as 0.52 USD per kWh), which puts a very heavy burden on HH budgets and on the economy of the country as a whole.

In this latter respect, Mt. Coffee will bring a very substantial improvement of the situation, as illustrated in the following Table.

Table 24-1: Energy generation costs from different sources

Energy source	Diesel	WAPP[1]	Mt. Coffee HPP
USD/kWh	0.32	0.17	0.10

Source: World Bank 2011

[1] WAPP interconneiction project making electricty available from Ivory Coast and Guinea

This shows quite clearly that diesel based electricity generation is expensive (and, given the recent development of fuel prices, expected to increase further). Again, Mt. Coffee would contribute very considerably to improving the situation.

24.2.2 Alternative Designs for Mt. Coffee HPP

Basically, there are two possibilities, namely:

- choosing a different site for the reconstruction of the dam and/or the power house, and
- choosing a different technology.

Concerning the first option, there is no different site available (except for choosing an entirely different project, as e.g. one of the other sites identified for the St. Paul river cascade). Furthermore, according to the Stanley Consultant's Reports (2012), some of the existing structures are still in good shape and can be used for the rehabilitation project. Therefore, considering a slightly different site would also not make sense from an economic point of view.

The Design Report (2012) of Stanley Consultants evaluates three alternatives for reconstruction of the breached part of the dam, namely:

- earthfill embankment dam (as the original one),
- roller-compacted concrete dam (RCC), and
- reinforced concrete buttress wall.

In addition, the possibilities of small changes in dam axis alignment for this part are evaluated.

The conclusion there is that, considering aspects of engineering, dam safety, availability of construction material and costs, the embankment dam is the preferred option.

From an environmental and socio-economic impact point of view, these alternatives would not change the project effects. For these reasons there is no preferred option to be recommended.

24.2.3 Increasing Installed Capacity to 80 MW

In the last phase of preparation of the ESIA, the possibility was discussed to increase the installed capacity of Mt. Coffee HPP from 66 to 80 MW. This option is discussed here briefly, whereby it has to be taken into account that there is no specific detailed feasibility study for it as yet. Therefore, the discussion is made under the following assumptions:

- No change in dam layout and dimensions, and mainly no increase in dam height.
- No increase in reservoir FSL; such an increase would potentially have, if at all feasible, major consequences on reservoir size and therefore on resettlement.
- No change in water availability (case without Via reservoir).
- The only major change would be to install four turbines with a capacity of 19.4 MW each instead of the ones with 16.5 MW.

This change in power house design would have two main effects, namely

1. an increase in power production, and
2. a change in water use.

The consequences of this second effect are summarised in the following Table; the values provided are estimates of the Consultant based on the increase in installed capacity and should not be taken as final and exact values. The figures in the Table as well as in the graphs below reflect the situation with the application of a residual flow of 8 m³/s as described and recommended in Section 8.2.3

Table 24-2: Effect of increasing the capacity from 66 to 80 MW

Item	Unit	Project	Alternative
Total installed capacity	MW	66	80*
Total electricity generated	GWh/year	357	432
Water output per turbine @ 100%	m³/s	85	103
Total water output (all units @ 100%)	m³/s	340	412
Water required for running 1 unit @ 40%*	m³/s	34	41
Time with spilling	%	47.0	42.7
Time with spilling	days / year	171	156
Time with max. 1 unit @ 100%	%	16.2	20.5
	days / year	59	75
Not sufficient water for 1 unit @ 40%	%	7.3	7.8
	days / year	27	28

* This is an increase of 21%. It is assumed that the other parameters vary by the same amount.

** 40% capacity was indicated as the minimum at which a 16.5 turbine can be operated. It is assumed that this is also the case for the 19.4 turbines.

The conditions are also illustrated in the following graphs. For a comparison with the 66 MW project, refer to Figure 8-4 and Figure 8-7. It

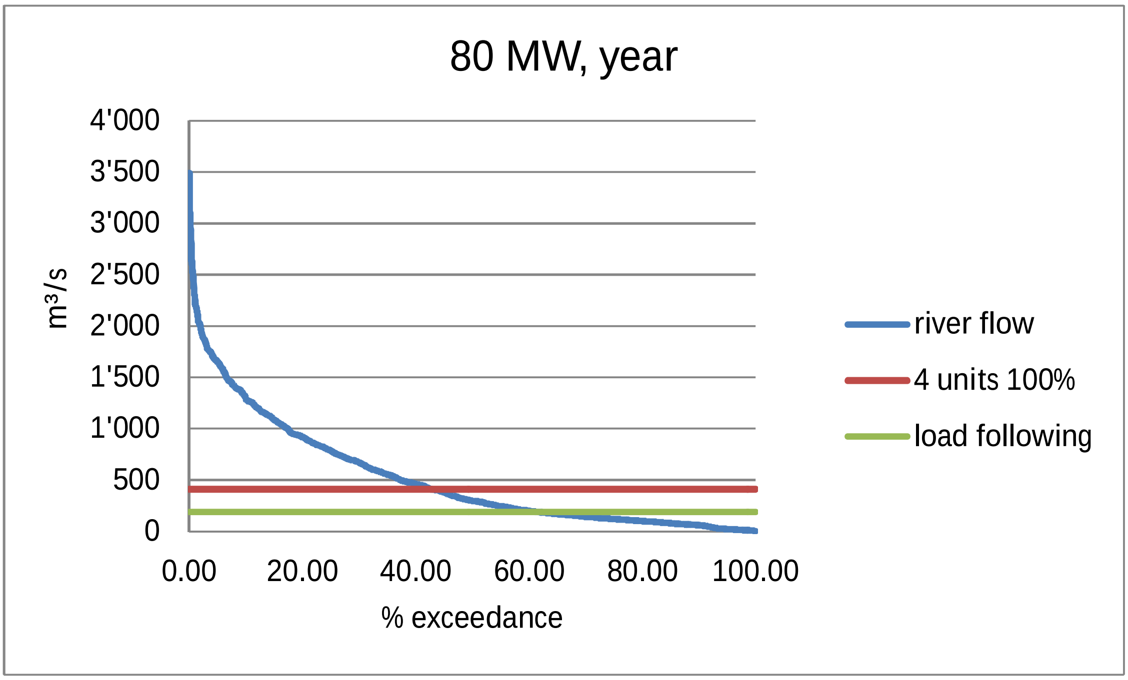


Figure 24-1: River flow and plant operating conditins, 80 MW

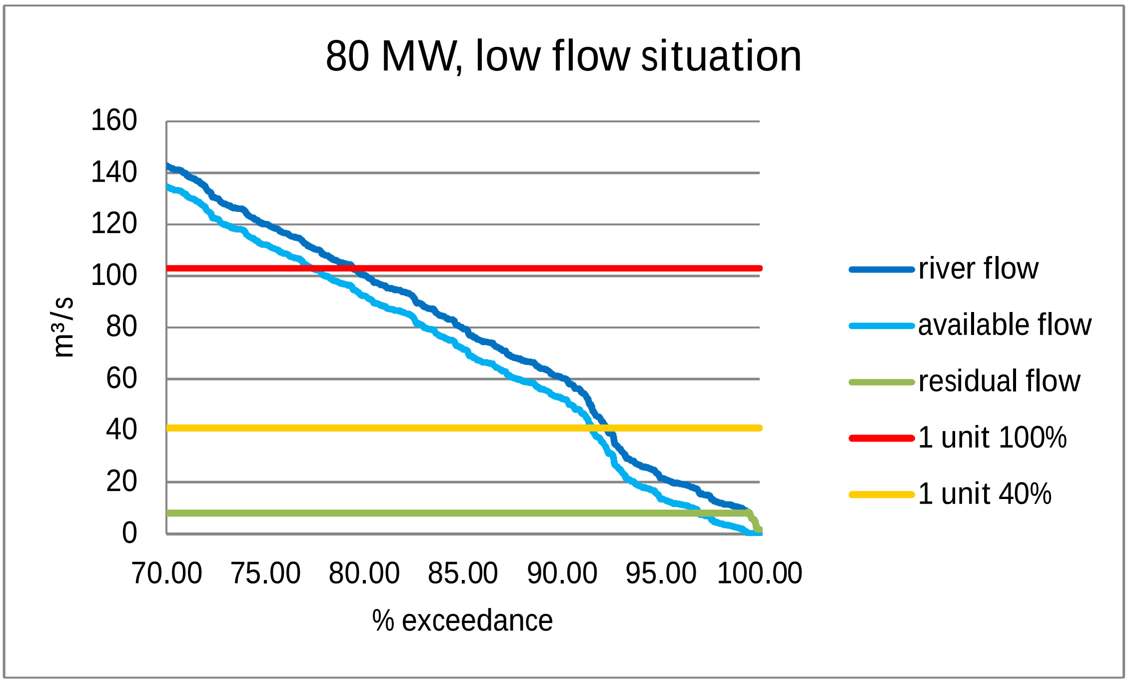


Figure 24-2: Plant operating conditions, 80 MW, low flow situation

The main consequences of this alternative, therefore, can be summarised as follows:

- There would be a considerable increase in electricity generation. The technical assessment of the project will have to determine if this increase justifies the increase in investment costs.
- The power plant would pass more water through the turbines, thus reducing the "loss" of spilling.

- The main consequence would be an increase in the average number of days per year (by 15, from 194 to 209) when there would be no spilling, i.e. when in the river between spillway and tailrace channel confluence there would only be the residual flow of 8 m^3/s left. However, this is not considered as being a major additional impact.
- The number of days with an insufficient water flow for operating at least one turbine at the minimum capacity of 40% would increase by 1, from 27 to 28; this is a marginal change.
- In the downstream area below the confluence of the main river with the tailrace channel the situation would not change, wince there the total amount of water flowing would remain unchanged.

It can therefore be concluded that from an environmental point of view there is no objection against this change in power plant dimensioning.

24.2.4 Alternative Energy Sources

Here as well, there are two main alternatives, namely (i) thermal power using fossil fuels, and (ii) alternative renewable energy sources.

24.2.4.1 Thermal Power

As mentioned above, presently most of the electricity in the country is generated in thermal (diesel fuelled) power plants. This is a high cost alternative, and therefore certainly not the way forward.

There is another aspect to be considered: the emission of GHGs. This is shown in the following Table, which assumes that the amount of electricity to be produced in Mt. Coffee HPP, 357 GWh annually, would be produced in thermal power plants using different types of fuel.

Table 24-3: GHG emissions from different fuels for producing 357 GWh/y

Fuel	Coal	Oil	Gas
fuel required (in t/year)	107'000	70'000	66'000
CO2 emission (t/year)	310'000	228'000	146'000

According to World Bank (2011: 31), there are no known hydrocarbon resources in Liberia. This means, first of all, that all fossil fuels have to be imported. The cost consequences are mentioned above.

In addition, generating electricity based on fossil fuels also causes very high GHG emissions. From an environmental point of view, substituting Mt. Coffee with thermal power would certainly not be the preferred option.

24.2.4.2 Renewables

Presently, LESPP has four projects for generating electricity from renewable resources, shortly illustrated in the following Table.

Table 24-4: Renewable electricity projects

Type	Installed capacity	Supply to	Observations
Mein River Mini Hydro	1 MW	>3000 consumers	potential for 1.5 MW; electricity "at less than half the current cost"
Wayavah Falls Micro Hydro	15 kW	150 HH	
Sorlumba Biomass Electricity Project	35 kW	200 HH	Fuel: crude palm oil
COCOPA Biomass Electricity Project	240 kW	4700 HH, 1 hospital	Fuel: rubber tree woodchips; estimated tariff 0.3-0.35 USD/kWh

Source. LESSP, direct communication 2012-04-23

From these few examples, it becomes quite evident that project of this type can be solutions especially for remote areas, for which it is unlikely that they will be connected to a main grid in the short or medium term. However, they cannot really be considered as an alternative to Mt. Coffee or other medium to large sized hydropower projects).

24.3 Conclusions

The main conclusion from this evaluation is that the rehabilitation of Mt. Coffee, as currently planned, is the preferred option from an environmental and social point of view. The benefits from this Project by far outweigh its negative impacts, and the evaluated alternatives are less advantageous.

25 ECONOMIC EVALUATION

25.1 Objective and Approach

25.1.1 Objective and Scope

The project to be considered under the present assignment (the Project) is the rehabilitation of the Mount Coffee Hydropower Plant (MCHPP). This project can shortly be described as follows:

- located on the St. Paul River, approximately 27 km northeast of Monrovia, in Montserrado County;
- dam with gated spillways, forebay dams, forebay canal, intake structure, penstocks, powerhouse designed to accommodate 6 vertical Francis units, tailrace canal, substation and transmission line;
- two units (installed 1966) of 15 MW each, and two units (installed 1972) of 17 MW each, total installed capacity 64 MW.
- designed as Run-of River (ROR) scheme;
- small reservoir with limited storage and regulating capacity;
- lowermost dam in a planned cascade of a total of 5 dams, the others going to be storage dams with large reservoirs.

Within the frame of the preparation of an Environmental and Social Impact Assessment (ESIA) and the preparation of a Resettlement Action Plan (RAP), the Terms of Reference of the Contract requires that an economic assessment of the rehabilitation project has to be carried out.

This assessment shall consider the following points:

- the project alternatives under discussion
- the present energy supply situation of the country
- the energy requirement forecasts, as far as available
- aspects of economy (including, but not limited to energy costs
- estimated construction duration
- environmental and social effects
- the no-project case (i.e. the present situation without rehabilitation of the power plant).

25.1.2 Data Base

25.1.2.1 Preliminary Remarks

Numerous studies concerning the power situation in Liberia and the Mount Coffee Hydropower Plant have been carried out in the last years. For the present evaluation of the MC HPP data have been collected in Liberia and from the internet.

The collected data can be grouped in the following categories:

- General economic framework of the country
- Power market
- Liberia Electricity Company
- Mount Coffee Hydropower Plant.

25.1.2.2 General Economic Framework of the Country

To obtain an understanding of the general economic framework existing now and expected to prevail in the near future in Liberia, the following reports were consulted:

- Liberia Economic Recovery Assessment, US Aid, January 2008
- Liberia Poverty Reduction Strategy 2008-2012
- Republic of Liberia: Abridged Budget Framework Paper, Ministry of Finance, March 2011
- Central Bank of Liberia, Annual Report 2011, January 2012
- Liberia Poverty Reduction Strategy, Final Report, June 2008-December 2011, February 2012
- Liberia Economy Profile 2012, Globserver, March 2012
- Liberia Investment Climate Statement 2011, 2012, Government of United States.

25.1.2.3 Power Market

The following documents were reviewed to get a picture of the power market of Liberia:

- Liberia: National Energy Sector White Paper, February 2007
- Liberia: National Energy Policy: an Agenda for Action and Economic and Social Development
- Liberia Infrastructure: A Continental Perspective, World Bank, March 2011
- Options for the Development of Liberia Energy Sector, The World Bank, October 2011.

25.1.2.4 Liberia Electricity Company

From the Liberia Electricity Company (LEC), the following documents were obtained:

- LEC Electric Master Plan, March 2011
- LEC Tariff Policy, March 2011
- LEC Year 2 (July 2011-June 2012) Investment Plan, April 2011
- LEC Monthly Status Report to the board of Directors, February 2012.

25.1.2.5 Mount Coffee Hydropower Plant

The firm Stanley Consultants has been and is still involved in technical studies related to the rehabilitation studies of Mount Coffee Hydropower Plant. The following two reports have been studied:

- Technical and Financial Feasibility Study for the Reconstruction and Expansion of the Mount Coffee Hydropower Facility in Liberia, Final Report, December 2008
- Design Report, Final, February 2012
- Feasibility Study Review Report, Final, February 2012.

25.1.3 Approach

The economic analysis carried out for the project of the rehabilitation of Mount Coffee Hydropower Plant consists of the following main steps:

- Summary of the relevant main characteristics of the to be rehabilitated Mount Coffee Hydropower Plant
- Definition of the macro-economic framework, within which the rehabilitated hydropower plant will operate
- Estimation of the existing and future electricity demand of the city of Monrovia and of Liberia
- Description of the existing electricity supply system and identification of the future electricity supply options
- Computation of the electricity demand, which can be covered by the rehabilitated Mount Coffee Hydropower Plant
- Determination of the best alternative to the project rehabilitation of Mount Coffee Hydropower Plant
- Examination of the financial aspects of the operation of the Liberia Electricity Company, among others costs and revenues (tariffs)
- Realization of the economic analysis, taking into account the characteristics of the project framework derived in the preceding steps of the study.

The review of the documents mentioned under Section 1.2 indicated how to set up the to be performed economic analysis and provided the basis to define the values of the parameters required for the economic analysis.

25.1.4 Content and Organization of the Chapter

The organization of the present report is directly related to the sequence of steps of the approach described in the preceding section.

Accordingly Chapter 25.2 deals with the presentation of the various issues concerning the rehabilitation project of Mount Coffee Hydropower Plant.

Chapter 25.3 “Power Market” presents all the issues, which define the framework, within which Mount Coffee Hydropower Plant is expected to operate. The issues covered are the macro-economic situation of Liberia, the actual and future demand for electricity, the existing and planned electricity production system and the tariffs.

Chapter 25.4 describes the approach followed to perform the economic analysis and summarizes the obtained results.

The Report ends with Chapter 25.5 Conclusions and Recommendations.

Short and summary tables are included in the main text. Detailed tables are grouped in the Annex 25.

25.2 Mount Coffee Hydropower Plant

25.2.1 Stanley Consultants' Study 2008

The firm Stanley Consultants completed in December 2008 the Technical and Financial Feasibility Study for the Reconstruction and Expansion of the Mount Coffee Hydropower Facility. This study is very comprehensive and covers all the topics normally pertaining to a feasibility study, from project optimization to financial and economic analysis.

In the next paragraphs, the technical characteristics and parameters of the proposed project relevant for the present study are summarized.

Given the characteristics of the situation in Liberia prevailing at the time of the preparation of the feasibility study, Stanley Consultants proposed the following three-step process to meet internal demands for electricity:

- First Step: Rehabilitate Mount Coffee Hydropower Plant, with four turbines with a total installed capacity of 66 MW and construct a new storage reservoir near the confluence of the St. Paul and Via Rivers (Via Storage Project) to firm up the energy production
- Second Step: Implement Stage 1 developments at Projects SP-1B and SP-2. These projects would be sized to take full advantage of the storage provided by the Via Project
- Third Step: Implement the much larger "Ultimate" Via Storage Project, Project SP-4 and Hydroelectric Project V-1.

Most relevant for the present study is the rehabilitation of Mount Coffee Hydropower Plant. Via Storage Reservoir Project and the Projects SP-1B and SP-2 on the St. Paul River will also be considered, where appropriate.

The capacity installed at Mount Coffee Hydropower Plant will amount to 66 MW, with and without the Via Storage Project. For the average electricity production, Stanley Consultants retained the following figures:

- Without Via Project: 342 GWh
- With Via Project: 435 GWh.

A summary of the probable project costs obtained by Stanley Consultants is given in the following table, in million US $:

Table 25-1: MCHPP Rehabilitation, total project cost

Project Name	Mount Coffee HPP	Via Storage Project	Total
Total cost	162	221	383

The costs of the project are expressed in US $ of 2008. They include all the project components, administration, contingencies, indirect costs, taxes and import duties.

Stanley Consultants estimated that the project could be realized in four and a half years and proposed the following annual investment requirements, in million US $:

Table 25-2: MCHPP Rehabilitation, annual investment requirements

Project	2008	2009	2010	2011	2012	2013	Total
Mt Coffee	1	30	33	62.5	33.5	2	162
Via	1	22	33	82.5	82.5	0	221
Total	2	52	66	145	116	2	383

25.2.2 Study Options for the Development of Liberia’s Energy Sector

The paper “Options for the Development of Liberia’s Energy Sector” was completed in October 2011 for the International Bank for Reconstruction and Development. Its purpose was to show options for the supply of electricity to Liberia. Accordingly a Least-Cost Energy System Expansion for the Period 2010 to 2040 was developed.

For the preparation of this system expansion plan, about a dozen options were studied. The rehabilitated Mount Coffee Hydropower Plant and a few other hydropower projects to be located on the St. Paul River formed some of the considered options.

The technical and economical characteristics of the considered hydropower plant options were taken over from the Stanley Consultants Feasibility Study of 2008 and are:

Table 25-3: Considered HPP options, technical and economic characteristics

Project Name	Capacity	Energy	Capital Cost
	MW	GWh	Million US $
Mount Coffee	66	342	162
Mount Coffee + Via storage	66	435	383
SP-1B +SP-2 + Via storage	198	1’960	879

St Paul-2 (SP-2) project is located on the St Paul River 60 km downstream of the planned Via Reservoir. It will produce 1’330 GWh. St Paul-1B (SP-1B) will be located 40 km downstream of SP-2 and will produce 630 GWh.

The capital costs shown in the preceding table are expressed in 2008 US $. For the development of the least cost expansion plan, these costs were updated to the year 2009 and discounted to the year 2010 with a discount rate of 12%.

25.2.3 Stanley Consultants Studies Completed in 2012

After the year 2008, Stanley Consultants have been involved in further studies for the rehabilitation project of Mount Coffee Hydropower Plant. Among others, the amount of energy produced was recomputed using a weekly time step, the design was optimized and a new cost estimate was prepared. These new results are documented in reports published in February 2012.

The studies concluded in the year 2012 concern only the rehabilitation of Mount Coffee Hydropower Plant. The project Via Storage is not mentioned any more.

The new power plant operation studies led to a mean annual production of 357 GWh instead of 342 GWh, the installed capacity being equal to 66 MW. The new total cost of the project amounts now to 178 million US $.

25.2.4 Characteristics of the Project Considered in the Present Study

The characteristics of the Mount Coffee Hydropower Plant Rehabilitation Project applied in the present study are based on the figures proposed in Stanley Consultants' studies completed in early 2012.

Accordingly, a mean annual energy production of 357 GWh was considered and the total construction cost, including all the outlays, was taken equal to 178 million US $.

25.3 Power Market

25.3.1 General Framework

25.3.1.1 Liberia Poverty Reduction Strategy (PRS)

After several years of civil war, Liberia has been at peace since 2003. A new government has been put in place in January 2006 and has introduced a strong set of policy reforms to spur the reconstruction and the development of the country.

The Poverty Reduction Strategy was based on the following four pillars:

- Expanding peace and security
- Revitalizing the economy
- Strengthening governance and the rule of law
- Rehabilitating infrastructure and delivering basic services.

Lack of electricity generation was found to be a main constraint in the energy sector and as one of the main constraints to overall economic revitalization.

During the implementation of the PRS, the following issues in the energy sector were addressed:

- Provision of electricity to some sectors of Monrovia and rehabilitation of the network
- Completion and publication of the national energy policy and master plan
- Further expansion of the Monrovia grid and beginning of the expansion of the grid to other cities

- Development of hydropower production (rehabilitation of Mount Coffee HPP).

Substantial progress has been achieved since the year 2006, but there is still a long way to go.

25.3.1.2 Recent Economic Developments

The country's economic growth has been helped by the impressive reconstruction and aid donors since the end of the civil war in 2003. Some statistics related to the economic activity are summarized in the following table:

Table 25-4: Liberia: some economic indicators

Year	2004	2005	2006	2007	2008	2009	2010	2011
GDP, million US $	530.9	559.0	602.6	659.2	706.0	719.3	743.6	772.8
Real GDP Growth. %	2.6	5.3	7.8	9.4	7.1	4.4	7.7	8.6
CPI Inflation, %	3.6	6.9	7.2	11.4	17.5	7.8	5.0	5.3

The macro-economic indicators of the preceding table show the progress made in the past years by the economy of the country.

The sectorial contributions to the Real Gross Domestic Product of Liberia in the fiscal Year 2009/2010 were as follows, in per cent:

- Agriculture and fisheries, 42.34%
- Services, 30.21%
- Forestry, 15.67%
- Manufacturing: 10.05%
- Mining and quarrying: 1.74%.

Currently the Liberian Dollar is exchanged at 73.50 Liberian Dollar to the US $.

25.3.1.3 Expected Future Developments

There is a growing investor interest in Liberia. Accordingly the Liberian Government expects strong levels of growth in the upcoming years. In the Abridged Budget Framework Paper of the Ministry of Finance of March 2011, the average overall GDP growth was estimated to be of the order of 8.6%, most of the growth coming from the Mining & Panning Sector. Without the Mining Sector, the mean GDP growth would still amount to 5.0%.

The expected future strong development of the economy of Liberia has of course important consequences for the demand for electricity.

25.3.2 Existing Power Market

25.3.2.1 Institutional Set-up

By the end of the civil war in 2003, the power sector had been seriously damaged. The reminder was destroyed by looting until 2005. The new government elected in 2006 has been working toward the reconstruction of the electricity sector at the urban, rural and regional levels.

In 2007, a Renewable Energy and Energy Efficiency Policy and Action Plan were published by the government of Liberia. In 2009, a National Energy Policy (NEP) was formulated, which further developed the ideas of the Policy and Action Plan. NEP defines as principal objective of the national policy the universal access to modern energy services in an affordable sustainable and environmentally-friendly manner, in order to foster the economic, political and social development of the country.

By law, the Liberia Electricity Corporation (LEC) has the franchise for providing power to the country. With the help of an emergency program, the operations of LEC were resumed and basic electricity supply in Monrovia was restored. LEC is managed by a joint venture between Manitoba Hydro International and Kenyan Power and Light Corporation on the basis of a five-year Management Contract (MC). MC has started 1st July 2010 and ends by 30 June 2015.

25.3.2.2 Current Situation

LEC is currently a very small entity serving approximately 2’500 residential and small commercial and industrial customers. The installed capacity of LEC amounts to 23 MW Diesel power. All the generating units are located in or near Monrovia. There is no generation capacity outside of Monrovia beyond privately-owned generators and scattered donor-funded pilot projects.

LEC’s electricity production infrastructure consists of four High Speed Diesel (HSD) generating stations in the areas of Paynesville (2x0.3 MW), Congo Town (2x1.0 MW), Kru Town (5x1.0 MW) and Bushrod Island (15x1.0 MW) and a number of 22 kV feeders serving areas around and between the Generating Stations.

A 66 kV sub-transmission line tying all four stations together has been recently commissioned and all generation is now supplied from Bushrod Island.

25.3.2.3 Electricity Generation

Complete statistics on the amount of energy produced could not be obtained. In the present situation with only one generating plant, this type of information is anyhow of limited value.

In the month of February 2012, the maximum demand reached 8.60 MW. In the same month, 4’235 MWh were produced, while the corresponding figure for the month of January was 4’509 MWh. A very preliminary computation indicates that in the Fiscal Year 2011-2011 the amount of energy generated was of the order of 30’000 MWh.

25.3.2.4 Electricity Sold

Complete statistics on electricity sales could neither be obtained. The amount of sales can be computed using the statistics of power distribution losses prepared by LEC.

Power distribution losses are the sum of technical and non-technical losses. The total losses are calculated as the difference between the total kWh generated and the total kWh billed. In the month of February 2012 the total losses amounted to 21.2%. According to LEC computations, the cumulated non-technical losses in the Fiscal Year 2011-2012 reached 9.3%.

25.3.2.5 Electricity Cost

The numbers given hereafter have been taken from the Monthly Status Report prepared by LEC for the month of February 2012.

According to this Report, the total operating costs of LEC amounted in the month of February to 1.619 million US $, of which 1.389 million US $ represented the fuel costs.

Between July 2011 and February 2012, the total operating cost per unit sold varied, on a monthly basis, roughly between 48 and 60 US cents per kWh. In February, the total operating cost per unit sold was 49.5 US cents per kWh.

For the same period, the total generation cost per unit sold varied between 40 and 52 US cents per kWh. In February, the generation cost per unit sold was 42.2 US cents per kWh.

The plant efficiency varied, on a monthly basis, between 12.50 and 12.84 kWh per Gallon in the period extending from July 2011 to February 2012. In February this efficiency reached 12.81 kWh per US Gallon.

LEC paid in February 2012 4.20 US $ per Gallon.

25.3.2.6 Tariffs

LEC has developed a model to compute the tariffs at which the generated electricity has to be sold. The calculated tariff for the third quarter of the Fiscal Year 2011-2012 under the agreed methodology is approximately 54.0 US cents per kWh.

This tariff is based on the following assumptions:

- Forecasted monthly sales 3’182 MWh
- Distribution losses 18%
- Collection rate 93%
- Fuel price 4.20 US $ per Gallon.

If the duty relief on fuel had been given, the calculated tariff would be 51.1 US cents per kWh.

On the advice of LEC management, and in the absence of any fuel duty relief, the Board decided to leave the tariff at 54 US cents per kWh while instabilities in distribution and collection efficiencies are tackled, and until the duty relief is fully implemented.

25.3.3 Future Power Market and Supply

25.3.3.1 Preliminary remarks

Essentially the following documents were reviewed:

- Mount Coffee Hydropower Plant, Technical and Financial Feasibility Study, Stanley Consultants, December 2008
- LEC Electric Master Plan, March 2011
- Options for the Development of Liberia Energy Sector, World Bank, October 2011

The reports so far published by Stanley Consultants in the year 2012 do not address explicitly issues related to the future power market of Liberia and are hence not mentioned in the present section.

The following points are of interest in the present study:

- The magnitude of the expected future demand for electricity
- The options considered to cover the additional demand
- The identified preferred options.

The review of the three reports will be focused on these issues.

25.3.3.2 Stanley Consultants Report December 2008

In the Stanley Consultants Report, the maximum demand and the energy requirements for the Monrovia area were assumed to develop as follows:

Table 25-5: Greater Monrovia area, maximum demand and energy requirements

	Unit	2015	2020	2025	2030	2035	2040
Peak	MW	69.0	85.0	102.0	124.0	153.0	191.0
Energy	GWh	273.8	321.9	373.1	440.8	525.4	635.4

In their economic and financial analyses Stanley Consultants estimated that the energy produced by Mount Coffee HPP could be used as follows, all numbers in GWh:

Table 25-6: Use of the energy produced by MCHPP

	2015	2020	2025	2030	2035	2040
Mt Coffee, prod	435.0	435.0	435.0	435.0	435.0	435.0
Sales to Monrovia	273.8	321.9	373.1	435.0	435.0	435.0
Sales to Others	161.2	113.1	61.9	0	0	0

According to the figures shown in the preceding table, the complete amount of energy produced by Mount Coffee Hydropower Plant can be immediately used. In the first years after the completion of the hydropower plant, the energy requirements of the Monrovia area are smaller than the amount of energy produced by Mount Coffee Hydropower Plant. The excess amount of energy produced is assumed to be sold either to mines or exported to neighbour countries.

The-30 year (2012-2041) levelized cost and rate tariff computed by Stanley Consultants are as follows:

- Cost recovery requirements (LEC cost): 11.1 US cents/kWh
- Tariff (to end-use customers): 14.8 US cents/kWh.

To perform the economic analysis, a coal power plant was considered by Stanley Consultants to be the best competitor.

25.3.3.3 LEC: Electric Master Plan March 2011

Context, Approach and Constraints

The LEC Electric Master Plan (EMP) covers both the period of the five year Management Contract with Manitoba Hydro International and the period beyond. The Management Contract sets strict annual targets on customer connections in Monrovia. The EMP details expenditures and capital additions to transmission, distribution and generation in order to meet the Management Contract targets, shows what connection targets can be met and considers the risks of slippage in committed generation components.

Two planning horizons are considered: the 5 years of the Management Contract, which are covered in detail and a less detailed 20 year load forecast and investment outlook. The uncertainties in the latter are very high, among others because there is a lack of detailed feasibility and cost assessment of the longer term generation options.

The Management Contract objectives are focused on improving access to electricity, primarily for low income households, and on creating a financially and technically sustainable municipal electric utility. Planning for the electrification of Monrovia had to consider these objectives.

Several constraints had an impact on the preparation the EMP. The most important ones were:

- Limited amount of investment funds
- Availability of generation facilities
- Service area limited to greater Monrovia; no consideration of other communities or rural areas
- Access to electricity for low income households
- Radial build-out of transmission and distribution capacities. The sequence of service extension is influenced by the location and capacity of existing infrastructure as well as by the location of priority customer classes
- Lack of skilled LEC staff.

The following sections deal with the load forecast, the considered supplied options and the studied capacity expansion scenarios.

Load Forecast

The load forecast was prepared for the Greater Monrovia area including 49 distinct communities. It is based on the following assumptions:

- Load factor: 0.70
- Diversity factor: 90%
- Losses: 12%.

For the period of the Management Contract, the following three scenarios were prepared:

- Scenario A1: Constrained Transmission and Distribution Funding and Committed Generation
- Scenario A2: Constrained Transmission and Distribution Funding and Committed Generation, Slipped
- Scenario A3: Unconstrained Transmission and Distribution Funding and Generation.

Scenario A1 is the Base Case. It meets the Management Contract requirements and demonstrates that the set objectives can be met with the available funds and committed generation.

For the period covering the year 6 to the year 20 the main assumptions were:

- Funding for Transmission and Distribution by the donor community to continue but decreasing annually until 2020. Thereafter self-finance by LEC
- From 2020 onward level of investments in Transmission and Distribution tied to GDP growth forecasts.

The computed maximum peak demands are in MW:

Table 25-7: Greater Monrovia area, maximum demand forecasts

Scenario	Qualification	2015	2030
Scenario A1	Base Case	47.8	174.8
Scenario A2	Slipped	33.0	-
Scenario A3	Slipped new gene.	75.1	202.2

For the Long Term Load Growth Forecast, as an alternate method to compute the future demand, an access rate to electricity of 70% was postulated. This led for the Greater Monrovia area to a maximum peak demand of 450 MW in round figures in the year 2030.

Considered Energy Supply Options

A detailed review of the possible types of electricity generation sources was carried out for the preparation of the EMP. Finally the following options were retained to determine the capacity expansion plan of the LEC system:

- Imports of power from the West Africa Power Pool (WAPP)
- Additional Diesel generation
- Heavy Fuel Oil (HFO) generation
- Buchanan Renewable Power (BRP) project (with biomass)
- Mount Coffee rehabilitation.

The Management Contract states a capacity of 18 MW for the imports from the WAPP through the Côte d'Ivoire-Liberia-Sierra-Leone- Ghana (CLSG) interconnection project.

For the HFO option, a unit size of 5 MW was used for the planning exercise. For the BRP project a capacity of 31 MW at the plant was selected.

The Mount Coffee Hydropower Project was considered without upstream storage. The following two alternatives were introduced in the capacity expansion programming:

- Two turbines, installed capacity 34 MW and mean annual energy production 211 GWh
- Four turbines, installed capacity 66 MW and mean annual energy production 342 GWh.

The options based on further hydropower developments of the St Paul River Basin, the coal, wind and solar energy were discarded for various reasons.

Twenty Year Generation and Demand Scenario

For the five year term of the Management Contract the best near-term generation options were evaluated. The options studied were:

- Scenario B1: Mount Coffee Hydropower Plant staged with traditional financing
- Scenario B2: HFO plants, staged to meet the demand
- Scenario B3: BRP plant
- Scenario B4: Mount Coffee Hydropower Plant with special financing.

Levelized 6-10 year and year 6-20 tariffs were computed. The obtained results are shown in the following table, in US cents/kWh:

Table 25-8: Electricity supply options B1 to B4, levelized tariffs

Scenario	Lev Tariff Yrs 6-10	Lev Tariff Yrs 6-20
B1: Mount Coffee, traditional financing	13.8	20.6
B2: HFO plants, staged	28.3	34.8
B3: BRP plant	22.9	30.6
B4: Mount Coffee, special financing	18.8	26.8

The Mount Coffee Hydropower Plant project has the lowest levelized tariffs.

Five scenarios C1 to C5 were prepared for the 20 year planning horizon. They were:

- Scenario C1: Committed Generation and Mount Coffee special financing

- Scenario C2: Committed Generation, Slipped and Mount Coffee Special Financing
- Scenario C3: Unconstrained Transmission and Distribution Funding and Generation Additions and Mount Coffee Special Financing
- Scenario C4: Unconstrained Transmission and Distribution Funding and Committed Generation, Slipped and Mount Coffee Special Financing
- Scenario C5: Committed Generation and BRP and Mount Coffee Special financing.

Mount Coffee Hydropower Plant and HFO plants are included in all the five analysed scenarios. The EMP provides only capacity balances for the five scenarios. No other results are included in the EMP.

25.3.3.4 World Bank: Options for the Development of Liberia Energy Sector, Oct. 2011

Context

The report "Options for the Development of Liberia Energy Sector", which was published in October 2011, is the most recent document giving a complete view of Liberia's energy sector, which was available for the preparation of the present study. As such, it includes the findings of the reports reviewed in the preceding sections.

This report has identified options for the development of Liberia's energy sector. The objective was to enable the people of Liberia to gain access to electricity in a cost effective manner.

Relevant for the present study are the following topics:

- The demand for electricity
- The possible energy supply options
- The generating options proposed to close the medium-term and the long-term gap.

These three topics will be reviewed in the next sections.

Liberia's Projected Electricity Demand 2010-2040

The purpose of the report "Options for the Development of Liberia Energy Sector" was to assess the demand for electricity for the whole country. For this purpose the following geographical and sectorial demand segments were defined:

- Segment 1: Monrovia electrical on-grid demand
- Segment 2: Other anticipated on-grid demand
- Segment 3: Urban and rural off-grid demand
- Segment 4: Non-Monrovia industrial demand.

A bottom-up approach was applied to determine the demand for electricity. For all four segments a low-growth and a high-growth scenario were evaluated. The report describes in great detail the approach followed and the applied assumptions.

The results obtained for the Slow Growth Scenario are for the demand, in MW:

Table 25-9: Total capacity demand in Liberia, Slow Growth Scenario

Segment	2010	2015	2020	2030	2040
Monrovia	18.66	34.30	41.98	63.15	127.28
Total on grid	19.02	36.00	103.49	159.15	268.93
Total off grid	17.48	75.84	198.26	338.61	471.09
Total Liberia	36.51	111.84	301.75	497.76	740.02

For the energy demand, the following results were obtained for the Slow Growth Scenario, in GWh:

Table 25-10: Total energy demand in Liberia, Slow Growth Scenario

Segment	2010	2015	2020	2030	2040
Monrovia	117.46	216.89	268.70	553.18	1’114.95
Total on grid	120.44	231.25	652.00	1’154.48	2’008.09
Total off grid	109.80	477.79	1’234.83	2’114.79	2’961.29
Total Liberia	230.24	709.13	1’886.83	3’269.27	4’969.37

For the High-Growth Scenario the obtained results are in MW:

Table 25-11: Total capacity demand in Liberia, High-Growth Scenario

Segment	2010	2015	2020	2030	2040
Monrovia	19.66	54.50	75.58	149.99	417.78
Total on grid	20.10	108.47	189.67	378.05	678.50
Total off grid	17.69	131.07	354.18	604.63	841.12
Total Liberia	37.79	239.54	543.86	982.68	1’519.62

For the energy demand, the following results were obtained for the High-Growth Scenario, in GWh:

Table 25-12: Total energy demand in Liberia, High-Growth Scenario

Segment	2010	2015	2020	2030	2040
Monrovia	123.59	340.75	474.74	1’313.94	3’659.73
Total on grid	127.48	682.17	1’187.69	2’744.10	5’333.61
Total off grid	111.62	830.19	2’206.51	3’788.08	5’343.42
Total Liberia	239.10	1’512.36	3’394.20	6’532.17	10’677.03

Liberia's Energy Supply Options 2010-2040

The report "Options for the Development of Liberia Energy Sector" has identified the following energy supply options for the period 2010-2040 for Liberia:

- Diesel
- Leasing Diesel
- Heavy Fuel Oil (HFO)
- Biomass
- Hydropower
- West African Power Pool Transmission Interconnection for Côte d'Ivoire, Liberia, Sierra Leone and Guinea (WAPP CLSG).

Basically the generation options retained in the World Bank report are similar to the ones mentioned in the Electric Master Plan of LEC.

For the generation option hydropower, the following projects were considered:

- Hydro 1, Mt Coffee phase 1, without Via Reservoir, 66 MW
- Hydro 2, Mt Coffee and Via Reservoir, 66 MW
- Hydro 4, SP-1B and SP-2 and Via Reservoir, 198 MW
- Hydro 3: Mano River, 90 MW.

For the imports of electricity the following four options retained are:

- WAPP phase 1 Low, 28 MW
- WAPP phase 2 Low, 23 MW
- WAPP phase 1 High, 50 MW
- WAPP phase 2 High, 47 MW.

Least Cost Energy System Expansion in the Medium and Long Term

The medium-term covers the period 2009-2015 and the long-term, the complete period 2010-2040.

The WAPP CLSG interconnection project is expected to be operational at the earliest in the year 2015. According to the calculations done in the Report "Options for the Development of Liberia Energy Sector", a gap in the supply-demand balance would appear, starting in the year 2012. It is proposed to eliminate this gap by adding HFO generating units and in the year 2015 the WAPP CLSG would supply the additionally required capacity and energy.

To determine the least cost energy system expansion in the long-term (2010-2040), the standard approach usually applied in such a case was followed. The selected model determines the overall production cost for any additional capacity installed over time, subject to meeting the growing demand, the power plant constraints and the required reliability levels. The capital and operating cost of each supply alternative are combined and discounted to obtain a net present value of all the costs incurred over the period 2010-2040 for each studied least-cost generation expansion scenario. The generation expansion scenario presenting the lowest net present value of cost is then considered as the most attractive one.

To determine the least-cost energy system expansion the following main assumptions were applied:

- Period of study: 2010-2040
- Time step for the computations: 5 year
- All the costs and benefits were discounted to the beginning of the calendar year 2010
- All the economic figures were expressed in US $ of 2009
- A discount rate of 12% was used.

The least cost energy system expansion was computed for the Slow-Growth and the High-Growth Scenario. A large number of sensitivity analyses were carried out. For the present study however, only the results obtained for the Base Case are given in the continuation.

The following power plants, respectively sources of energy, have to be commissioned in the period 2010-2040 in the Slow-Growth Scenario:

- Diesel
- HFO
- WAPP
- Hydro Mount Coffee
- Hydro St Paul
- Hydro Mano.

The options Leasing Diesel and Biomass were not considered.

Mount Coffee Hydropower Plant with the alternative 36 MW has to be commissioned in the year 2015, while the option Saint Paul is expected to start its operation in the year 2020.

The average generation cost for this capacity expansion scenario varies between 14.0 US cents /kWh and 11.0 US cents/kWh over the considered time horizon.

The following power plants, respectively sources of energy, have to be commissioned in the period 2010-2040 in the High-Growth Scenario:

- Diesel
- Leasing Diesel
- HFO
- WAPP
- Hydro Mount Coffee
- Hydro St Paul
- Hydro Mano.

The option Biomass was not considered.

Mount Coffee Hydropower Plant with the alternative 66 MW has to be commissioned in the year 2015, while the option Saint Paul is expected to start its operation in the year 2020.

The average generation cost for this capacity expansion scenario varies between 17.0 US cents /kWh and 15.0 US cents/kWh over the considered time horizon.

25.3.3.5 Comments

The just reviewed three studies present a high degree of homogeneity in what concerns the future demand of electricity, the described generation options and the proposed capacity expansion plans. Of course differences in some issues have been noted between the three reports. These differences are however either a consequence of the latest developments recorded in Liberia or concern issues which are not that much relevant for the present study. Under these circumstances the comments given in the following paragraphs are based on the results of the Report "Options for the Development of Liberia Energy Sector".

Two important issues for Mount Coffee Hydropower Plant project are:

- Amount of energy produced by this plant

How much of this production can be absorbed by the LEC system in the first say 5 years of operation of the plant?

When will the entire production of this plant be needed by the LEC system?

- Is Mount Coffee really the next best option?

The Mount Coffee Hydropower Plant project, which does not include the development of the Via Reservoir, has an installed capacity of 66 MW and its average annual energy production amounts to 357 GWh.

The following table recalls the key results of the demand forecast (Slow-Growth Scenario) shown in the Report "Options for the Development of Liberia Energy Sector" for the on grid system (Great Monrovia area and others located in the vicinity of the grid):

Table 25-13: Liberia on grid demand 2015 and 2020, Slow-Growth Scenario

	Unit	2015	2020
Maximum demand	MW	36.00	103.49
Annual energy	GWh	231.35	652.00

The level of demand forecasted for the period 2015-2020 and onward is such that one can assume that the entire production of Mount Coffee Hydropower Plant can be absorbed by the LEC grid within a few years after the commissioning of the hydropower plant.

Conservative estimates indicate that about 80% of the energy produced by Mount Coffee hydropower plant can be absorbed by the LEC grid in the first year of operation of the power plant and that the full production is needed in the fifth year of operation.

For the second issue, namely whether Mount Coffee Hydropower Plant project is really the next best generation option, the Report “Options for the Development of Liberia Energy Sector” provides a table giving Total Levelized Cost (in US cents/kWh) for the studied generation options. The next table shows some related relevant figures:

Table 25-14: Supply options for Liberia and cost estimates

Generation option	Capacity	Capital Cost	Levelized Cost
Unit	MW	Million US $	US cents/kWh
Mount Coffee	66	162	10.0
HFO	10	15	16.0
WAPP, phase1 Low	28	160	17.0
WAPP, phase2 Low	23	160	11.0

The figures of the preceding table call for the following comments:

- Mount Coffee shows the lowest levelized cost
- The levelized cost for electricity import phase 2 is attractive; the figures quoted for the two phases are however very preliminary and the timely availability of this energy is not yet guaranteed
- Finally the levelized cost for HFO is surely underestimated, since the price of oil has risen since the preparation of the report.

Mount Coffee Hydropower Plant project is an attractive option according to the just quoted figures. There are however two disadvantages, which are not adequately shown by the levelized tariff. First Mount Coffee has a large size as compared to the incremental demand of the LEC system during the period 2015-2020. Second it requires a large upfront investment. Especially this last point is critical.

25.4 Economic Analysis of the Project

25.4.1 General

The present chapter deals with the economic analysis of the Mount Coffee Hydropower Plant Rehabilitation Project. The chapter begins with a presentation of the cost parameters used to perform the analysis. Then follows the determination of the returns resulting from the operation of the power plant. These data are finally used to perform the economic analysis. The chapter concludes with some comments on the obtained results.

The economic analysis focuses on the costs of the project and the benefits of it which accrue to a community, a nation or a group of nations. Typically, prices are adjusted to reflect border prices for internationally traded goods and services and all transfer payments, subsidies, taxes etc. are excluded. The objective of this analysis is the calculation of the Economic Internal Rate of Return (EIRR) and the Net Present Value (NPV) of the project.

The economic analysis is generally carried out for constant or real prices (no consideration of inflation). In the present case, US Dollars at 2012 level were used. All the costs and benefits were compared over a period of operation of 50 years, which corresponds to the average economic life of a hydropower plant. For the Base Case a discount rate of 10% was used.

25.4.2 Costs

25.4.2.1 Investment Cost

According to the latest report prepared by the firm Stanley Consultants, the total construction cost for the rehabilitation of the Mount Coffee Hydropower Plant is equal, in round figures, to 178 million US $. This amount includes all the costs incurred for the implementation of the rehabilitation of Mount Coffee Hydropower Plant.

In the economic analysis, as was mentioned in Section 4.1, all transfer payments, subsidies, taxes have to be excluded. Stanley Consultants estimated that taxes and duties represented a sum of 13.50 million US $. That means that the investment cost to be considered for the economic analysis is equal to 164.1 million US $.

The distribution of the investment cost over the construction period is as follows, in million US $:

Table 25-15: MCHPP Rehabilitation Project, distribution of cost

Year	-4	-3	-2	-1	1
Percentage	14.60	17.00	37.90	30.10	0.40
Amount	23.959	27.897	62.194	49.394	0.656

25.4.2.2 Annual Operation and Maintenance Cost

The annual operation and maintenance cost covers the following outlays:

- Operation and maintenance
- Renewals, respectively replacement
- Insurance
- General and administrative.

Usually for hydropower projects, the annual operation and maintenance cost is related to the corresponding investment cost. In the present analysis, it was assumed that the annual operation and maintenance cost is equal to 1% of the investment cost. This percentage takes into account the type and size of the Mount Coffee Hydropower Plant.

Hence in the present study, the annual operation and maintenance cost was taken equal to 1.641 million US $.

25.4.3 Revenues

25.4.3.1 Preliminary Remarks

Amount of electricity produced and value of the kWh define the revenues to be attributed to the Mount Coffee Hydropower Plant Rehabilitation Project. These two parameters will be defined in the following sections.

25.4.3.2 Energy Production

Stanley Consultants proposed in the report published in the end of February 2012 a new estimate of the average annual amount of energy produced by the rehabilitated Mount Coffee Hydropower Plant.

The revised mean annual energy production is equal to 357 GWh, taking into account a constant riparian release requirement equivalent to the "7-day 10-year streamflow".

In the present study, it was assumed that in the first year of operation 80% of the mean annual energy production could be sold. In the following years, this percentage increases in steps of 5% to reach 100% in the fifth year. This gives the following values, in GWh:

Table 25-16: MCHPP, annual sales in the first five years of operation

Year	1	2	3	4	5
Annual production	285.60	303.45	321.30	339.15	357.00

25.4.3.3 Value of Energy Produced

Approach

The unit value of the electricity generated is defined as the unit generation cost of the next best option to the Mount Coffee Hydropower Plant Rehabilitation Project.

On the basis of the results shown in the Report "Options for the Development of Liberia's Energy Sector", a HFO thermal power plant can be considered as the next best alternative to the Mount Coffee Hydropower Plant Rehabilitation Project.

The unit cost of electricity generated by a HFO thermal plant with an installed capacity of 10 MW was taken in this report as the measure of the value of the energy produced by Mount Coffee Hydropower Plant Rehabilitation project.

The following cost components, respectively factors, must be considered to compute the unit cost of the electricity generated by the HFO thermal plant:

- Discount rate
- Investment cost
- Technical duration of life
- Load factor

- Specific fuel consumption
- Fuel cost
- Operation and maintenance cost.

The various relevant cost components are derived in the next sections.

Capital Cost

The review of the information available on the magnitude of the investment cost for a HFO thermal plant indicated that a value of 1’300 US $ per kW installed was a good preliminary estimate for the required specific investment cost. If one assumes that the economic life of such a plant is 30 years and the load factor is equal to 7’000 hours per year, the following capacity costs per kWh generated are obtained:

- Discount rate 8%: 1.650 US cents per kWh
- Discount rate 10%: 1.970 US cents per kWh
- Discount rate 12%: 2.306 US cents per kWh.

Fixed and Variable Annual Operation and Maintenance Cost

For the annual operation and maintenance costs, the following values were retained:

- Variable 0.450 US cents per kWh
- Fixed: 0.143 US cents per kWh
- Total: 0.593 US cents per kWh.

Fuel Cost

Fuel prices have been recently very volatile. Quite generally these prices experienced a strong decline in the second quarter of 2012.

For the present economic analysis, a HFO price of 650 US $ per ton was selected, the corresponding WIT barrel price being of the order of 85 US $.

If one assumes an average specific fuel consumption per kWh generated of 180 gr, a fuel cost of 11.70 US cent per kWh generated is obtained. For the sensitivity analysis, an increase of 25% of the fuel cost was applied, which led to a unit cost of 14.625 US cents per kWh.

Unit Value of the Energy Produced

The next table sums up the results obtained in the preceding sections for the selected three discount rates of 8%, 10% and 12%, in US cents per kWh:

Table 25-17: HFO thermal power plant, production cost

Cost component	**8%**	**10%**	**12%**
Investment	1.650	1.970	2.306
Fixed O & M	0.143	0.143	0.143
Variable O & M	0.450	0.450	0.450
Sum without fuel	2.243	2.563	2.899
Fuel , base case	11.700	11.700	11.700
Total, Fuel base case	13.943	14.263	14.599
Fuel, +25%	14.625	14.625	14.625
Total, Fuel +25%	16.868	17.188	17.524

For the economic analysis, the values of the preceding table were rounded off. Accordingly, the following rounded figures were used for the value of the electricity generated by Mount Coffee for the three discount rates 8%, 10% and 12%, in US cents per kWh:

Table 25-18: Value of the electricity generated by MCHPP

Fuel price	**8%**	**10%**	**12%**
Base case	14.00	14.25	14.50
Fuel price + 25%	17.00	17.25	17.50

25.4.4 Results of the Economic Analysis

25.4.4.1 Studied Cases

The economic analysis was carried out for various cases. A Base Case and a few sensitivity cases were defined.

For the Base Case, the following parameter values were applied:

- Discount rate: 10%
- Project cost: amount estimated by Stanley Consultants (February 2012)
- In the first five year of operation, progressive increase of the amount of energy sold.

For the Sensitivity Cases, the parameter values were varied as follows:

- Discount rate: 12% and 8%
- Amount of energy sold: 100% starting from the first year
- Construction cost: +25%
- Fuel cost: + 25%.

25.4.4.2 Discount Rate 10%

The next table summarizes the results obtained for a discount rate of 10%:

Table 25-19: Discount rate 10%, results of the economic analysis

Case			NPV	EIRR	Prod cost
Constr. cost	**Fuel price**	**Full prod in**	**Mio US $**	**%**	**US cts/kWh**
100%	100%	Year 5	193.729	21.68	5.89
100%	100%	Year 1	207.686	23.07	5.66
125%	100%	Year 5	159.640	18.08	7.36
100%	125%	Year 5	263.221	25.18	5.89

The percentage numbers for the construction cost and the fuel price refer to the Base Case. A percentage of 125 means that for the sensitivity analysis the value of the relevant parameter has been increased by 25% as compared to the Base Case.

Year 5 indicates that the full production is sold starting from the fifth year of operation of the hydropower plant; Year 1 that the full production is sold starting from the first year of operation of the hydropower plant.

The details of the computations are shown in Annexes 25 (Annex 25.1 to 25.4).

25.4.4.3 Discount Rate 12%

The following table summarizes the results of the economic analysis for a discount rate of 12%:

Table 25-20: Discount rate 12%, results of the economic analysis

Case			NPV	EIRR	Prod cost
Constr. cost	**Fuel price**	**Full prod in**	**Mio US $**	**%**	**US cts/kWh**
100%	100%	Year 5	132.098	21.99	7.13
100%	100%	Year 1	144.875	23.40	6.81
125%	100%	Year 5	100.121	18.35	8.92
100%	125%	Year 5	185.892	25.46	7.13

The details of the computations are shown in Annexes 25 (Annex 25.5 to 25.8).

25.4.4.4 Discount Rate 8%

The following table summarizes the results of the economic analysis for a discount rate of 8%:

Table 25-21: Discount rate 8%, results of the economic analysis

Case			NPV	EIRR	Prod cost
Constr. cost	**Fuel price**	**Full prod in**	**Mio US $**	**%**	**US cts/kWh**
100%	100%	Year 5	287.162	21.38	4.73
100%	100%	Year 1	302.438	22.74	4.58
125%	100%	Year 5	250.547	17.82	5.91
100%	125%	Year 5	380.067	24.90	4.73

The details of the computations are shown in Annexes 25 (Annex 25.9 to 25.12).

25.4.5 Comments

The results of the performed economic analyses indicate that for all the studied cases (Bases Case and Sensitivity Analysis):

- The Net Present Value is positive
- The Economic Internal Rate of Return is higher than 17%
- The cost of the generated electricity comparatively low.

As a summary, the rehabilitation of the Mount Coffee Hydropower Plant is an economically attractive project.

25.5 Conclusions and Recommendations

25.5.1 Summary of the Results

Within the frame of the preparation of the Environmental and Social Impact Assessment (ESIA) and the preparation of a Resettlement Action Plan (RAP), an economic analysis of the Mount Coffee Hydropower Plant Rehabilitation Project was carried out.

For this purpose the latest information and reports were collected in Liberia, documenting the conditions prevailing in the power market of Liberia and the main features of the Mount Coffee Hydropower Plant Rehabilitation Project.

The review of the collected material showed that Liberia is in an urgent need for electricity. Under these circumstances and taking into account that the implementation of the Mount Coffee Hydropower Plant Rehabilitation will take four to five years, one can expect that within a short period of time the complete production of Mount Coffee Hydropower Plant can be absorbed by the consumers of Liberia.

The various possible other options to supply the growing need for electricity were identified and compared. Mount Coffee Hydropower Plant and HFO thermal power plant turned out to be the most promising options.

To perform the economic analysis updated information (end of February 2012) on the Mount Coffee Hydropower Plant Rehabilitation Project could be obtained. Especially relevant were the mean annual energy production and the construction cost.

The value of the energy generated by Mount Coffee Hydropower Plant was taken as equal to the unit cost of electricity produced by a HFO thermal plant.

The economic analysis was performed for the Base Case with a discount rate of 10% and for various Sensitivity Cases. For the sensitivity analysis, discount rates of 12% and 8% were used, the construction cost increased by 25% and the fuel cost (HFO) raised also by 25%. For all the cases studied, the Net Present Value (NPV) was always significantly higher than zero. The Economic Internal Rate of Return (EIRR) was higher than 17% and the unit cost of the generated electricity, below 9.5 US cents per kWh.

Under these circumstances Mount Coffee Hydropower Plant Rehabilitation Project is surely economically a very attractive option for the supply electricity to the Greater Monrovia area. This conclusion is in line with the ones drawn in the reviewed previous studies.

25.5.2 Carbon Credits

Before ending the present report, two points still need to be mentioned. They are the Carbon Credits issue and the issue of the funding of the project.

Liberia is a signatory to the Kyoto Protocol and a party to the United Nations Framework Convention on Climate Change (UNFCCC).

Mount Coffee Hydropower Rehabilitation Project will displace greenhouse gas emissions. The displaced greenhouse gas emissions correspond to those emissions that would have been produced from fossil fuel generated power plants, in case Mount Coffee Hydropower Plant was not rehabilitated. Consequently Mount Coffee Hydropower Plant Rehabilitation project is eligible under the UNFCCC Clean Development Mechanism (CDM) for potential carbon financing.

This fact has not been taken into account so far in the present study. It is recommended to apply for such credits. This will provide some funds upfront for the implementation of the rehabilitation of the hydropower plant as well annual revenues during the period of operation of the hydropower plant.

25.5.3 Project Funding

One important issue of the implementation of Mount Coffee Hydropower Plant Rehabilitation is the funding of the Project.

The cost of the Mount Coffee Hydropower Plant Rehabilitation amounts to 178 million US $. Not included in this number are the cost escalation during construction, interest during construction and the financial cost. If one adds these costs, the magnitude of required funds easily exceeds 200 million US $. Usually about 30% of this amount or about 60 million US $ are required as equity.

Currently LEC’s annual total budget for investment that is for power generation, transmission and distribution is of the order of 10 million US $. The comparison of LEC’s current annual budget for investment to the required equity shows clearly that the funding of Mount Coffee Hydropower Plant Rehabilitation is a critical issue.

One approach to solve this issue is to resort to Public Private Partnership (PPP) models for the implementation of Mount Coffee Hydropower Plant Rehabilitation Project.

PPP models are contractual arrangements between public (government and their implementing agencies) and private power developers, construction companies, power plant operators and investors, who all have some interest in a particular element of the design, construction, financing, ownership and operation of the asset.

PPP structures allow for greater private sector participation in the delivery of public infrastructure projects. There are numerous models for PPP. The model finally selected for a particular project must be tailored to the conditions prevailing in the concerned country. To be successful a certain number of conditions have to be met by the selected PPP model. Some of these conditions are favourable investment climate, new policy frameworks and regulation, favourable equity arrangements, secured revenues, positive technical performance.

Hence the structuring of a PPP is not an easy task. However, if realized in an appropriate way, it can be beneficial for all the parties involved. It is recommended to consider this option for the implementation of Mount Coffee Hydropower Plant Rehabilitation.

26 EMERGENCY ACTION PLAN

26.1 Risk Assessment

26.1.1 Causes of Rupture of Embanked Dams

There are three causes of rupture of an embanked dam:

1. Natural causes: The natural causes that can rupture a dam are:
    a. Seismic activities that can weaken the foundation of the construction work;
    b. Out-of-season rainfall that can cause unexpected floods that are far above the estimated dimensioning in the proposed feasibility studies prior to the construction of the dam ;
    c. Landslide: of the foundation or support structures to the construction work, or a massive landslide into the reservoir which could trigger a wave that would overtop the dam. In the case of Mt. Coffee, this can be largely excluded, since there are no steep, landslide-prone slopes present around the reservoir.
2. Human Causes: Man can directly or indirectly cause a dam to rupture in the following ways:
    a. By error of measurement either due to lack of know-how or ineffective supervision of the project;
    b. By operating, monitoring or maintenance error;
    c. By malicious intent (terrorism, sabotage).
3. Technical causes: The main technical causes are:
    a. Disfunctioning of the floodgate causing outflow of water during floods.
    b. Faulty conception plan, wrong materials or more so faulty construction ;
    c. Ageing of the facilities.

26.1.2 Types of Rupture of Embankment Dams

The rupture of a dam can take place in two ways: (i) by internal erosion or (ii) by overflow. The way a dam ruptures depends on the specific characteristic of that dam.

Studies indicate that in 38% of cases, the rupture is caused by overtopping of the dam (Johnson et Ills 1998). Such a situation arises if the amount of water considerably exceeds the design flow for which the structures were dimensioned.

The water overflowing the dam causes «erosion heads» near the bottom of the embankment, which then run upstream right up to the dam crest.

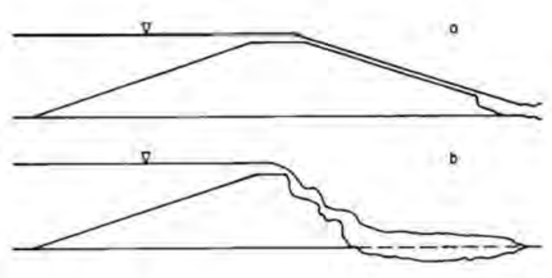


Figure 26-1: Overflow and erosion of an embankment dam

Source: Powledge and al, 1989b

Subsurface erosion is caused by weathering of the dam material by permeating water. This takes place in many ways, for example: suffusion, piping. It begins downstream and proceeds towards upstream. The increase in the percolation rate and of the velocity of flow continuously increases erosion of the dam materials or the foundation. When finally a part of the dam gives way, this leads to the formation of a breach.

The final width of the breach that is formed can be in the order of magnitude of 5 to 10 times the height of the dyke. In the case of the MC dam, the height of the embankment is 18 m, therefore a breach of a width of 90 to 180 m could be assumed (note: in the case of MC dam, this hypothesis can be checked, since it was breached already 20 years ago).

Still, the rupture of an embankment dam is a rather slow process in comparison to the breaking of a concrete structure, and therefore less dangerous. It gives more time for taking measures, like lowering the reservoir level by opening the spillways, and alerting the population in the endangered downstream area. Likewise, the increase in river discharge is, while still being rapid, gradual and not a massive surge wave.

The linear shape of the MC dam and its shallow depth (in fact, it is a long dyke) makes complete rupture of the dam impossible. The common type of risk of rupture envisaged on this type of dams is the gaps in the impoundment. The rate of outflow will therefore be equal to a partial or complete opening of the spillway gates.

The upstream villages around the reservoir would not be affected by dam rupture; on the other hand, all the settlements downstream of the dam just bordering on the river will suffer a more or less rapid rise of the water level depending on the distance from the dam. This excessive rise in water level can cause partial or complete flooding of villages, and accidents to persons close to or on the river, as well as loss of material and property.

26.1.3 Prevention and Protection Strategies

26.1.3.1 Dimensioning of the Dam

The most important prevention measure is the dimensioning of the dam, which will have to be done in a way as to minimise the risk of a dam break.

Evaluations of the dam break risk situation were made in Stanley Consultant's Dam Safety Report (Draft, February 2012).

26.1.3.2 The Dam Breaching Event of 1990

An analysis of the consequences of the breaching which occurred in 1990 could provide indications on the type of effects to be expected in such an event, which in turn could be valuable information for the design of the Disaster Preparedness Plan that will have to be prepared. However, no information describing the effects of this event has been found. Given the situation of the country at that time, this is not surprising.

26.1.3.3 Warning Systems

In any case, it will be necessary to have an information and warning system combined with very slow opening of the gates and slow water flow increase to allow people to escape from the river. Danger zones inside the reservoir near the intake and flood gates needs to be secured preventing people (fishermen) to have access to these zones (500 m downstream and 1000 m upstream of the dam site). Mechanical and electrical equipment should also be fenced to protect people. An organisation which is in charge of this warning system, the dam monitoring and the handling of the emergency situation has to be implemented.

26.1.4 Effect of Dam Breaching

The Dam Safety report mentioned above also provides a preliminary analysis of the immediate effects of a breaching of the dam. According to this report, the maximum flood wave resulting from such an event would be reduced to less than 0.6 m approximately 3 km below the dam. No infrastructure and no houses are located in immediate vicinity of the dam along this part of the river.

This has been analysed in more detail by Stanley Consultants who carried out a modelling of changes in water level due to dam failure for different scenarios. The scenarios were a dam failure during an event of PMF (Probable Maximum Flood) and fractions of PMF (0.75, 0.5, 0.4 and 0.2) and a case called "sunny day", i.e. assuming overtopping and breaching of the dam in conditions of normal to low flow in the river. the results are illustrated and commented shortly below.

The Figures show:

- differences in maximum flood elevation in the case of a dam breach during a PMF event or floods of a fraction of PMF;
- the same situation with the additional "sunny day" case; and
- maximum flood elevations without and with dam failure for two cases, namely, PMF and "sunny day".

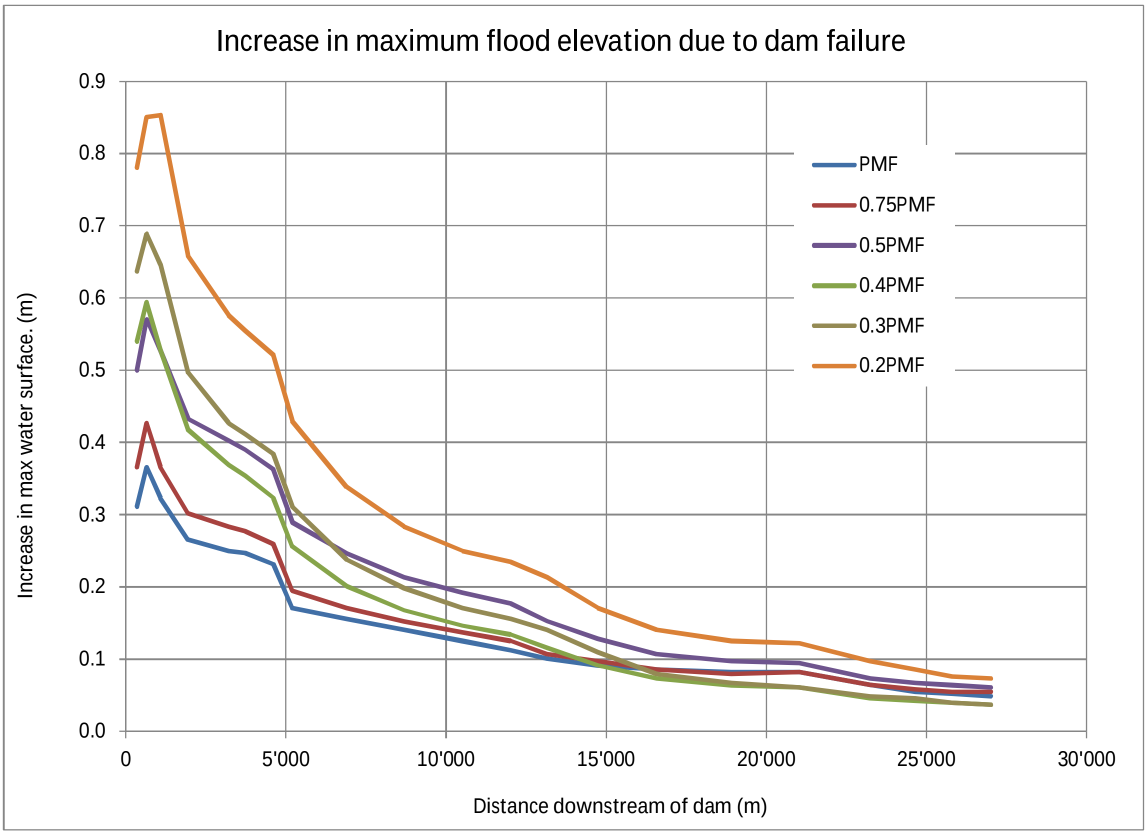


Figure 26-2: Difference in maximum flood elevation during flood events

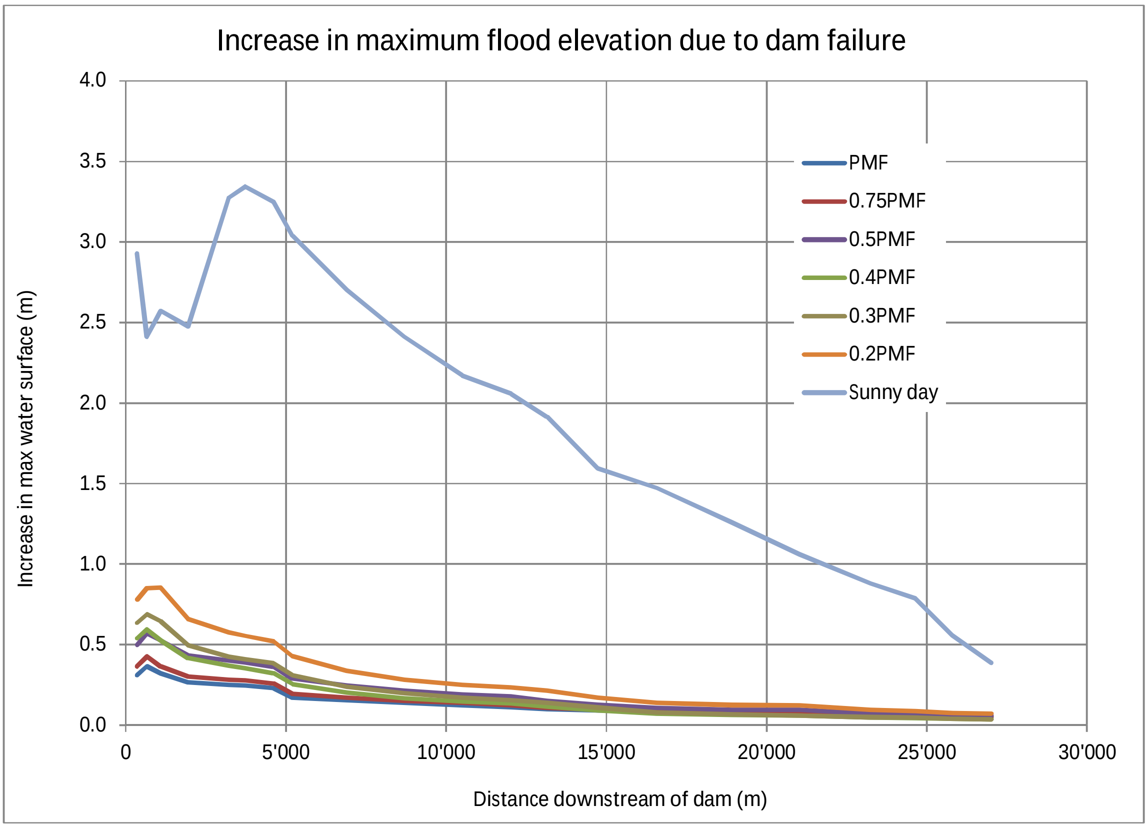


Figure 26-3: Difference in maximum flood elevation: sunny day

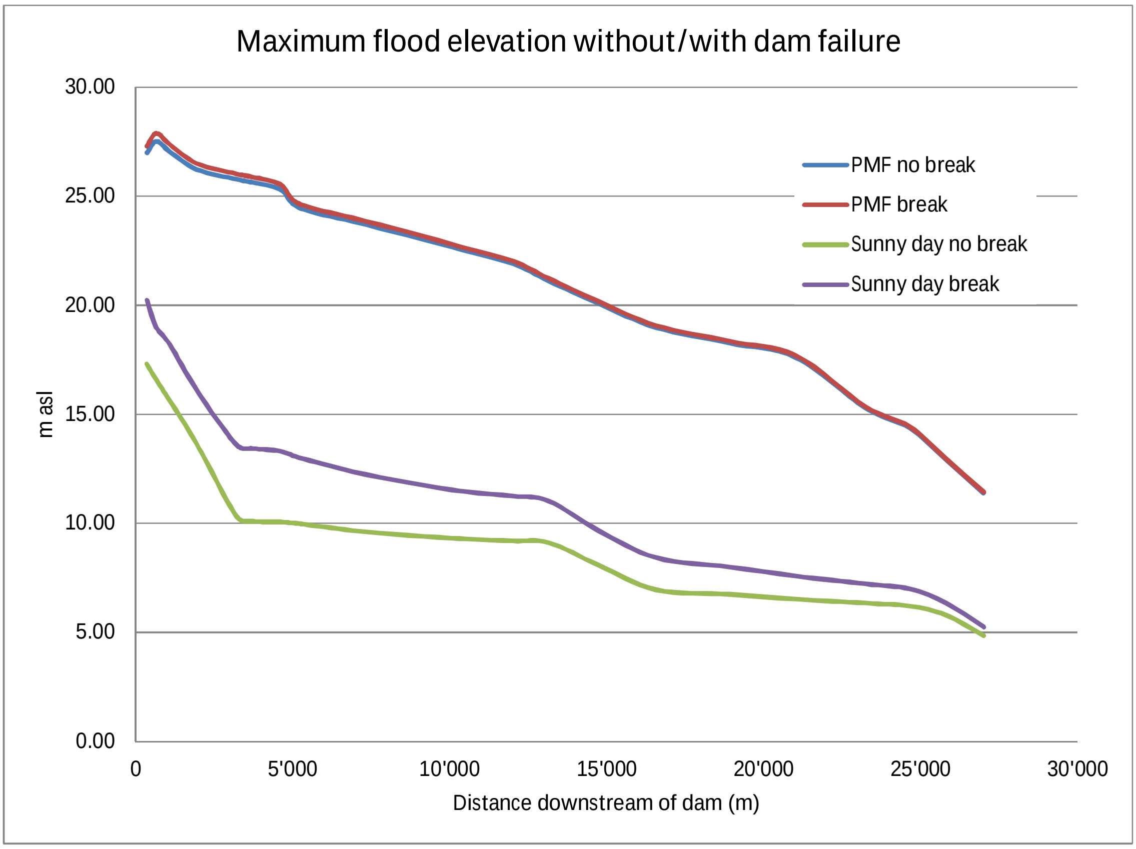


Figure 26-4: Maximum flood elevation without and with dam failure

Source for Figures 26-2 to 26-4: Stanley Consultants

The Figures show the following:

- Dam failure increases flood elevation rapidly, and this then is reduced quickly further downstream.
- The higher the flow (or the flood), the smaller is the increase in flow level due to dam failure; this is explained mainly by the higher flow velocity and the larger surface at higher levels.
- In the case of a flood event (Figure 26-2), the maximum increase in flood level due to dam failure would be reached immediately below the dam, and it would be less than 1 m (and only 37 cm in the case of PMF). At about 4 km d/s of the dam, this increase would have been reduced to less than 0.5 m, decreasing further towards downstream.
- In the "sunny day" scenario, increase, i.e. difference between the without and with breach case would be much higher, reaching a maximum of nearly 3.5 m just below the dam; it would still be about 3 m at a distance of 5 km below the dam, i.e. in the area of the confluence of the river with the tailrace channel (Figure 26-3).
- This, however, would occur at an elevation which is far lower than the one reached during PMF, as is shown in Figure 26-4. This Figure, which compares the PMF with the "sunny day" case also shows that during a flood event water levels would be very high (and probably causing damage), while the difference

without and with dam brake is marginal. In the case of lower river flows however (the "sunny day" case), the difference caused by a dam brake would be much more marked, but the maximum level attained would be far beyond flood levels (with or without dam break). In such a case, the flood caused by a dam break could be contained within the river banks.

27 DECOMMISSIONING PLAN

27.1 Present Situation

Mt. Coffee HPP presents, in a way, a rather unique situation in that it is a reconstruction of a plant that existed already. It is not a scheme to be newly developed, but at the same time it is much more than a rehabilitation of an existing project, given the state of the remaining structures.

At present, there are mainly three parts which still exist, namely:

- The spillway: the gates are not in working order, but the structure is still in place.
- The power house: it has been completely striped of all equipment, only the concrete shell of the building remains.
- The embankment dam: it was breached close to the power house, but large parts of it still exist.

Rehabilitation of existing and/or replacement of missing structures is being defined in the technical study (prepared by Stanley Consultants). According to first discussions with them and their preliminary reports (February 2012), the remaining structures are in a good state and can probably be used for rehabilitating or rebuilding the power plant. Details remain to be clarified.

27.2 Final Decommissioning

Normally, the expected operating life for dam projects is about 50 years. However, if the quality of construction and maintenance of the structures is good, the dam and plant can last much longer. Some dams and power plants have been in operation for 100 years.

The end of the operating life of a dam is usually signalled by the fact that the structures, particularly the dam, have reached an age where their safety can no longer be guaranteed. Once this stage is reached, the concerned structures should be removed. There are generally two main options, either (i) to remove the structures (dam, plant and ancillary structures) so as to, if possible, restore the original situation, or (ii) to replace the structures, the dam in particular, in order to continue operations with a new plant.

The option eventually chosen will depend on the situation at that time (technical considerations, state of the site and the plant, economic situation, energy supply, environmental considerations, etc...), which cannot be predicted now. Currently, experiences with the dismantling of hydro structures are few, and there is nothing that could be considered as "normal procedure" in these cases. For these reasons, opportunities and key points to consider are illustrated by a recent example: the case of the Rheinfelden plant.

The Rheinfleden hydroelectric plant was built in the 1890s on the River Rhine, which forms the border between Switzerland and Germany, about a hundred km downstream from Lake Constance. It was a run-of-rive scheme, part of a cascade of 11 hydroelectric plants between Lake Constance and the city of Basel, with a dam 18 m high and an installed capacity of 25.7 MW.

All the structures were regularly monitored and well maintained. In the 1980s, these controls revealed that the condition of the foundations of the dam indicated the approach of the end of the operating life of this structure. It was therefore necessary to either remove or replace dam and plant. Extensive studies were then conducted to carefully assess the various options (technical studies, EIA: EWI 1987). These studies were designed to identify the best solution, which would then be implemented from 2000 to 2006.

In addition to technical considerations, both economic and financial (cost of decommissioning work with or without replacement of structures, power generation), the most important points to consider were environmental issues:

- Landscape: In over 100 years of existence of the reservoir, the surrounding landscape, including the developed and inhabited zones, had adapted to a "lake" situation; lowering the water level by about ten metres (and more in the vicinity of the dam) would cause a significant change in this situation.
- Sediment: thanks to the great lake of Constance and the other reservoirs upstream of the dam, the amount of sediment that had accumulated in the reservoir was relatively small and did not in any way affect the continuous operation of the plant. Nevertheless, the dismantling of the dam without replacement would have meant mobilizing these sediments. Now, there was a risk that these sediments could contain unknown amounts of harmful substances, the result of industrial activities for a period of almost 50 years upstream of the dam. As long as the sediments were still in place, these substances did not constitute a risk, but mobilising the sediments would have necessitated preventive measures (excavation and disposal on land of these substances), which would have been very costly.

The solution adopted in this case, taking into account the considerations described briefly, involved the construction of a new dam and power plant a hundred metres downstream of the existing dam, which was then removed. With this solution, energy production could be maintained and even increased significantly (installed capacity of the new plant: 100 MW), and the situation in the reservoir area (water level and thus the landscape, sediment) remained unchanged. The construction started in 2006, and the new plant was commissioned in 2010.

In the case of Mount Coffee power plant, when the time comes, a similar procedure will have to be followed, with a detailed analysis of the options. It will certainly be necessary to carry out technical feasibility studies, and as with the construction, to prepare an ESIA for the dismantling or replacement of the dam. Just like in the case of Rheinfelden, the issue of sediments will be something to consider, among others. According to the available technical studies, sedimentation is not of major concern in the Mount Coffee reservoir. Depending on the development of the cascade (with the large Via storage reservoir and additional dams and power plants between it and Mt. Coffee) sediment input to the latter could still be further reduced. Nevertheless, it is obvious that over an operation period of 50 to 100 years still a large amount of sediment will be accumulated in the reservoir, which would be transported downstream should the dam be removed. This could cause serious problems downstream of the site, e.g. for the fauna (fish), water use (like drinking water intakes) and the estuary (mangroves). This will have to be evaluated carefully, taking into account the situation at that moment.

28 CUMULATIVE IMPACT ASSESSMENT OF ST. PAUL RIVER DEVELOPMENT

28.1 Scope

This Chapter provides an assessment of cumulative impacts of the planned hydropower cascade on Mount Coffee River. The assessment is done entirely based on available documentation and information. No site visits to or specific field work for the three planned reservoirs upstream of Mt. Coffee HPP were carried out.

28.2 The St. Paul River Cascade

A short description of the cascade was provided in Section 3.7. For easier reference, the figure providing an overview of the cascade is reproduced here.

Figure 28-1: St. Paul River Drainage Basin including the HPP Developments.

Source: provided by LEC during Kick-off-Meeting

Project Name	Stage 1	Stage 2
Mount Coffee	66 MW	122 MW
SP-1B	78 MW	143 MW
SP-2	120 MW	220 MW
Via	---	132 MW
Total:	264 MW	617 MW

The cascade to be used as a reference for the CIA still needs to be defined. Presently, there are mainly two descriptions, one provided in the Main 1982 reports, the other from the Stanley 2008 report. The latter focuses on the “Optimal” Mt. Coffee Development

(Stage 1 above), as opposed to the "Ultimate" one (Stage 2 above). The main difference between these two is the size of the Via reservoir. Since this, from an environmental point of view, is a very decisive parameter, data from the Main 1982 reports are used for this preliminary assessment.

As just mentioned, the Via reservoir is a decisive feature of the cascade. It is a large reservoir which will provide storage and regulating capacity for the entire cascade. Since the catchment of this dam, the Via River, is rather small, Stage 2 development foresees the construction of an additional dam, SP-4, u/s of the confluence of St. Paul River with Via River; this (rather small) reservoir will be connected with the Via reservoir by a channel, and water will be diverted to this large storage reservoir (see Figure 28-2).

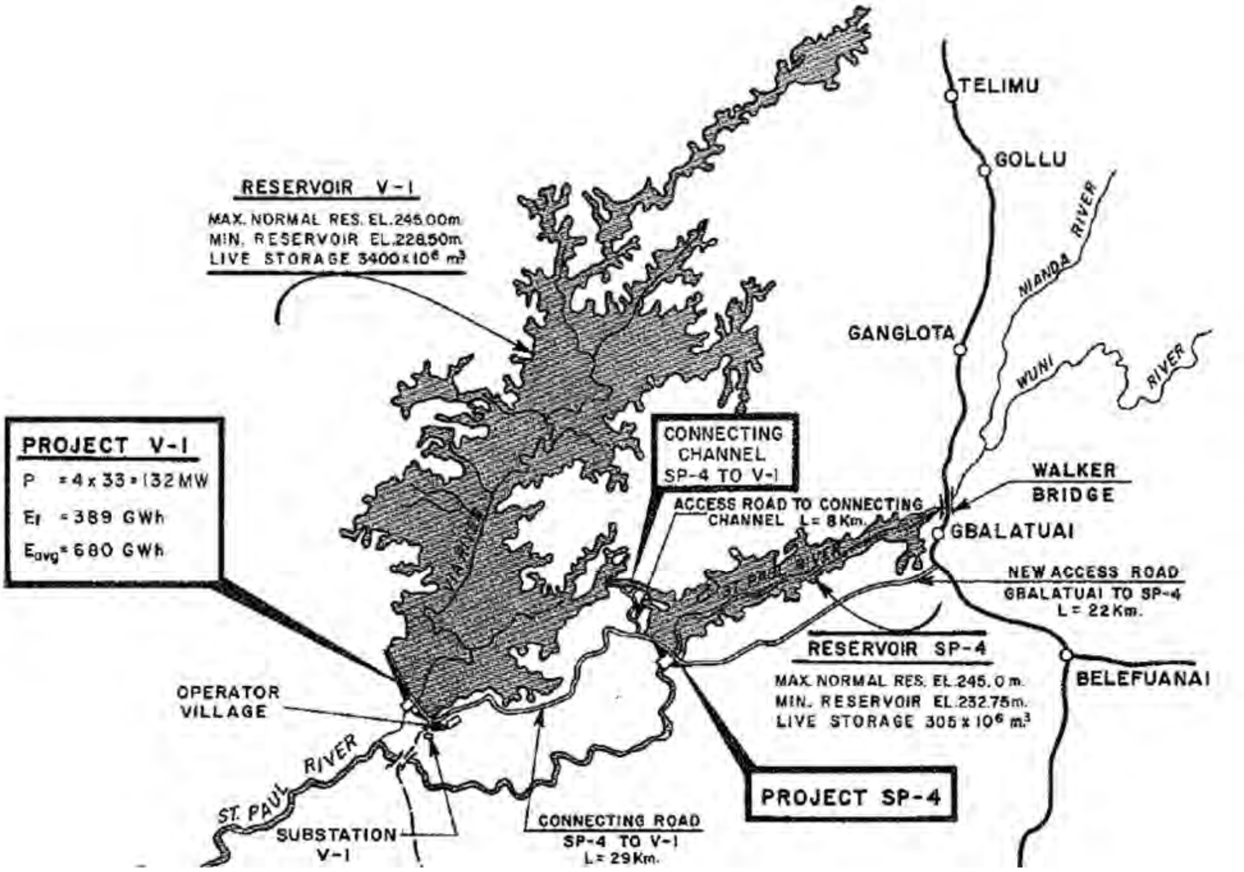


Figure 28-2: Via Reserovir and SP-4 project: layout

Source: Main 1982

The entire cascade is shown in the Figure below. This Figure also provides an indication on the sizes of the different reservoirs; unfortunately, the report does not provide any data on reservoir size.

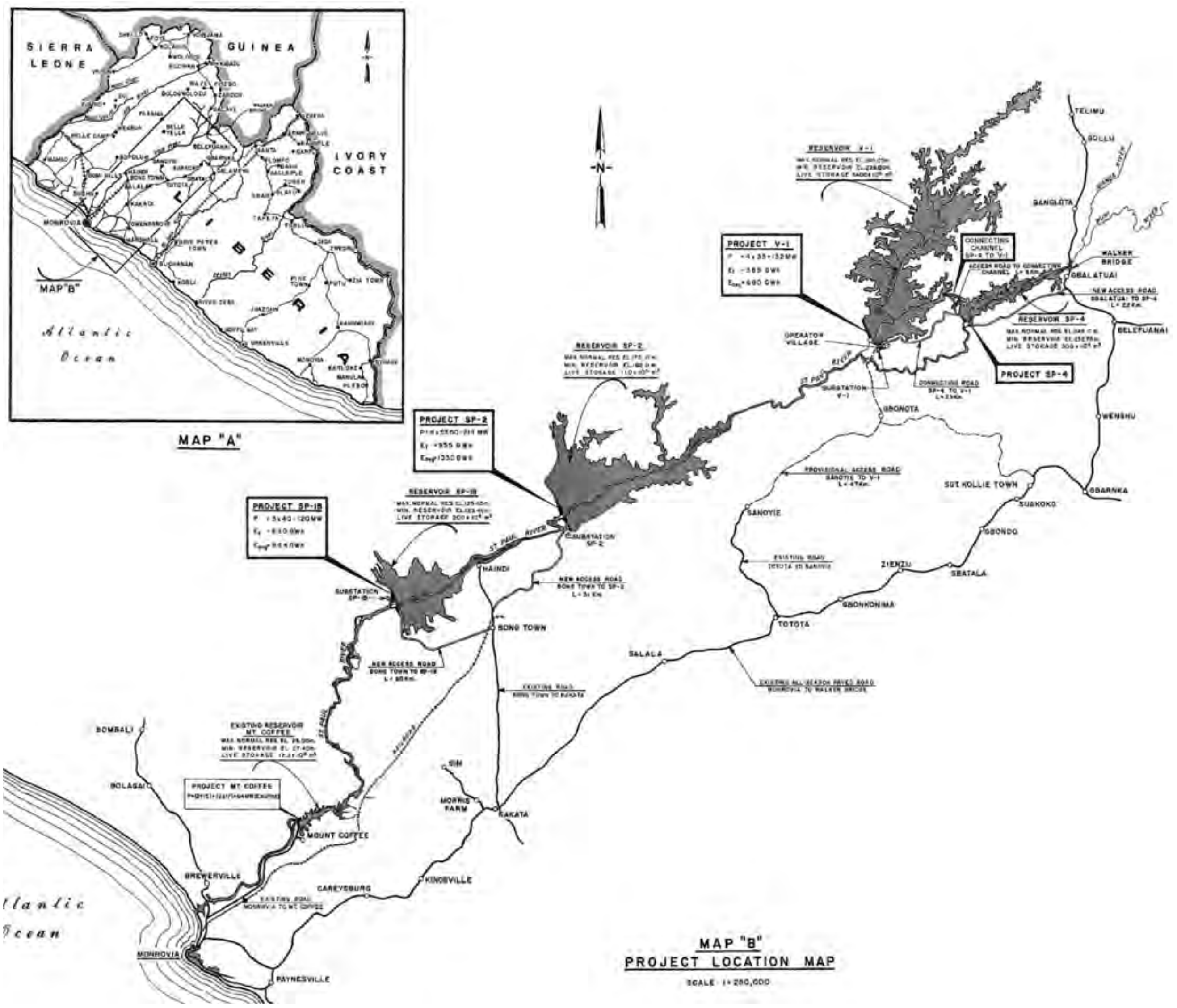


Figure 28-3: St. Paul River Cascade

Source: Main 1982

Some main parameters of the cascade components are summarised in the following Table. Here again, mainly the 1982 data have been used, except for the Mt. Coffee HPP (MC) itself.

Table 28-1: Main characteristics of the Mt. Coffee cascade

Parameter	**unit**	**V-1**	**SP-4**	**SP-2**	**SP-1B**	**MC**
Location	km[a]	187[b]	214[c]	122	85	24
dam height	m	52	60	43	49	18.3
crest elevation	m asl	248.8	253.7	175	129.2	
average discharge	m³/s	95.7	265.7	n.a.	n.a.	564
Reservoir						
area	km²	208				8.1
FSL	m asl	245	245	170	125.4	29
MOL	m asl	228.5	232.75	168	123.4	
tot. storage	10^6 m³	4'950	450	110	200	
live storage	10^6 m³	3'400	305	110	200	
Inst. capacity	MW	132	none	214	120	66

[a] = km u/s from mouth of St. Paul River

[b] = on Via River, about 4.5 km u/s of its confluence with St. Paul River

[c] = on St. Paul river u/s of confluence with Via river; reservoir connected by channel to Via reservoir

[d] = no indications of res. area in Main 1982 report; figure from Stanley 2008, but referring to "*Optimum*" Via, with a smaller reservoir (FSL at 235.4 m asl) than the scheme proposed by Main (which probably corresponds to the "*Ultimate*" Project in the Stanley report.

Note: the Main 1982 report contains some conflicting figures, e.g. on dam heights or reservoir volumes. In general, the figures listed in summarising Tables are being used here.

Shortly, the different parts of the cascade can be described as follows:

- **SP-4:** dam on St. Paul River, with medium-sized reservoir, connected to V-1 by a channel. No power plant, the only purpose of this structure is to divert water to the large Via storage reservoir.
- **V-1:** dam on Via River, large reservoir with seasonal storage. The surface area indicated in the Table above is for the "optimum" Via reservoir, the surface of the final stage as shown in Figure 24-2 is probably closer to 250 km². The reservoir provides storage volume for the entire cascade, retaining water during the high flow season for being used during the dry season.
- **SP2:** dam on St. Paul river, with a rather large reservoir which, however, has a rather small volume, not sufficient for seasonal storage. Operated as run-of-river (ROR) plant.
- **SP1-B:** dam on St. Paul River with medium sized reservoir with no seasonal storage capacity. Operated as ROR plant.
- **MC:** Mount Coffee HPP; existing/to be rehabilitated structure; dam on St. Paul River; very small reservoir with very little storage. Operated as ROR scheme.

28.3 Prevailing Situation

Figure 28-4 below gives an indication of predominant land use forms and vegetation in the St. Paul River basin.

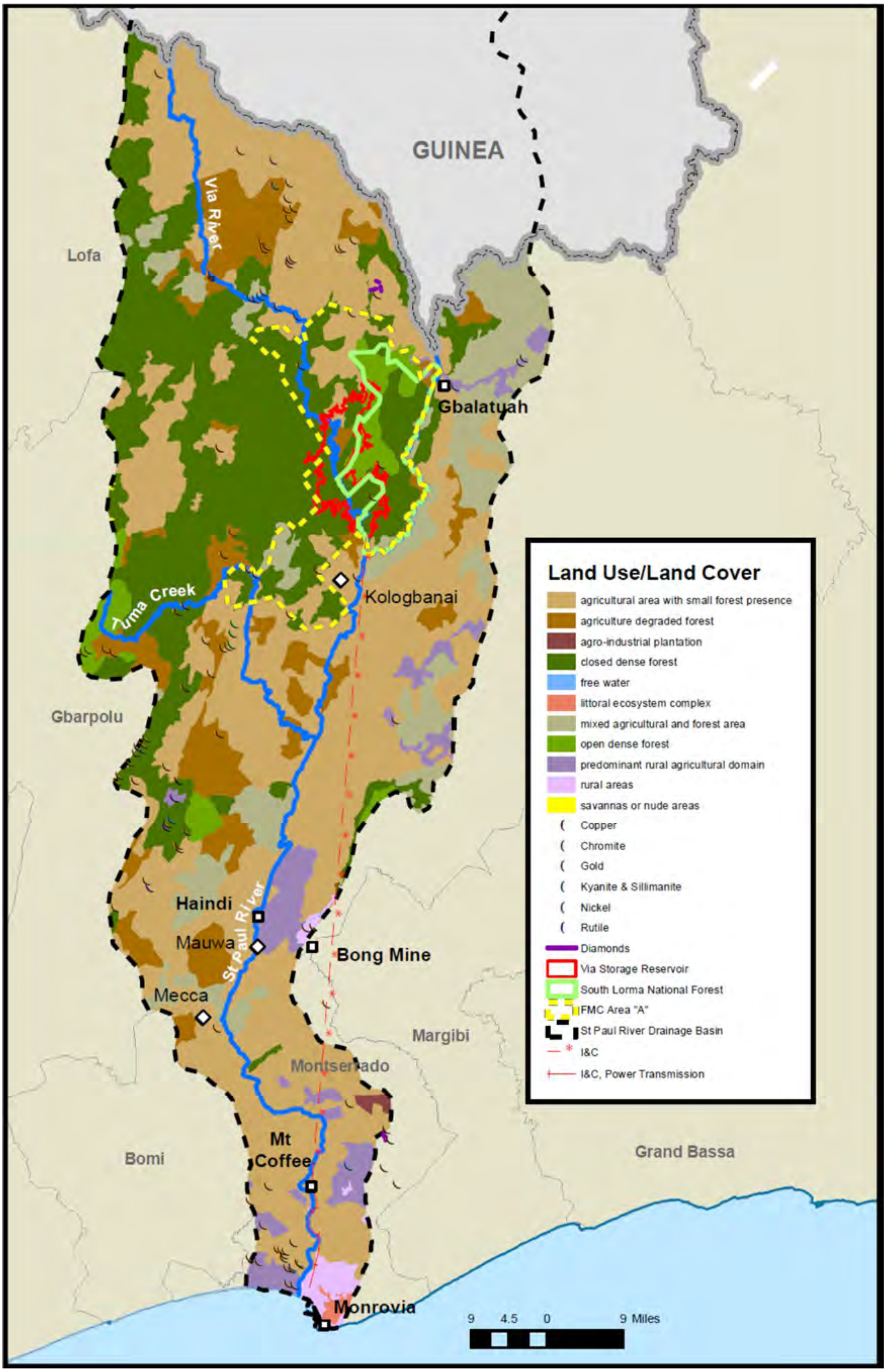


Figure 28-4: Vegetation and land use in the St. Paul River basin

Source: Fig. 11-1 in Stanley 2008

It can be seen that the three lower steps of the cascade are located in an area which is dominated by agriculture, with very little (presumably secondary, degraded) forest. On the other hand, Via and SP-4 reservoirs are located in a forested and at least partly protected area.

28.4 Preliminary Assessment of Impacts

28.4.1 Main Direct Impacts

In Chapter 5.1, the main impacts, in a general way, of dam and hydropower projects were listed and described shortly. These can be used here as a characterisation of the potential impacts of the cascade.

Table 28-2: Main impacts of the cascade

Main impact	V-1	SP-4	SP-2	SP-1B	MC	Cascade
Interruption of river continuum	xx	xx	xx	xx	xx	xxx
Change in river discharge pattern	xxx	xx	(x)	(x)	(x)	xxx
Change from river to lake conditions	xxx	xx	xx	x	(x)	xx
Destruction of terrestrial habitats	xxx	xx	xx	x	x	xx
Access to area by new access roads	xx	xx	x	x	(x)	xx
Social impacts (resettlement)	xxx	?	?	?	(x)	xxx

Potential negative impacts:

- xxx strong
- xx medium
- x small
- (x) negligible (small or none)
- ? potentially important, but no information available

A short description of main impacts follows:

Interruption of a river continuum: each of the dams will interrupt the river and will be a complete barrier for fish migrations; the importance of this will still have to be addressed in the detailed study. The effects of the cascade are cumulative, since each additional dam contributes incrementally to fragmentation of habitats and populations.

Change in river discharge pattern: the three lower dams of the cascade, operated as ROR schemes, have little if any effect on river discharge. There might be, to some extent, some daily variations, but the seasonal pattern is not influenced by these three schemes. Via reservoir, on the other hand, will have a very decisive effect. Its main objective is to accumulate water during the high-flow season and to release it during the low-flow season. In this way, water that cannot be used (turbined) during the rainy season is stored and is then available for power generation in the dry season, where otherwise there would not be sufficient water for HPP operation. While this is highly advantageous for power production, it can negatively affect habitats along the river, and possibly especially in the estuary, which depend on seasonal variations in river flow. SP-4 adds to this effect of V-1; in addition, it will have a negative effect on the 25 or so river kilometres between the dam and the confluence with Via River, since there the amount of water flowing will be reduced very considerably, and on a permanent basis, potentially to zero. The effects on Mt. Coffee HPP, and their consequences, are described below.

Change from river to lake conditions: the extent of this change is in direct relation to the size and volume of the reservoir. While the MC reservoir, given its small size and the amount of water flowing through, will be more like a large, slow-flowing river, Via reservoir will be a large lake, with the other reservoirs being between these two, nevertheless, with more lake-like conditions than the MC reservoir. While this can be negative for fish and other organisms depending on flowing water, it can be positive for others, which prefer stagnant water. Likewise, reservoirs can be good fishing grounds, and/or can be used for aquaculture. The two topmost reservoirs in the cascade, V-1 and SP-4, in addition to their size, will have a considerable drawdown (16.5 m in the case of V-1). This means that during the dry season an increasingly large area will be left dry all around the receding water body. This is a condition which is usually not very favourable for the development of fish stock.

Destruction of terrestrial habitats: this impact is related, on the one hand, to the size of the reservoir, and on the other hand to the types of land use, vegetation and habitats present before impoundment. At the moment of impoundment, all terrestrial habitats in the reservoir area are submerged and permanently destroyed (unlike in the case of an exceptional flood, which might cause extensive damage, but where the habitats will recover again afterwards). MC has, as shown in the previous Chapters of this report, very little negative effect here, since the reservoir is small and all the area to be submerged was a reservoir before, meaning that there can be no long-term valuable habitats (like mainly natural primary forest). The SP-2 and SP1B reservoirs are considerably larger, and their effect will therefore be more marked, although probably not very important from a biodiversity point of view, given the important human interference in this area. Via and SP-4 reservoirs, however, are located in a forested area, and at least partly in a forest reserve. Therefore, their impact could be quite severe.

Access to the area provided by new access roads: new access roads will be required for V-1 and SP-4, and these potentially make accessible a protected area which was not easily accessible before. This can have considerable negative impacts on natural habitats, like e. g. (illegal) logging activities or poaching. In the case of the lower dams in the cascade, access roads exist. Here, the positive effects of having an improved access will probably outweigh the negative impacts.

Social impacts: here, we address mainly the potential negative effects of the reservoirs on the socio-economic situation, and first of all resettlement. The effect of MC, in the sense of physical relocation; is rather small, and compensation for fields that were established in the reservoir area after the breaching of the dam will be required. Via reservoir on the other hand, despite its remote location, will cause a considerable amount of resettlement. The 1982 report mentions a number of 1200 people living in the reservoir area; obviously, this number might have changed considerably in the meantime. No information in this respect is available for SP-2 and SP-1B reservoirs, but given their size and the fact that they are located in an agriculturally used, and therefore presumably rather densely populated area, it is likely that in these cases also a considerable resettlement issue will arise.

28.4.2 Effects of the Cascade on Hydrology

Hydrological effects of the cascade, on the basis of the available information on the schemes u/s from Mt. Coffee, can only be estimated rather roughly. In the following Figure, the probable outcome is illustrated, whereby the following basic assumptions were made:

- As a general rule for large storage reservoir on strongly seasonal rivers, water is being retained for filling the reservoir during the high flow (rainy) season; this water is then used for producing electricity during the low flow (dry) season.
- This leads directly to a decrease of river flow d/s of the dam in the rainy season, and to an increase in the dry season.
- According to the available information, Via reservoir (with the SP 4 extension), will provide regulating capacity for the entire cascade, while the other reservoirs, including Mt. Coffee, will be operated as ROR schemes.
- The regulating effect of Via reservoir will be as described under the first bullet point: in the rainy season (June to November), a part of the high flows will be retained; enough water will be released to satisfy the requirements of the other plants in the cascade and the requirements of other water users, and there will also be some spilling. In the dry season, more water will be released than what is available under natural conditions. During this time, Via reservoir will be drawn down, to be filled again during the next rainy season.

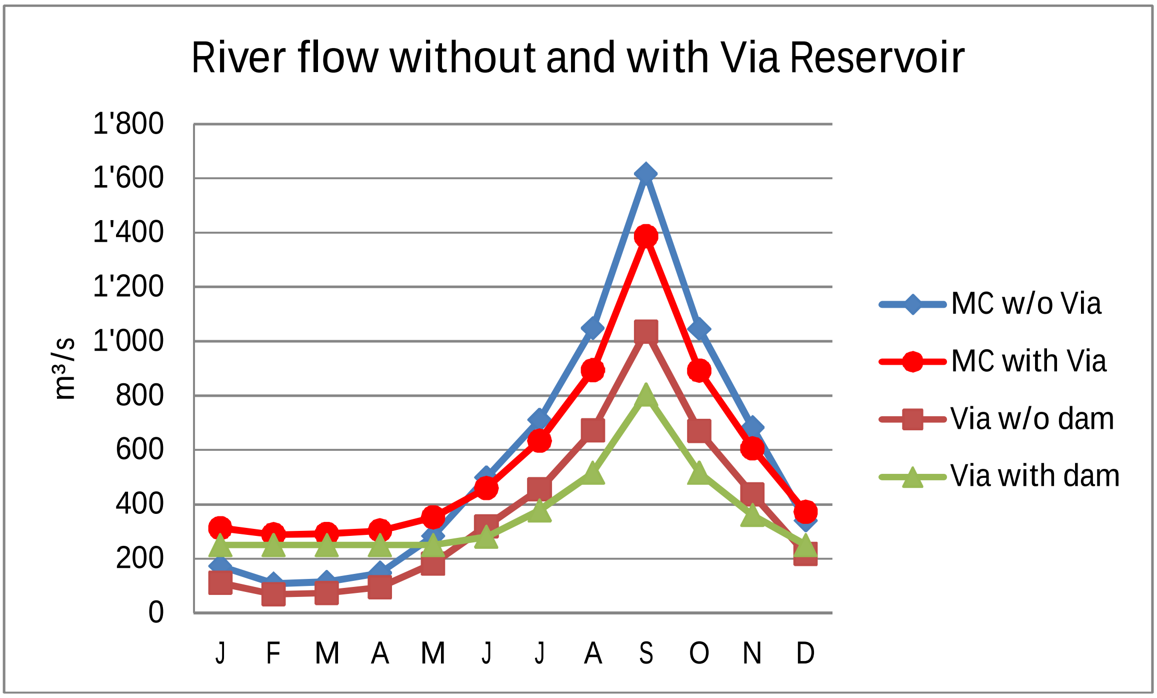


Figure 28-5: Effects of Via reservoir on river flows at Mt. Coffee

The flow values in this graph should not be taken as exact values, but rather as a general illustration of the type of impact the large Via reservoir will have.

The natural flow at Mt. Coffee (MC w/o Via) illustrates the present situation, which, as has been shown in Chapter 8, will be changed only very marginally by Mt. Coffee HPP. This flow is composed of the natural flow at Via (Via w/o dam) and the yield from the intermediate catchment.

Via dam will, first of all, change the river flow pattern at that site: reducing the wet season flow and increasing the dry season flow rather considerably (situation Via with dam).

These changes will be transmitted directly to Mt. Coffee reservoir in the following way:

- The wet season flow will be reduced by the amount of water retained at Via. This will not affect energy production at Mt. Coffee, since there will be always enough water available for production at full capacity, but it will reduce spilling.
- The dry season flow will increase considerably. Under the assumptions made for the Figure above, there will be enough water available for generating electricity at or near full capacity all the time, as opposed to only about 50% of the time in the case without Via; this, obviously, will have to be analysed in more detail in the technical feasibility of Via reservoir.

The direct effect of this, and obviously the reason for envisaging this cascade, is a very marked increase in energy production in Mt. Coffee. In addition to that, a higher river discharge in the area d/s of Mt. Coffee HPP would also have an effect on water quality, by reducing or even halting salt water intrusion from the sea into this part of the river, and possibly up to the water intake of the White Plains water treatment plant. This would be a positive side effect of the cascade.

The reduction in spilling mentioned above would have an effect on the part of the river between spillway and tailrace confluence. From the graph above, it can be concluded roughly that the period with spilling, i.e. with a discharge of over 340 m³/s, would remain approximately the same, while the amount would be reduced (in September, the wettest month, by up to 200 m³/s). Still, even under these conditions St. Paul river would continue to show a highly seasonal flow pattern. Negative effects on the aquatic habitat due to this change are not expected.

28.4.3 Important Secondary Impacts

Some of the main direct impacts described above will have potentially highly relevant secondary impacts. The most important, from the present point of view, are described briefly hereunder.

Fish migrations: a number of fish species living in the St. Paul River undertake migrations and depend on them for reproduction. Dams interrupt the migration routes, and this can lead to the disappearance of affected species from the river. It could be argued that these migrations, if there are of any importance, were already interrupted by the original Mt. Coffee dam. This would mainly have affected any species migrating upstream from the sea (there is always a way down, although, since it leads trough the turbines, a very hazardous one). Nevertheless, every additional dam will create an additional barrier, affecting species migrating within the river as such. Presently, there is not enough information for coming to a firm conclusion on the importance of his effect.

Greenhouse gas emissions: large reservoirs submerging high amounts of vegetation can become substantial sources of greenhouse gasses (GHG). This is especially the case in for deeper reservoirs, which will develop a stable thermal stratification. In such a case, the deeper parts of the reservoir will quickly become anoxic, since all the available oxygen will have been consumed by the process of vegetation decomposition. The ongoing breakdown of organic matter (mainly leaves, herbs and finer twigs, the so-called "soft biomass" will lead to the generation of methane, which is a very powerful GHG. While this will not occur in the case of MC HPP (small and shallow reservoir, large amount of water flowing through and therefore constant replenishment of oxygen also in its deeper parts, see analysis in Section 8.3.5), there is certainly a high probability for such a situation to occur in the case of the very large Via reservoir, which is also deep enough for most probably developing a stratification. Other negative effects on water quality can occur in such a situation, most noticeably the development of hydrogen sulphide (H_2S), which is very toxic for fish and very corrosive for metal and concrete structures.

Impact on forests and wildlife: as mentioned, the two uppermost reservoirs are located in a forested area, and at least partially in a forest reserve. These forests are probably also an important habitat for wildlife. A part of the reserve will be destroyed permanently by becoming submerged. In addition, the construction of access roads and the presence of a large work force during the construction period will likely generate additional pressure on these habitats and their wildlife.

Impacts on riparian habitats: all along the river, there are habitats which depend on or are adapted to the high seasonal fluctuations in river discharge. A large storage reservoir in the upper parts of the river basin will considerably reduce these seasonal fluctuations (lowering peak flow in the rainy season and increasing low flows in the dry season, see above). This can have positive effects (reduction of the risk of floods, higher availability of water during the dry season), but it can negatively affect riparian habitats like floodplains, gallery forests etc., and the wildlife as well as human uses of such areas.

Effects on the estuary: the effect just described will also be observed in the estuary of the river. This can have mainly two indirect effects. The first one is on salt and the risk of salt intrusion. Higher flows in the dry season will result in a reduction of the risk of salt intrusion and therefore be beneficial. On the other hand the reduction in seasonal high flows might reduce the self-regulating capacity of the system by reducing its ability to wash out salt. Without in-depths analyses, it is difficult to recognise which of these contrasting effects will prevail. A second effect, closely linked to the first one, could be on the mangroves in this area. They depend on the dynamic of the system, and especially on a balance between salt and fresh water, and a change in this balance could put an additional stress on them.

Impacts on water users d/s of dams: this could be a subject especially in the 25 or so river km below SP-4 dam. If no measures are taken, all the water from the St. Paul River will be diverted to the Via reservoir, leaving nothing (except the runoff from the small intermediate catchment) in this part of the river. This would have a detrimental impact on any aquatic biota in this area, and could severely affect human populations which use the water there in any way (for fishing, drinking, washing, transport etc.). A residua flow will have to be defined for this part of the river.

28.5 Conclusions and Preliminary Identification of Mitigation Measures

The advantage of the cascade from an energy generation point of view is quite obvious. Given the very marked seasonal variation in river discharge, and especially the very low dry season flows, it is quite obvious that with ROR power schemes it will not be possible to produce a sufficient amount of electricity in the dry season. Therefore, Via reservoir is the cornerstone for the development of the entire cascade, because only with this in place will there be enough storage capacity. There is no doubt that the country needs a sufficient, reliable and affordable supply of energy, and hydropower is certainly a good solution. The positive environmental (by substituting fossil fuel) and socio-economic (by considerably improving the living conditions of the entire population) effects are obvious.

On the other hand, as has been shown above, Via reservoir is also the component with the most important, and most marked, negative environmental and social impact (change in river dynamics, submerging of forests, risk of GHG emissions, resettlement). From this, it is clear that adequate mitigation measures will have to be taken with the aim of reducing negative impacts to an acceptable level.

First of all, each component of the cascade will have to undergo an ESIA process, and a RAP will have to be prepared for each of them. This is a legal requirement, and a prerequisite of all financing institutions. But, more importantly, it is a very real necessity for properly identifying impacts and for being able to mitigate them.

A few possible (or probable) mitigation measures are mentioned here briefly (whereby the order in which they are presented in no way implies an order of importance):

- Fish passes: in case of important fish migrations, fish passes (or fish ladders) can be a way to maintain them. It is not possible, at this point in time, to decide whether such structures would be required in the case of the St. Paul River cascade. Obviously, these structures have two main negative effects, namely the costs involved and the loss of water. Therefore, the situation has to be analysed carefully before a decision is being taken. Furthermore, there are certain conditions which must be given for allowing the installation of a fish pass. It would seem that in the case of MC HPP, this would be possible. The other dams, however, are considerably higher, more than 40 m, and there the effectiveness of a fish pass is difficult to achieve. In general it can be stated that there are no effective fish passes for dams with a height of more than 30 m. The available studies made so far do not mention the possibility of fish passes.

- Fish and fisheries management in the reservoirs: reservoirs can be suitable fishing grounds. However, in many cases fish populations soared shortly after impoundment, due to the high availability of nutrients in the water, but then decreased again considerably after a few years. The introduction of exotic fish species into reservoirs has often created problems, especially considerably reducing the diversity of the local fish fauna. For these reasons, a comprehensive fish and fisheries management program should be developed for larger reservoirs, drawing on experience from other reservoirs.

- Pre-impoundment clearing: the risk of GHG development was mentioned. The only way to prevent this, in the case of large reservoirs, is an adequate pre-impoundment clearing, which mainly serves the purpose of reducing the amount of biomass that will be submerged. Studies made so far apparently proposed only a very limited extent of reservoir clearing, focussing mainly on extraction of commercial timber, and this not in the least because of the costs involved in clearing a large surface. It is advisable to evaluate this point carefully.

- Impact on forest and wildlife: forests and other habitats in the reservoir area will be lost. Since the purpose of the reservoirs, and especially of the Via reservoir, is to store water, a reduction in reservoir size would not be an option. Therefore, in order to mitigate the impact, compensatory measures have to be taken. Such measures can be e.g. reforestation of other surfaces (similar in size and conditions), or, in the case of protected areas, including other suitable surfaces (if available) into the protected area and/or to improve protection for the remaining parts of the protected area. One additional set of measures are those which aim at preventing or reducing an increase of pressure on the remaining area (e.g. strict control of poaching by the work force, providing access control to sensitive areas, etc.).
- Impacts on riparian habitats: if there are important habitats which depend on seasonal flooding, it is sometimes possible to simulate this situation by controlled releases of higher flows during certain times, creating “artificial floods”. Such measures, obviously, have to be designed specifically for the situation at hand.
- Residual flow: the only way to reduce the impacts of a reduced flow below a diversion dam like SP-4 (or like V-1, from which at certain times no water might be released) is to provide a residual flow, to be delivered to the river as a minimum flow at all times. This would have to be dimensioned in a way as to guarantee all relevant basic functions of the affected stretch of river (maintenance of aquatic habitats and especially of fish populations, sufficient water for needs of riparian population). The available studies make no mentioning of such a residual flow, and this has probably not been included in the economic analysis of the project.

Obviously, these are just preliminary recommendations. The measures will have to be developed in detail once the impacts will have been identified in the respective ESIAs, as part of the ESMPs for all plants in the cascade. Given the fact that the cascade will have cumulative impacts as shown here, it is recommended to prepare the ESIA as well as the ESMP for the entire cascade, and not for the individual dams.

29 MAIN CONCLUSIONS AND RECOMMENDATIONS

29.1 Main Difficulties Encountered

During the preparation of this Report, the Consultant was faced by two main problems. These are of entirely different nature and are discussed briefly here.

29.1.1 Lack of Basic Data

Considerable effort was made for gathering relevant information. This, however, proved to be difficult due to a general lack of sound and reliable information on a number of points. The main reasons for this are the facts that during the war, a lot of data were lost, and data collection campaigns were interrupted. Since the end of the war, the institutions in charge have made considerable efforts to close these gaps; however, this is a lengthy, costly and time consuming process. No immediate remedy is available for this.

29.1.2 Problem of Orientation in the Field

One of the main objectives of the study was to identify the sites which will be submerged at the filling of the reservoir. This implies identifying, at least approximately, the FSL of 29.1 m asl. Under the given situation (complex topography without any marked elevations or clearly defined valley flanks, undulating terrain, dense and high vegetation), this proved to be a very difficult task. Two main approaches were used, namely;

- GPS measurements for locating sites and providing estimates of elevation; however, while location is rather precise, this is not the case for elevation, these measurements can vary strongly due to changing weather conditions and can only provide a rough estimate.
- Information from long-term residents of the region on "where the water was when the reservoir was there"; this is presumably rather accurate as far as location of houses are concerned (houses which were not affected by the reservoir or sites which had to be abandoned at the former filling of the reservoir and were then occupied again after the breaching of the dam). However, it cannot be expected that in this way a very accurate assessment of fields to be submerged can be made.

Such an assessment will be very important for the RAP, where questions of compensation will have to be clarified. To a certain extent, old topographical maps showing the reservoir might be of use in the further analysis, in combination with the recent orthophotos of this area (received from Stanley Consultants).

Nevertheless, for the finalisation of the RAP and for its implementation, as well as the implementation of the ESMP (pre-impoundment clearing of the reservoir area), it is highly recommended to carry out a topographical survey of the area, whereby the FSL of the reservoir (preferably the 30 m asl contour line) would be clearly marked in the field, with markers which cannot easily be removed or relocated. This would then allow to clearly identify all assets to be submerged, and to identify the area from which trees (and, to the extent possible, other vegetation) should be removed, without an encroachment of these activities on surrounding land above the water level of the reservoir. This work should be carried out as soon as possible.

29.2 Project Compliance with World Commission of Dams requirements

The WCD Report,

World Commission on Dams (WCD), 2000: Dams and Development: a New Framework for Decision-Making. Earthscan Publications Limited, London and Sterling, VA, 404 pp.

in an attempt to bring together representatives of all stakeholders involved in or concerned by the construction of large dams, has developed recommendations and guidelines to be applied in the development of dam projects in order to ensure sustainability, of the projects as well as of the use of the resource which are at the basis of such projects.

The seven Strategic Priorities as shown below are commented related to compliance in Table 29-1.

Strategic Priority 1: Gaining Public Acceptance

1 Stakeholder Analysis

2 Negotiated Decision-Making Processes

3 Free, Prior and Informed Consent

Strategic Priority 2: Comprehensive Options Assessment

4 Strategic Impact Assessment for Environmental, Social, Health and Cultural Heritage Issues

5 Project-Level Impact Assessment for Environmental, Social, Health and Cultural Heritage Issues

6 Multi-Criteria Analysis

7 Life Cycle Assessment

8 Greenhouse Gas Emissions

9 Distributional Analysis of Projects

10 Valuation of Social and Environmental Impacts

11 Improving Economic Risk Assessment

Strategic Priority 3: Addressing Existing Dams

12 Ensuring Operating Rules Reflect Social and Environmental Concerns

13 Improving Reservoir Operations

Strategic Priority 4: Sustaining Rivers and Livelihoods

14 Baseline Ecosystem Surveys

15 Environmental Flow Assessment

16 Maintaining Productive Fisheries

Strategic Priority 5: Recognising Entitlements and Sharing Benefits

17 Baseline Social Conditions

18 Impoverishment Risk Analysis

19 Implementation of the Mitigation, Resettlement and Development Action Plan

20 Project Benefit-Sharing Mechanisms

Strategic Priority 6: Ensuring Compliance

21 Compliance Plans

22 Independent Review Panels for Social and Environmental Matters

23 Performance Bonds

24 Trust Funds

25 Integrity Pacts

Strategic Priority 7: Sharing Rivers for Peace, Development, and Security

26 Procedures for Shared Rivers

Table 29-1: Project compliance Analysis

Strategic Priority	Guideline	Comments
Strategic Priority 1: Gaining Public Acceptance Public acceptance of key decisions is essential for equitable and sustainable water and energy resources development. Acceptance emerges from recognising rights, addressing risks, and safeguarding the entitlements of all groups of affected people, particularly indigenous and tribal peoples, women and other vulnerable groups. Decision making processes and mechanisms are used that enable informed participation by all groups of people, and result in the demonstrable acceptance of key decisions. Where projects affect indigenous and tribal peoples, such processes are guided by their free, prior and informed consent.	1. Stakeholder Analysis	The main stakeholders (other than those directly involved in HPP development) have been identified as the local inhabitants and NGOs active in the area. A social survey was performed and the inhabitants of the project area were informed. Household and village questionnaires as well as focus group discussions were used. Meeting with the NGOs (FAO, Bureau of Fisheries etc.) concerning the environmental issues were held and the problems discussed.
	2. Negotiated Decision-Making Process	The stakeholders have not participated in any decision on the Project. Structures as suggested by the guidelines are not in place. Stakeholders had the opportunity to formulate their concerns and expectations, however, these cannot yet be considered as firm parts of the project.
	3. Free, Prior and Informed Consent	The affected population cannot be qualified as an indigenous, tribal or ethnic minority population as defined in WB OP 4.10. They have indicated their consent with the project and listed their expectations. Agreements will have to be reached.
	Conclusions:	Stakeholder Analysis was carried out (to a sufficient extent for this stage). It is now important that the process which has started successfully is being maintained and will continue. Firm agreements on requests made must be reached before a final decision on the project.
Strategic Priority 2: Comprehensive Options Assessment Alternatives to dams do often exist. To explore these alternatives, needs for water, food and energy are assessed and objectives clearly defined. The appropriate development response is identified from a range of possible options. The selection is based on a comprehensive and participatory assessment of the full range of policy, institutional and technical options. In the assessment process social and environmental aspects have the same significance as economic and financial factors. The options assessment process continues through all stages of planning, project development and operations	4. Strategic Impact Assessment for Environmental, Social, Health and Cultural Heritage Issues	A SEA for regional development cannot be made as part of an EIA for a specific project. However, based on available information a preliminary CIA of the planned cascade on the St Paul river has been carried out.
	5. Project Level Impact Assessment for Environmental, Social, Health and Cultural Heritage Issues	These aspects are all being taken into consideration. An ESIA including a Social Survey were carried out for the Project with regard to the main points. While social and environmental aspects are of some concern, cultural heritage is not an issue in this case.
	6. Multi Criteria Analysis	Such analyses are under way, however, so far without participation of stakeholders. Namely, an economic analysis for the project was carried out as part of the present study, which shows the benefits of the project and its advantages over possible alternatives.
	7. Life Cycle Assessment	Is, at least to some extent, being carried out.
	8. Greenhouse Gas Emission	Given the situation (small reservoir, high turnover of water, low risk of eutrophication) it can be said that the Project rates favourable in this respect.

Strategic Priority	Guideline	Comments
	9. Distributional Analysis of Projects	This is being done mainly with respect to the directly affected population.
	10. Valuation of Social and Environmental Impacts	Done in the ESIA study.
	11. Improving Economic Risk Assessment	While important, this is not being done within the framework of E&S assessment.
	Conclusions:	The points addressed under this Strategic Priority have been addressed and show the advantages of the project over possible alternatives.
Strategic Priority 3: Addressing Existing Dams. Opportunities exist to optimise benefits from many existing dams, address outstanding social issues and strengthen environmental mitigation and restoration measures. Dams and the context in which they operate are not seen as static over time. Benefits and impacts may be transformed by changes in water use priorities, physical and land use changes in the river basin, technological developments, and changes in public policy expressed in environment, safety, economic and technical regulations. Management and operation practices must adapt continuously to changing circumstances over the project's life and must address outstanding social issues.	12. Ensuring Operational Rules Reflect Social and Environmental Concerns	Requires continued attention during detailed design and operation.
	13. Improving Reservoir Operations	Same as above. The reservoir, besides energy generation, also has a potential for fisheries. Given its small size, margins for operational variation (basically ROR with some load following) are limited..
	Conclusions:	The issue of existing and planned dams in the wider area is addressed in this report, and benefits and risks are discussed.
Strategic Priority 4: Sustaining Rivers and Livelihoods Rivers, watersheds and aquatic ecosystems are the biological engines of the planet. They are the basis for life and the livelihoods of local communities. Dams transform landscapes and create risks of irreversible impacts. Understanding, protecting and restoring ecosystems at river basin level is essential to foster equitable human development and the welfare of all species. Options assessment and decision-making around river development prioritises the avoidance of impacts, followed by minimisation and compensation.	14. Baseline Ecosystem Surveys	The baseline data on the ecosystem in the area of the project is very weak since almost no actual long term studies have been carried out in this region. Still it can be stated that the negative effect of the project on the habitats is acceptable, since the area to be submerged had already been covered with water 20 years ago; in the meantime, not in the least due to shifting cultivation, no especially valuable habitats have develop in the project area
	15. Environmental Flow Assessment	Has been addressed in the study.
	16. Maintaining Productive Fisheries	Fish fauna has been investigated. Recommendations on mitigation measures are given in the ESIA Report
	Conclusions:	Important points which are being addressed in the ongoing planning.

Strategic Priority	Guideline	Comments
Strategic Priority 5: Recognising Entitlements and Sharing Benefits Joint negotiations with adversely affected people result in mutually agreed and legally enforceable mitigation and development provisions. These recognise entitlements that improve livelihoods and quality of life, and affected people are beneficiaries of the project. Successful mitigation, resettlement and development are fundamental commitments and responsibilities of the State and the developer. They bear the onus to satisfy all affected people that moving from their current context and resources will improve their livelihoods. Accountability of responsible parties to agreed mitigation, resettlement and development provisions is ensured through legal means, such as contracts, and through accessible legal support.	17. Baseline Social Conditions	Were analysed for the ESIA as well as for the RAP in a sufficient way for that stage of the project.
	18. Impoverishment Risk Analysis	This is a point of main concern of the Socio-economic Analysis. The affected population is very poor. Project impacts will be mainly positive (improving access; creation of income, although mainly temporary). Nevertheless, loss of land for cash crops could prove detrimental for affected households, and this must be compensated if and when it occurs. A solution needs to be found that the local population will also be able to plant cash crop on community owned land. On the other hand, it has also to be seen that the project, by producing cheap and reliable energy, will contribute to the reduction of poverty not only in the project area, but ultimately (provided access by means of expanding the grid is granted) in the whole country.
	19. Implementation of the Mitigation, Resettlement and Development Action Plan	A RAP is being prepared as part of this assignment. It will have to be implemented and, where required, updated during the process.
	20. Project Benefit-Sharing Mechanism	The affected population expects improved access, electrification of the villages, and health and education facilities and jobs. The economic situation in the project area will certainly improve.
	Conclusions:	Important aspects for the future planning and implementation process. The Project is on track.
Strategic Priority 6: Ensuring Compliance Ensuring public trust and confidence requires that the governments, developers, regulators and operators meet all commitments made for the planning, implementation and operation of dams. Compliance with applicable regulations, criteria and guidelines, and project-specific negotiated agreements is secured at all critical stages in project planning and implementation. A set of mutually reinforcing incentives and mechanisms is required for social, environmental and technical measures. These should involve an appropriate mix of regulatory and non-regulatory	21. Compliance Plans	These rules for plan implementation will have to be established. A monitoring system will have to be implemented which will ensure compliance of the project, during construction as well as during operation, with the conditions defined during the planning phase.
	22. Independent Review Panels for Social and Environmental Matters	Such a panel is recommended. It is important that it is being maintained throughout the planning and implementation process (until measures are implemented in a satisfactory way).
	23. Performance Bonds	This would be an option, to be decided.
	24. Trust Funds	as above
	25. Integrity Pacts	as above
	Conclusions:	Compliance with the plans, once they will have been established, must be ensured.

Strategic Priority	Guideline	Comments
measures, incorporating incentives and sanctions. Regulatory and compliance frameworks use incentives and sanctions to ensure effectiveness where flexibility is needed to accommodate changing circumstances.		
Strategic Priority 7: Sharing Rivers for Peace, Development, and Security Storage and diversion of water on transboundary rivers has been a source of considerable tension between countries and within countries. As specific interventions for diverting water, dams require constructive co-operation. Consequently, the use and management of resources increasingly becomes the subject of agreement between States to promote mutual self-interest for regional co-operation and peaceful collaboration.	26. Procedure for Shared Rivers	The St. Paul river is an international river, since it originates in Guinea. However, Mt. Coffee HPP, being located in the lower reaches of this river near the coast, will not affect this upstream country in any way. For this reason, the condition of the guideline (notification of and cooperation with riparian states) is not applicable here. Nevertheless, the spirit of the guideline can also be applied within one country (e.g. different provinces with different needs and conditions, as is certainly the case here).
	Conclusions:	Not of concern in the present case.

29.2.1 Conclusion

It has to be seen that the WCD Guidelines present a kind of an "ideal" form of project planning and implementation, which so far has probably seldom if ever been complied with by any project. Nevertheless, the analysis provides some useful insights. The main are:

- The project for HPP development at the St Paul river is in line and in compliance with the relevant guidelines, namely with those describing standard EIA and SIA procedures.
- Some of the guidelines are not applicable here, or are of no concern under the given conditions like e.g. cultural heritage, international waters.
- No SEA has been carried and therefore the project is not in compliance with guideline No. 4. However, an SEA cannot be done in the framework of an EIA for a specific project.
- The public consultation process is ongoing.

30 ANNEXES

ANNEX 1: THE ASSIGNMENT

A1.1: The Terms of Reference

4. SCOPE OF SERVICES

The Consultant will be required to provide services in accordance with internationally recognized practices for consultancy services. The Consultant shall also perform the services independently in accordance with acceptable international standards, applicable laws and regulations in the various countries and the World Bank and EU directives as well as existing WAPP regulations, and ADB and EIB Guidelines. Should there be any contradiction between the applicable laws, regulations, directives and guidelines the more stringent of these directives, regulations and guidelines shall take precedence.

The Consultant shall keep accurate and systematic records and accounts in respect of the Services in such form and detail as is customary and as shall be sufficient to establish accurately that the costs and expenditures have been duly incurred.

4.1. Environmental and Social Impact Assessment (ESIA)

The ESIA will facilitate the understanding and determination of the likely implications of the proposed project, the relevant considerations, planning and mitigation options, that will ensure that the project is implemented in an environmentally sound and sustainable manner. It will also form the basis for consideration for environmental approval by funding agencies and permits from the Environmental Protection Agencies of Liberia for the implementation of the proposed project.

The Consultant shall review all necessary data and reports on the Mount Coffee Hydropower project, and any other additional information that could help in the development of the Environmental Impact Statement (EIS). The Consultant shall review the national and international environmental policies, procedures and legislation and regulatory frameworks as they apply to the assignment. The Consultant shall take into account the requirements of the various institutions in charge of environmental protection in Liberia and also the requirements indicated in Appendix 2 and comply accordingly. Requirements of Funding Agencies shall be taken into consideration in the conduct of the ESIA and preparation of the EIS.

As part of the ESIA Study, the Consultant shall be required to undertake a scoping exercise and prepare a Scoping Report, giving among others, a Project Brief and detailing the “Terms Of Reference” for review, in the form and format required by the authorities in charge of environmental protection in Liberia and in line with the prevailing environmental management and protection regulations and laws. The Consultant shall detail out the approval processes and reporting requirements in the country. The Consultant shall if required, make a presentation of the Scoping Study to the authorities in charge of environmental protection prior to the submission of the Scoping Report. The approval of the Scoping Study by the authority in charge of environmental protection may be required prior to the submission of the Environmental Impact Statement report. The Scoping Report and the Terms of Reference for the ESIA will be finalized after a public consultation (see 4.1.5).

The scope of work of the Environmental and Social Impact Assessment shall include, but not be limited to the following:

- A description of the institutional and legal framework
- A description of the project
- Study of existing Environment
- Identification & Assessment of potential environmental and social impacts
- Mitigation measures
- Provisional Environmental & Social Management Plan (ESMP)
- Preparation and submission of an Environmental & Social Management Monitoring Programme
- Public consultations and information
- Compensation in respect of Acquisition of Land and Right-of-Way
- Final Environmental & Social Management Plan
- Recommend training programmes to be undertaken by the environmental agency, ministries and utility
- Detailed overview of project alternatives
- Cost Estimates

4.1.1. Study of Existing Environment

A detailed study and description of the existing environment (physical, biological and socio-cultural/economy) within the project area (power plant, reservoir, upstream area, downstream area, incl. estuary, transmission lines and substations, and access road) shall be provided by the Consultant. These shall include, but not be limited, to the following:

a. Physical Environment
   - i. Topography, geology and soils
   - ii. Climate and air quality
   - iii. Noise

b. Biological Environment
   - i. Terrestrial Vegetation
   - ii. Wildlife
   - iii. Ecologically sensitive sites (e.g. wetlands, forest reserves)
   - iv. Fishlife
   - v. Biodiversity

c. Socio-Cultural / Economic Environment
   - i. Population and Demographics
   - ii. Ethnic, Religious and Cultural Heritage including shrines and cemeteries
   - iii. Historical resources

iv. Aesthetics and Tourism

v. Infrastructure

vi. Education

vii. Land tenure and Land Ownership

viii. Land Use

ix. Agriculture and fishery

x. Public Health (including HIV/AIDS)

4.1.2. Identification & Assessment of Potential Environmental and Social Impacts

Some environmental and social effects can occur during the pre-construction, constructional, operational and decommissioning phases of the project. The Consultant shall identify the major sources of these effects and describe the predicted impacts from these activities, including making use of experiences and data stemming from the previous period when the Plant was functioning. The Consultant shall elaborate on the methodology employed in the impact assessment study.

The Consultant shall evaluate the benefits of the project and their populations, the impact of the project on development sustainability, its contribution towards poverty alleviation, and the attainment of the Millennium Development Goals.

In order to provide further guidance under this TOR, the following aspects are indicated in further details, without being exhaustive or complete:

4.1.2.1. Environmental and Social Impact Assessment of (including preparation of detailed plans):

4.1.2.1.1. Upstream, reservoir and downstream biodiversity and the impact of the hydropower plant on this biodiversity,

4.1.2.1.2. Fisheries development program in the reservoir

4.1.2.1.3. Downstream fisheries

4.1.2.1.4. Fish migration

4.1.2.1.5. Macrophyte development and management in the reservoir area

4.1.2.1.6. Water quality baseline and water quality management and responsibility allocation

4.1.2.1.7. People in the reservoir area and water users downstream

4.1.2.1.8. Downstream erosion

4.1.2.1.9. Baseline on waterborne diseases (malaria, intestinal and urinary bilharzias, river blindness) and an analysis of health impacts of the rehabilitated dam and reservoir, including proposals how to mitigate and minimize these health impacts

4.1.2.1.10. Cultural heritage in the reservoir area, carrying out an archaeological survey

4.1.2.1.11. Reservoir GHG emissions

4.1.2.1.12. Overview and plan of biomass and vegetation clearance in the reservoir area and construction sites

4.1.2.1.13. St. Paul river estuary and maritime impact

4.1.2.1.14. Feasibility to qualify for CDM credits and compliance with Requirements of the EU Linking Directive

4.1.2.1.15. Tentative list of envisaged Site Specific Environmental Plans

4.1.2.1.16. Watershed management to protect the reservoir from sedimentation and to maintain water quality

4.1.2.2. Review of operational issues with respect to Environmental and Social Impact:

4.1.2.2.1. Rules regarding the reservoir filling and a reservoir filling plan

4.1.2.2.2. Operation of the reservoir

4.1.2.2.3. Environmental Management of the Operator, including definition of his environmental and social responsibilities

4.1.2.2.4. Need for watershed management in order to protect the reservoir from siltation

4.1.2.2.5. Review of environmental flow and proposals for requirements (in m3/s in dry and wet season), including the period of reservoir filling and possible impact on project design

4.1.2.3. Environmental and Social Impact on:

Rehabilitation of the access road to the Mount Coffee Hydropower plant site and the substation from Monrovia

4.1.3. Mitigation Measures

The Consultant shall propose mitigation measures, including needs for compensation for the potential environmental and social effects that would occur from pre-construction, construction and operational activities.

4.1.4. Provisional Environmental & Social Management Plan (ESMP)

The Consultant shall identify personnel and environmental management and training requirements for each stage of the project development and develop a Provisional Environmental & Social Management Plan (ESMP) as part of the overall ESIA report.

The ESMP shall include an appropriate monitoring programme to determine impacts on the physical, biological and human environments. This programme will be used to verify whether predictions of environmental and social impacts, developed in the design phase, are accurate and that unforeseen impacts are detected at an early stage. This will allow corrective measures to be implemented before significant damage takes place. The monitoring plan should specify what will be monitored (indicators), when, by whom and the cost implications (investment cost and recurrent costs). The ESMP shall include a Vegetation Management Plan as well as a plan for the Management of Archaeological and Cultural Property.

The Consultant shall take into consideration lessons learnt from similar ESIA's done on similar projects and shall reflect such in the ESMP. It is hoped that the information gained from a well-designed monitoring programme will be useful in refining future designs to be more cost-effective and have fewer, and less serious, environmental and social impacts.

4.1.5. Public Consultations and Information

The Consultant shall be required to undertake consultations with a number of relevant agencies including NGO's and the public, regarding the proposed project. The Consultant shall be required to make public consultations after the preparation of the draft Scoping Report (including a consultation on the draft Terms of Reference for the ESIA), after the preparation of the draft ESIA report and during the preparation of the ESMP.

The EIS shall include the attendants, dates, discussion/minutes and other records of such consultations.

The Consultant shall be required to prepare a non-technical summary report of the impact assessments in the local languages in the areas involved as mandated by the World Bank guidelines. The Consultant shall also be required to organise informative meetings with the communities impacted by the project after the Impact Assessment Study Final Report has been adopted.

4.1.6. Environmental & Social Management Plan

The Consultant shall develop an Environmental & Social Management Plan (ESMP) for the Mount Coffee Hydropower project.

The ESMP to be developed shall include the following:

a. Composition and job description of project environmental and social management unit of the Project Implementation Team (PIT), which should include an environmental and resettlement/social development specialist
b. Structure of reporting for project environmental and social management unit; this should be linked with operational and administrative activities
c. Training and development for capability building in LEC and institutions in charge of environmental protection
d. Institutional aspects on responsibility and timing for all relevant issues during the implementation of the ESMP
e. Parameters to be monitored, e.g., water quality, noise, electromagnetic force, etc. and definition of responsibilities
f. Sampling sites
g. Frequency of measurements
h. Method of sampling and analysis
i. Monitoring programme
j. Proper and adequate record keeping
k. Places to be restricted to unauthorized persons

l. Environmental audit and review programme covering all activities to assess compliance with contract requirements and ensure meeting requirements of the EPA and other stakeholders including the general public. The programme should include:

- Internal review - undertaken by LEC staff reporting internally
- External audit - undertaken by independent consultants reporting to LEC.

The ESMP should outline responsibilities for implementation, the time frame of implementation, and budget as required in the EU and/or World Bank's format of the preparation of such documents. Specific requirements relating to ESMP's are set out in Annex C of the World Bank's OP 4.01 and the Consultant shall conform to these requirements. The Consultant shall also conform to the requirements of EU directives. In case of contradiction, the most stringent shall apply.

The ESMP shall ensure that environmental and social 'due diligence' is observed in the operational/maintenance activities of the Mount Coffee Hydropower Project.

4.1.7. Preparation of Illustrative Materials

The Consultant shall include relevant maps, plans, tables, graphs, diagrams and any other illustrative material that would make easy appreciation of the content of the ESIA and ESMP. These materials shall show environmental sites/issues/risks and restoration / landscape of the study area. Examples of features that could be represented on the maps include:

a. Communities
b. Ecological zones
c. Natural resources (habitats, forests)
d. Places of historic and cultural interests
e. Risky zones (floods, landslides, etc.)
f. (Re) landscaping (devegetation, reforestation, quarries)

4.1.8. Training Programme

In order to ensure that commitments made under the Environmental Permits are acted upon in a comprehensive and reasonable manner, there is the need for training of staff of LEC and the institutions in charge of environmental protection. The training would cover the issues as outlined in the Provisional Environmental & Social Management Plan in the EIS which could include the following:

- Management and monitoring of health, safety and environmental and social issues
- Environmental and Social impact mitigations.

The Consultant shall design and propose the training programme, which should be approximately costed. The training shall be done in a workshop to be organized by the Consultant after receipt of Environmental Permit. The Consultant shall discharge LEC of all costs (including but not limited to venue, transportation, subsistence, interpretation, accommodation if necessary) of providing the training. The outcome of discussions at this training workshop would be an input to finalise the ESMP reports. At the conclusion of the training, the Consultant shall submit a comprehensive report on the training conducted, as part of the Monthly Report for the month in which the training was conducted.

The Consultant will analyse the need for additional capacity building for the involved institutions and actors, and design such programme, and provide a cost estimate (see also 4.1.6.c).

4.1.9. Public Information and Sensitisation Campaign

At the end of the study and elaboration of various reports approved by the relevant authorities in the country, the Consultant shall prepare a non-technical summary report of the impact assessments in the official languages of the country and in the local languages prevailing in the areas of the project.

The Consultant shall carry out informative and sensitization campaigns to the populations, and to public and private entities. The campaigns shall be undertaken in the official language of the country and in the local languages of the project area. The public informative and sensitization campaigns shall contain issues related but not be limited to:

- Project Implementation,
- Project benefits for the country and the populations,
- Environmental and social impacts of the project,
- Envisaged compensation measures
- Dangers and safety measures related to the project

The Consultant shall propose an appropriate approach and methodology that shall be approved by institutions in charge of environmental protection in the country. The Consultant shall prepare appropriate presentation material and propose a medium acceptable to institutions in charge of environmental protection in the country for the informative and sensitization campaign.

4.1.10. Project Alternatives

The Consultant will explore the potential of other alternative sources of power generation in the country and in particular for the power supply to Monrovia and comment on cost, economic aspects, construction time and environmental and social aspects, compared to the Mount Coffee Hydropower project.

4.1.11. Cost estimate

The Consultant shall prepare a detailed cost estimate of the actions resulting from the proposed mitigating and compensation measures and all the activities needed to implement the Management and Monitoring Plans and Programs.

4.2. Additional studies and tasks

The following additional studies and tasks are included in the scope of the work:

4.2.1. Emergency Action Plan

Preparation of an outline and ToR for an Emergency Preparedness and Action Plan, to be carried out outside this assignment, at a later date.

4.2.2. Decommissioning Plan

Preparation of an outline and financial arrangement for a decommissioning plan.

4.2.3. Cumulative impact assessment on the St Paul river developments

Summary assessment of the economic aspects and the least cost option for the development of the construction and operation of the St Paul river cascade, and elaboration on the cumulative impacts on the environmental and social aspects, in particular on the impact on the Mount Coffee Hydropower project (the rehabilitation), on the downstream area of Mount Coffee and on the Estuary and Maritime Region

The identified developments in addition to the Mount Coffee Hydropower project are:

- Via Reservoir
- SP-1B (stage 1)-78 MW
- SP-2 (stage 1)- 120 MW
- Mount Coffee (stage 2)- 122 MW
- SP-1B (stage 2)- 143 MW
- SP-2 (stage 2)- 220 MW
- V-1-132 MW

This assessment should make use of existing studies .

4.2.4. Impact of the project on the White Plains Water Treatment Plant

Downstream of the Mount Coffee Hydropower plant is the raw water intake from the St Paul River for the White Plains Water Treatment Plant, which serves the City of Monrovia.

An assessment should be carried out on the water quality of the raw water downstream of the Power plant, the impact of the tidal salt water intrusion from the sea in the intake area and the feasibility to transfer the raw water intake to the St Paul River upstream of the Mount Coffee Plant (including measures to be taken, construction needs, tentative cost, ROW for the pipeline relocation and/or extension and the related Environmental and Social Impacts).

4.2.5. World Bank Safeguard Policies

The Consultant should analyse and report on which World Bank Safeguard Policies have been triggered, as well as how these policies have been addressed.

A1.2: The ESIA and RAP Team

The members of the Consultant’s team who are so far included in the assignment are listed here.

Table 30-1: ESIA and RAP team

Name	Position	Nationality
Dr. Robert Zwahlen	Team Leader, ESIA Expert	Swiss
Ms. Britta Lammers	Biodiversity Expert, Deputy Team Leader	German
Mr. Alan Edwards	Hydropower Engineer	British
Mr. Thomas Langer	Environmental Specialist	Swiss
Ms. Imelda Yhr	Sociologist, Resettlement Expert	Danish
Mr. Victor Puomogne	Fisheries Expert	Cameroonian
Mr. Sylvain Nkwenkeu	Health Expert	Cameroonian
Mr. Nolé Tsabang	Botanist	Cameroonian
Mr. Mitchell S. Kumbelay	Forestry Expert	Liberia
Mr. Albert Thompson	Agricultural Expert	Liberian
Mr. E. Blamo Robinson	Communications Expert	Liberian
Mr. Wollor Topor	Sociologist	Liberian
Mr. Alfred B. Stevens	Data Bank Manager	Liberian
Mr. Wassim A. Hamdan	ESIA Evaluator	Liberian

ANNEX 2: LEGAL AND ADMINISTRATIVE FRAMEWORKE

Office of the Executive Director

REPUBLIC OF LIBERIA
ENVIRONMENTAL PROTECTION AGENCY
P.O. Box 4024
4th Street Sinkor, Tubman Boulevard,
1000 Monrovia, 10 Liberia

EPA

ED/ EPA-06/0116/12/ RL

Shahid Mohammed
Chief Executive Officer
Liberia Electricity Corporation
Monrovia Liberia

1 May 2012

Dear Sir:

I present my compliments and wish to acknowledge receipt of Project Brief and Scoping Report for the rehabilitation of the Mount Coffee Hydroelectric Power Plant in White Plains, Montserrado County.

I am pleased to inform you that the submissions are complete and consistent with the outline prescribed by the Agency. Consequently, I wish that you inform your independent environmental evaluators: Poyry Energy (International) and EarthTime (National) to proceed with the final Environmental & Social Impact Assessment (ESIA) studies.

Additionally, be informed that the appropriate permit fee for this undertaking will be communicated in the immediate future.

Thanks for your usual cooperation as we work together to ensure sound environmental management.

Kind regards

Anyaa Vohiri

Anyaa Vohiri
EXECUTIVE DIRECTOR

AV/vlc

Mobile: +231 6514013 *Fax 231 77523432* *E-mail:vohiri@yahoo.com*

ANNEX 3: THE PROJECT

No entries in this Annex

ANNEX 4: THE STUDY AREA

No entries in this Annex

ANNEX 5: THE ENVIRONMENT: GENERAL CONSIDERATIONS

No entries in this Annex

ANNEX 6: GEOLOGY AND SOILS

No entries in this Annex

ANNEX 7: CLIMATE

No entries in this Annex

ANNEX 8: WATER

Table 30-2: Water quality sample location

No.	*Sample Location*	*X (UTM)*	*Y (UTM)*	*Altitude (m)*	*Type*
1.	**St. Paul River, White Plains (LWSC)**	718465.93	317460.03	14	Surface water
2.	**St. Paul River, Mt. Coffee**	715067.68	314623.43	0	Surface water

Table 30-3: Water quality St Paul River, Mt. Coffee, Sampling Date: 22-01-2009

No.	*Parameter*	*Unit*	*Measured value*	*Limit value for analysis*	*Method*
1.	Faecal Coliform	CFU/100ml	1240	1CFU/100ml	Membrane filtration
2.	Total Coliform	CFU/100ml	1500	1CFU/100ml	Membrane filtration
3.	Arsenic	mg/ L	<0.001	0.001 mg/L	Graphite Furnace-AAS
4.	Boron	mg/ L	<0.05	0.05 mg/L	EPA200-7/8
5.	Barium	mg/ L	0.04	0.002 mg/L	EPA200-7/8
6.	Cadmium	mg/L	0.00048	0.00025 mg/L	Graphite Furnace-AAS
7.	Chromium	mg/L	<0.001	0.001 mg/L	Graphite Furnace-AAS
8.	Copper	mg/L	0.003	0.001 mg/L	Graphite Furnace-AAS
9.	Cyanide	mg/ L	<0.02	0.02 mg/L	Spectrophotometer HACH 8027
10.	Fluoride	mg/ L	<0.2	0.2 mg/L	Spectrophotometer HACH 8027
11.	Iron	mg/L	4.3	0.25mg/L	Frame-AAS
12.	Lead	mg/L	0.0028	0.001 mg/L	Graphite Furnace-AAS
13.	Manganese	mg/L	0.0311	0.001 mg/L	Graphite Furnace-AAS
14.	Mercury	mg/ L	<0.0005	0.0005 mg/L	EPA200-7/8
15.	Molybdenum	mg/L	<0.005	0.005 mg/L	Graphite Furnace-AAS
16.	Nickel	mg/L	<0.0025	0.0025 mg /L	Graphite Furnace-AAS
17.	Potassium	mg/L	0.8	0.05 mg/L	Flame emission photometry
18.	Sodium	mg/L	5	0.1 mg/L	Flame emission photometry
19.	Selenium	mg/L	<0.001	0.001 mg/L	Graphite Furnace-AAS
20.	Temperature	°C	25.4	-5.0 °C	Standard Platinum Resistance Thermometer (ITS-90)
21.	Turbidity	NTU	15.2	0.2 NTU	Nephelometric
22.	Conductivity	uS/cm at 25°C	28.7	0.1 uS/cm	Electrometric
23.	Apparent color	Pt Co units	201	1 Pt Co units	Colorimetric, Pt-Co
24.	pH	pH Units 25°C	6.17	0.01	Electrometric
25.	Hydroxide Alkalinity	mg/L as $CaCO_3$	0	*	*
26.	Carbonate Alkalinity	mg/L as $CaCO_3$	0	*	*
27.	Bicarbonate Alkalinity	mg/L as $CaCO_3$	25.2	*	*
28.	Total Hardness	mg/L as $CaCO_3$	9	1 mg/L $CaCO_3$	Titrimetric, EDTA
29.	Calcium Hardness	mg/L as $CaCO_3$	<1	1 mg/L $CaCO_3$	Titrimetric, EDTA
30.	Magnesium hardness	mg/L as $CaCO_3$	8.5	1 mg/L $CaCO_3$	Titrimetric, EDTA
31.	Calcium	mg/L Ca^{2+}	<0.4	**	**
32.	Magnesium	mg/L Mg^{2+}	2.1	**	**

No.	Parameter	Unit	Measured value	Limit value for analysis	Method
33.	Residual Chloride[1]	ppm	0.05	0.01	DPD-1 Free Chlorine
34.	Silica	mg/L Si	9.8	0.01 mg/L SiO_2	Colorimetric, Heteropoly
35.	Sulfate	mg/L SO_4^{2-}	<7	7 mg/L	Colorimetric
36.	Nitrate	mg/L NO_3^-	7.0	***	***
37.	Nitrate-Nitrogen	mg/L NO_3^- N	1.6	0.5 mg/L	Colorimetric
38.	Nitrite	mg/L NO_2^-	<0.007	***	***
39.	Nitrite-Nitrogen	mg/L NO_2^-N	<0.001	0.001 mg/L	Colorimetric
40.	Ammonia-Nitrogen	mg/L NH_3^-N	<0.09	0.09 mg/L	Colorimetric, salicylate
41.	Chlorides	mg/L $C1^-$	5.20	0.25 mg/L	Titrimetric, silver nitrate
42.	Total Dissolved Solids	mg/L 25°C	14.2	1.0 mg/L	Electrometric

*Alkalinity tests are done by titration with HCL as phenolphthalein and mixed indicator alkalinities (MDL 0.2 mg/L as $CaCO_3$) from which the corresponding OH, HCO_3, and CO_3 alkalinities are calculated.

**Calcium and magnesium are calculated from calcium and total hardness tests which are determined by titration with EDTA (MDL 0.2 mg/L as $CaCO_3$).

*** Nitrate and nitrite are determined colorimetrically, MDLs are 0.5 mg/L NO3-N and 0.001 mg/L NO_2-N,respectively

All tests are performed in accordance to the “standard Methods for the Examination of Water and Wastewater”, 21st Edition, 2005 as approved by the American Public Health Association, the American Water Works Association, and the Water Environment Federation unless otherwise noted.

[1] Values for Residual Chloride parameter were obtained on July 16, 2009.

Table 30-4: Water quality St Paul River, White Plains, Sampling Date: 22-01-2009

No.	***Parameter***	***Unit***	***Measured value***	***Limit value for analysis***	***Method***
1.	Faecal Coliform	CFU/100ml	466	1CFU/100ml	Membrane filtration
2.	Total Coliform	CFU/100ml	>500	1CFU/100ml	Membrane filtration
3.	Arsenic	mg/L	<0.001	0.001 mg/L	Graphite Furnace-AAS
4.	Boron	mg/ L	<0.05	0.05 mg/L	EPA200-7/8
5.	Barium	mg/ L	0.007	0.002 mg/L	EPA200-7/8
6.	Cadmium	mg/L	0.00036	0.00025 mg/L	Graphite Furnace-AAS
7.	Chromium	mg/L	<0.001	0.001 mg/L	Graphite Furnace-AAS
8.	Copper	mg/L	0.0023	0.001 mg/L	Graphite Furnace-AAS
9.	Cyanide	mg/ L	<0.02	0.02 mg/L	Spectrophotometer HACH 8027
10.	Fluoride	mg/ L	0.49	0.2 mg/L	Spectrophotometer HACH 8027
11.	Iron	mg/L	0.52	0.25mg/L	Frame-AAS
12.	Lead	mg/L	0.0034	0.001 mg/L	Graphite Furnace-AAS
13.	Manganese	mg/L	0.0046	0.001 mg/L	Graphite Furnace-AAS
14.	Mercury	mg/ L	<0.0005	0.0005 mg/L	EPA200-7/8
15.	Molybdenum	mg/L	<0.005	0.005 mg/L	Graphite Furnace-AAS
16.	Nickel	mg/L	<0.0025	0.0025 mg /L	Graphite Furnace-AAS
17.	Potassium	mg/L	1.1	0.05 mg/L	Flame emission photometry
18.	Sodium	mg/L	4	0.1 mg/L	Flame emission photometry
19.	Temperature	°C	26.8	-5.0 °C	Standard Platinum Resistance Thermometer (ITS-90)
20.	Selenium	mg/L	<0.001	v	Graphite Furnace-AAS
21.	Turbidity	NTU	2.3	0.2 NTU	Nephelometric
22.	Conductivity	uS/cm at 25°C	27.1	0.1 uS/cm	Electrometric
23.	Apparent color	Pt Co units	55	1 Pt Co units	Colorimetric, Pt-Co
24.	pH	pH Units 25°C	6.32	0.01	Electrometric
25.	Hydroxide Alkalinity	mg/L as $CaCO_3$	0	*	*
26.	Carbonate Alkalinity	mg/L as $CaCO_3$	0	*	*
27.	Bicarbonate Alkalinity	mg/L as $CaCO_3$	23.2	*	*
28.	Total Hardness	mg/L as $CaCO_3$	10	1 mg/L $CaCO_3$	Titrimetric, EDTA
29.	Calcium Hardness	mg/L as $CaCO_3$	3	1 mg/L $CaCO_3$	Titrimetric, EDTA
30.	Magnesium hardness	mg/L as $CaCO_3$	7	1 mg/L $CaCO_3$	Titrimetric, EDTA
31.	Calcium	mg/L Ca^{2+}	1.2	**	**
32.	Magnesium	mg/L Mg^{2+}	1.7	**	**
33.	Residual Chloride[2]	ppm	0.03	0.01	DPD-1 Free Chlorine
34.	Silica	mg/L Si	4.6	0.01 mg/L SiO_2	Colorimetric, Heteropoly
35.	Sulfate	mg/L SO_4^{2-}	<7	7 mg/L	Colorimetric
36.	Nitrate	mg/L NO_3^-	8.5	***	***
37.	Nitrate-Nitrogen	mg/L NO_3^- N	1.9	0.5 mg/L	Colorimetric
38.	Nitrite	mg/L NO_2^-	0.007	***	***
39.	Nitrite-Nitrogen	mg/L NO_2^-N	0.002	0.001 mg/L	Colorimetric

[2] Values for Residual Chloride parameter were obtained on July 16, 2009.

No.	Parameter	Unit	Measured value	Limit value for analysis	Method
40.	Ammonia-Nitrogen	mg/L $NH_3{}^{-}N$	<0.09	0.09 mg/L	Colorimetric, salicylate
41.	Chlorides	mg/L $C1^{-}$	5.0	0.25 mg/L	Titrimetric, silver nitrate
42.	Total Dissolved Solids	mg/L 25°C	13.6	1.0 mg/L	Electrometric

*Alkalinity tests are done by titration with HCL as phenolphthalein and mixed indicator alkalinities (MDL 0.2 mg/L as $CaCO_3$) from which the corresponding OH, HCO_3, and CO_3 alkalinities are calculated.

**Calcium and magnesium are calculated from calcium and total hardness tests which are determined by titration with EDTA (MDL 0.2 mg/L as $CaCO_3$).

*** Nitrate and nitrite are determined colorimetrically, MDLs are 0.5 mg/L NO_3-N and 0.001 mg/L NO_2-N,respectively

All tests are performed in accordance to the “standard Methods for the Examination of Water and Wastewater”, 21st Edition, 2005 as approved by the American Public Health Association, the American Water Works Association, and the Water Environment Federation unless otherwise noted.

Table 30-5: Water quality St Paul River, Mt. Coffee, Sampling Date: 16-07-2009

No.	***Parameter***	***Unit***	***Measured value***	***Limit value for analysis***	***Method***
1.	Faecal Coliform	CFU/100ml	40	1CFU/100ml	Membrane filtration
2.	Total Coliform	CFU/100ml	2300	1CFU/100ml	Membrane filtration
3.	Arsenic	mg/L	<0.001	0.001 mg/L	Graphite Furnace-AAS
4.	Boron	mg/L	<0.05	0.05 mg/L	EPA200-7/8
5.	Barium	mg/L	0.04	0.002 mg/L	EPA200-7/8
6.	Cadmium	mg/L	0.0045	0.00025 mg/L	Graphite Furnace-AAS
7.	Chromium	mg/L	<0.001	0.001 mg/L	Graphite Furnace-AAS
8.	Copper	mg/L	0.0034	0.001 mg/L	Graphite Furnace-AAS
9.	Cyanide	mg/L	<0.02	0.02 mg/L	Spectrophotometer HACH 8027
10.	Fluoride	mg/L	<0.2	0.2 mg/L	Spectrophotometer HACH 8027
11.	Iron	mg/L	1.45	0.25mg/L	Frame-AAS
12.	Lead	mg/L	0.00161	0.001 mg/L	Graphite Furnace-AAS
13.	Manganese	mg/L	0.0318	0.001 mg/L	Graphite Furnace-AAS
14.	Mercury	mg/L	<0.0005	0.0005 mg/L	EPA200-7/8
15.	Molybdenum	µg/L	<0.005	0.005 mg/L	Graphite Furnace-AAS
16.	Nickel	µg/L	0.00137	0.0025 mg/L	Graphite Furnace-AAS
17.	Potassium	mg/L	1.5	0.05 mg/L	Flame emission photometry
18.	Sodium	mg/L	4.0	0.1 mg/L	Flame emission photometry
19.	Selenium	mg/L	<0.001	0.001 mg/L	Graphite Furnace-AAS
20.	Temperature	°C	27.1	-5.0 °C	Standard Platinum Resistance Thermometer (ITS-90)
21.	Turbidity	NTU	18.8	0.2 NTU	Nephelometric
22.	Conductivity	uS/cm at 25°C	20.1	0.1 uS/cm	Electrometric
23.	Apparent color	Pt Co units	164	1 Pt Co units	Colorimetric, Pt-Co
24.	pH	pH Units 25°C	5.86	0.01	Electrometric
25.	Hydroxide Alkalinity	mg/L as $CaCO_3$	0	*	*
26.	Carbonate Alkalinity	mg/L as $CaCO_3$	0	*	*
27.	Bicarbonate Alkalinity	mg/L as $CaCO_3$	14.2	*	*
28.	Total Hardness	mg/L as $CaCO_3$	16	1 mg/L $CaCO_3$	Titrimetric, EDTA
29.	Calcium Hardness	mg/L as $CaCO_3$	10	1 mg/L $CaCO_3$	Titrimetric, EDTA
30.	Magnesium hardness	mg/L as $CaCO_3$	6	1 mg/L $CaCO_3$	Titrimetric, EDTA
31.	Calcium	mg/L Ca^{2+}	4	**	**
32.	Magnesium	mg/L Mg^{2+}	1.5	**	**
33.	Residual Chloride[3]	ppm	0.05	0.01	DPD-1 Free Chlorine
34.	Silica	mg/L Si	4.44	0.01 mg/L SiO_2	Colorimetric, Heteropoly
35.	Sulfate	mg/L SO_4^{2-}	<7	7 mg/L	Colorimetric
36.	Nitrate	mg/L NO_3^-	<2.0	***	***
37.	Nitrate-Nitrogen	mg/L NO_3^- N	<0.5	0.5 mg/L	Colorimetric
38.	Nitrite	mg/L NO_2^-	0.004	***	***
39.	Nitrite-Nitrogen	mg/L NO_2^-N	0.001	0.001 mg/L	Colorimetric

[3] Values for Residual Chloride parameter were obtained on July 16, 2009.

No.	***Parameter***	***Unit***	***Measured value***	***Limit value for analysis***	***Method***
40.	Ammonia-Nitrogen	mg/L $NH_3{}^{-}N$	<0.09	0.09 mg/L	Colorimetric, salicylate
41.	Chlorides	mg/L $C1^{-}$	4.2	0.25 mg/L	Titrimetric, silver nitrate
42.	Total Dissolved Solids	mg/L 25°C	10.0	1.0 mg/L	Electrometric

*Alkalinity tests are done by titration with HCL as phenolphthalein and mixed indicator alkalinities (MDL 0.2 mg/L as $CaCO_3$) from which the corresponding OH, HCO_3, and CO_3 alkalinities are calculated.

**Calcium and magnesium are calculated from calcium and total hardness tests which are determined by titration with EDTA (MDL 0.2 mg/L as $CaCO_3$).

*** Nitrate and nitrite are determined colorimetrically, MDLs are 0.5 mg/L NO_3-N and 0.001 mg/L NO_2-N,respectively

All tests are performed in accordance to the "standard Methods for the Examination of Water and Wastewater", 21st Edition, 2005 as approved by the American Public Health Association, the American Water Works Association, and the Water Environment Federation unless otherwise noted.

Table 30-6: Water quality St Paul River, White Plains, Sampling Date: 16-07-2009

No.	***Parameter***	***Unit***	***Measured value***	***Limit value for analysis***	***Method***
1.	Faecal Coliform	CFU/100ml	1700	1CFU/100ml	Membrane filtration
2.	Total Coliform	CFU/100ml	4500	1CFU/100ml	Membrane filtration
3.	Arsenic	mg/L	<0.001	0.001 mg/L	Graphite Furnace-AAS
4.	Boron	mg/L	<0.05	0.05 mg/L	EPA200-7/8
5.	Barium	mg/L	0.033	0.002 mg/L	EPA200-7/8
6.	Cadmium	mg/L	0.00039	0.00025 mg/L	Graphite Furnace-AAS
7.	Chromium	mg/L	<0.001	0.001 mg/L	Graphite Furnace-AAS
8.	Copper	mg/L	0.0037	0.001 mg/L	Graphite Furnace-AAS
9.	Cyanide	mg/L	<0.02	0.02 mg/L	Spectrophotometer HACH 8027
10.	Fluoride	mg/L	<0.2	0.2 mg/L	Spectrophotometer HACH 8027
11.	Iron	mg/L	0.79	0.25mg/L	Frame-AAS
12.	Lead	mg/L	0.0123	0.001 mg/L	Graphite Furnace-AAS
13.	Manganese	mg/L	0.0206	0.001 mg/L	Graphite Furnace-AAS
14.	Mercury	mg/L	0.003	0.0005 mg/L	EPA200-7/8
15.	Molybdenum	µg/L	<0.005	0.005 mg/L	Graphite Furnace-AAS
16.	Nickel	µg/L	0.00428	0.0025 mg/L	Graphite Furnace-AAS
17.	Potassium	mg/L	1.1	0.05 mg/L	Flame emission photometry
18.	Sodium	mg/L	4.5	0.1 mg/L	Flame emission photometry
19.	Selenium	mg/L	<0.001	0.001 mg/L	Graphite Furnace-AAS
20.	Temperature	°C	26.6	-5.0 °C	Standard Platinum Resistance Thermometer (ITS-90)
21.	Turbidity	NTU	3.8	0.2 NTU	Nephelometric
22.	Conductivity	uS/cm at 25°C	18.16	0.1 uS/cm	Electrometric
23.	Apparent color	Pt Co units	136	1 Pt Co units	Colorimetric, Pt-Co
24.	pH	pH Units 25°C	5.86	0.01	Electrometric
25.	Hydroxide Alkalinity	mg/L as $CaCO_3$	0	*	*
26.	Carbonate Alkalinity	mg/L as $CaCO_3$	0	*	*
27.	Bicarbonate Alkalinity	mg/L as $CaCO_3$	18.2	*	*
28.	Total Hardness	mg/L as $CaCO_3$	13	1 mg/L $CaCO_3$	Titrimetric, EDTA
29.	Calcium Hardness	mg/L as $CaCO_3$	6	1 mg/L $CaCO_3$	Titrimetric, EDTA
30.	Magnesium hardness	mg/L as $CaCO_3$	7	1 mg/L $CaCO_3$	Titrimetric, EDTA
31.	Calcium	mg/L Ca^{2+}	2.4	**	**
32.	Magnesium	mg/L Mg^{2+}	1.7	**	**
33.	Residual Chloride[4]	ppm	0.03	0.01	DPD-1 Free Chlorine
34.	Silica	mg/L Si	4.10	0.01 mg/L SiO_2	Colorimetric, Heteropoly
35.	Sulfate	mg/L SO_4^{2-}	<7	7 mg/L	Colorimetric
36.	Nitrate	mg/L NO_3^-	2.0	***	***
37.	Nitrate-Nitrogen	mg/L NO_3^- N	0.5	0.5 mg/L	Colorimetric
38.	Nitrite	mg/L NO_2^-	0.008	***	***
39.	Nitrite-Nitrogen	mg/L NO_2^-N	0.002	0.001 mg/L	Colorimetric

[4] Values for Residual Chloride parameter were obtained on July 16, 2009.

No.	Parameter	Unit	Measured value	Limit value for analysis	Method
40.	Ammonia-Nitrogen	mg/L $NH_3^{-}N$	<0.09	0.09 mg/L	Colorimetric, salicylate
41.	Chlorides	mg/L $C1^{-}$	3.6	0.25 mg/L	Titrimetric, silver nitrate
42.	Total Dissolved Solids	mg/L 25°C	9.09	1.0 mg/L	Electrometric

*Alkalinity tests are done by titration with HCL as phenolphthalein and mixed indicator alkalinities (MDL 0.2 mg/L as $CaCO_3$) from which the corresponding OH, HCO_3, and CO_3 alkalinities are calculated.

**Calcium and magnesium are calculated from calcium and total hardness tests which are determined by titration with EDTA (MDL 0.2 mg/L as $CaCO_3$).

*** Nitrate and nitrite are determined colorimetrically, MDLs are 0.5 mg/L NO_3-N and 0.001 mg/L NO_2-N,respectively

All tests are performed in accordance to the “standard Methods for the Examination of Water and Wastewater”, 21st Edition, 2005 as approved by the American Public Health Association, the American Water Works Association, and the Water Environment Federation unless otherwise noted.

ANNEX 9: VEGETATION

Table 30-7: Plants identified in the parcels in the dam's zone of influence

	Downstream	**Reservoir**	**Upstream**
1	*Afroseralisia afzelii*	*Albizia adianthifolia*	*Afzelia bracteata*
2	*Alstonia boonei*	*Albizia ferruginea*	*Allanblackia floribunda*
3	*Anopyxis klaineana*	*Albizia zyzia*	*Amphimas pterocarpioides*
4	*Anthonotha fragrans*	*Alchornea cordifolia*	*Anthocleista vogelii*
5	*Berlinia occidentalis*	*Amphimas pterocarpoides*	*Anthonotha fragrans*
6	*Blighia sapida*	*Anisophyllea meniaudi*	*Anthonotha macrophylla*
7	*Blighia welwitschii*	*Anthocleista vogelii*	*Araliopsis tabouensis*
8	*Brachystegia leonensis*	*Cathormion altissimum*	*Barteria fistulosa*
9	*Casearia inaequalis*	*Ceiba pentandra*	*Beilschmiedia mannii*
10	*Cassipourea nialatou*	*Cleistopholis staudtii*	*Brachystegia leonensis*
11	*Cathormion altissimun*	*Dacryodes klaineana*	*Bridelia grandis*
12	*Ceiba pentandra*	*Drypetes sp*	*Bussea occidentalis*
13	*Chidlowia sanguinea*	*Funtumia elastica*	*Calpocalyx aubrevillei*
14	*Copaifera salikounda*	*Harungana madagascariensis*	*Canarium schweinfurthii*
15	*Coula edulis*	*Hevea brasiliensis*	*Carapa procera*
16	*Crudia gabonensis*	*Macaranga barteri*	*Cassipourea nialatou*
17	*Dacryodes klaineana*	*Macaranga hurifolia*	*Cathormion altissimun*
18	*Dacryodes staudtii*	*Macaranga monandra*	*Chrysophyllum perpulchrum*
19	*Duboscia macrocarpa*	*Macaranga schweinfurthii*	*Cleistopholis patens*
20	*Entandrophragma candolei*	*Macaranga spinosa*	*Cola sp*
21	*Eribroma oblongum*	*Macaranga staudtii*	*Cola verticillata*
22	*Ficus vogeliana*	*Myrianthus arboreus*	*Copaifera salikounda*
23	*Garcinia gnetoides*	*Nauclea diderrichii*	*Coula edulis*
24	*Guibourtia ehie*	*Nauclea pobeguinii*	*Cryptosepalum tetraphyllum*
25	*Haplormosia monophylla*	*Pentaclethra macrophylla*	*Cynometra ananta*
26	*Musanga cecropioides*	*Pterocarpus santalinoides*	*Dacryodes klaineana*
27	*Nauclea diderrichii*	*Pycnanthus angolensis*	*Dacryodes macrophylla*
28	*Nesogordonia papaverifera*	*Saccoglottis gabonensis*	*Daniellia ogea*
29	*Omphalocarpum elatum*	*Strombosia macrophylla*	*Diospyros sanza-minika*
30	*Ongokea gore*	*Tabernaemontana crassa*	*Diospyros sp*
31	*Parinaris excels*	*Uapaca guineensis*	*Entandrophragma angolense*
32	*Pterocarpus santalinoides*	*Uapaca heudelotii*	*Erythrophleum ivorensis*
33	*Quassia undulate*	*Xylopia staudtii*	*Erythroxylum mannii*
34	*Sacoglottii gabonensis*		*Funtumia africana*
35	*Santiria trimera*		*Gambecola sp*
36	*Scytopetalum tieghemii*		*Garcinia sp*
37	*Strombosia glaucescens*		*Gilbertiodendron splendidum*
38	*Tetraberlinia tubmaniana*		*Guarea cedrata*
39	*Tetrapleura tetraptera*		*Guibourtia ehie*
40	*Triplochiton scleroxylon*		*Irvingia gabonensis*
41	*Uapaca heudelotii*		*Khaya anthotheca*
42	*Xylopia aethiopica*		*Kigeria africana*
43			*Lophira alata*
44			*Nauclea diderrichii*
45			*Newtonia aubrevillei*

46			*Oldfieldia Africana*
47			*Ongokea gore*
48			*Panda oleosa*
49			*Parinaris excels*
50			*Pellegriniodendron diphyllum*
51			*Pentadesma butyracea*
52			*Penthaclethra macrophylla*
53			*Petersianthus macrocarpus*
54			*Piptadeniastrum africanum*
55			*Pschotria sp*
56			*Rhodognaphalon brevicuspe*
57			*Rinorea dentata*
58			*Saccoglottis gabonensis*
59			*Santiria trimera*
60			*Stachyothyrsus stapfiana*
61			*Strombosia glaucescens*
62			*Symphonia globulifera*
63			*Terminalia ivorensis*
64			*Terminalia superb*
65			*Tetraberlinia tubmaniana*
66			*Uapaca guineensis*
67			*Vitex corbisieri*
68			*Vitex micrantha*
69			*Xylopia aethiopica*
70			*Xylopia staudtii*
71			*Xylopia parviflora*
72			*Zanthoxylum tessmannii*

Table 30-8: Plants listed in the IUCN Red List

No.	Family	Species	IUCN
1	Annonaceae	*Monocyclanthus vignei*	EN
2	Sapotaceae	*Neolemonniera clitandrifolia*	EN
3	Sapindaceae	*Placodiscus pseudostipularis*	EN
4	Sapotaceae	*Tieghemella heckelii*	EN
5	Euphorbiaceae	*Amanoa bracteosa*	VU
6	Euphorbiaceae	*Amanoa strobilacea*	VU
7	Rhizophoraceae	*Anopyxis klaineana*	VU
8	Leguminosae	*Anthonotha vignei*	VU
9	Leguminosae	*Berlinia occidentalis*	VU
9	Leguminosae	*Copaifera salikounda*	VU
10	Boraginaceae	*Cordia platythyrsa*	VU
11	Leguminosae	*Cryptosepalum tetraphyllum*	VU
12	Euphorbiaceae	*Drypetes afzelii*	VU
13	Meliaceae	*Entandrophragma angolense*	VU
14	Meliaceae	*Entandrophragma candollei*	VU
15	Meliaceae	*Entandrophragma utile*	VU
16	Sterculiaceae	*Eribroma oblonga*	VU
17	Leguminosae	*Gilbertiodendron bilineatum*	VU
18	Meliaceae	*Guarea cedrata*	VU
19	Meliaceae	*Guarea thompsonii*	VU
20	Leguminosae	*Guibourtia ehie*	VU
21	Rubiaceae	*Hallea ledermannii*	VU

22	Leguminosae	*Haplormosia monophylla*	VU
23	Sterculiaceae	*Heritiera utilis*	VU
24	Flacourtiaceae	*Homalium smythei*	VU
25	Meliaceae	*Khaya anthotheca*	VU
26	Meliaceae	*Khaya ivorensis*	VU
27	Leguminosae	*Loesenera kalantha*	VU
28	Ochnaceae	*Lophira alata*	VU
29	Meliaceae	*Lovoa trichilioides*	VU
30	Moraceae	*Milicia regia*	VU
31	Leguminosae	*Millettia warneckei*	VU
32	Leguminosae	*Monopetalanthus compactus*	VU
33	Rubiaceae	*Nauclea diderrichii*	VU
34	Annonaceae	*Neostenanthera hamata*	VU
35	Sterculiaceae	*Nesogordonia papaverifera*	VU
36	Ochnaceae	*Ouratea amplectens*	VU
37	Rubiaceae	*Pausinystalia lane-poolei ssp. lane-poolei*	VU
38	Euphorbiaceae	*Phyllanthus profusus*	VU
39	Annonaceae	*Piptostigma fugax*	VU
40	Combretaceae	*Terminalia ivorensis*	VU
41	Leguminosae	*Tetraberlinia tubmaniana*	VU
42	Anacardiaceae	*Trichoscypha albiflora*	VU
43	Anacardiaceae	*Trichoscypha atropurpurea*	VU
44	Anacardiaceae	*Trichoscypha beguei*	VU
45	Anacardiaceae	*Trichoscypha cavalliensis*	VU
46	Annonaceae	*Uvariodendron occidentale*	VU
47	Flacourtiaceae	*Casearia barteri*	VU
48	Boraginaceae	*Cordia millenii*	VU
49	Leguminosae	*Pterocarpus santalinoides*	VU
50	Sterculiaceae	*Triplochiton scleroxylon*	VU
51	Leguminosae	*Didelotia idea*	VU

Sources: CBD Strategy and Action Plan – Liberia (Part II, English version),

ANNEX 10: TERRESTRIAL FAUNA

Table 30-9: Amphibian species

Family	Species	Common Name	IUCN
Arthroleptidae	*Arthroleptis spp**		LC
	Cardioglossa leucomystax		LC
Astylosternidae	*Astylosternus occidentalis*		LC
Bufonidae	*Bufo maculatus*	Flat-Backed Toad	LC
	Bufo regularis		LC
	Bufo superciliaris	Cameroon Toad	LC
	Bufo togoensis		NT
Hyperoliidae	*Afrixalus dorsalis*	Striped Spiny Reed Frog	LC
	Afrixalus nigeriensis		NT
	Hyperolius chlorosteus		NT
	Hyperolius concolor		LC
	Hyperolius fusciventris		LC
	Hyperolius guttulatus		LC
	Hyperolius picturatus		LC
	Leptopelis hyloides		LC
	Leptopelis macrotis		NT
	Leptopelis occidentalis		NT
	Phlyctimantis boulengeri		LC
Petropedetidae	*Petropedetes natator*		NT
	Phrynobatrachus accraensis		LC
	Phrynobatrachus alleni		NT
	Phrynobatrachus annulatus		EN
	Phrynobatrachus cf. *annulatus*		(EN)
	Phrynobatrachus fraterculus		LC
	Phrynobatrachus guineensis		NT
	Phrynobatrachus liberiensis		NT
	Phrynobatrachus phyllophilus		NT
	Phrynobatrachus plicatus		LC
	Phrynobatrachus tokba		LC
	Phrynobatrachus villiersi		VU
Pipidae	*Silurana tropicalis*		LC
Rhacophoridae	*Chiromantis rufescens*		LC
Ranidae	*Amnirana albolabris*		LC
	Amnirana occidentalis		EN
	Conraua alleni		VU
	Hoplobatrachus occipitalis	Crowned Bullfrog	LC
	Ptychadena aequiplicata		LC
	Ptychadena bibroni		LC
	Ptychadena longirostris		LC
	Ptychadena superciliaris		NT

*Records possibly comprise several species

Sources: Annika Hillers and Mark-Oliver Rödel, 2007, The amphibians of three national forests in Liberia, West Africa.

ANNEX 11: AQUATIC FAUNA

A11.1: Fish Species of the St. Paul river

Table 30-10: Fish species list of St. Paul river

No.	Species	Name	Family	Habitat	Length (cm)	Trophic Level	Status	IUCN	Migration Behaviour
1	*Brycinus longipinnis*	Longfin tetra	Alestidae	pelagic	14.6 TL	2.2	native		potamodrom
2	*Brycinus macrolepidotus*	True big-scale tetra	Alestidae	pelagic	64.7 TL	2.3	native		potamodrom
3	*Brycinus nurse*	Nurse tetra	Alestidae	pelagic	25.0 TL	2.4	native		potamodrom
4	*Hydrocynus forskahlii*	Elongate tigerfish	Alestidae	pelagic	95.2 TL	4	native		potamodrom
5	*Micralestes occidentalis*		Alestidae	pelagic	8.0 TL	3.1	native		
6	*Amphilius atesuensis*		Amphiliidae	demersal	11.4 TL	3	native		
7	*Amphilius platychir*	Mountain barbel	Amphiliidae	demersal	20.4 TL	3	native		
8	*Doumea chappuisi*		Amphiliidae	demersal	13.9 TL	3.1	native	VU	
9	*Paramphilius firestonei*		Amphiliidae	demersal	7.4 TL	3	native	EN	
10	*Ctenopoma kingsleyae*	Tailspot ctenopoma	Anabantidae	benthopelagic	24.5 TL	3.2	native		
11	*Anomalochromis thomasi*		Cichlidae	benthopelagic	6.1 TL	3.2	native		
12	*Hemichromis bimaculatus*	Jewelfish	Cichlidae	benthopelagic	16.6 TL	3.9	native		potamodrom
13	*Hemichromis fasciatus*	Banded jewelfish	Cichlidae	benthopelagic	24.9 TL	3.2	native		potamodrom
14	*Pelmatochromis buettikoferi*		Cichlidae	demersal	20.0 TL	3.4	native		
15	*Pelvicachromis humilis*		Cichlidae	demersal	12.5 TL	3.3	native		
16	*Sarotherodon caudomarginatus*		Cichlidae	demersal	19.0 TL	2.2	native		
17	*Sarotherodon melanotheron melanotheron*	Blackchin tilapia	Cichlidae	demersal	34.2 TL	2	native		
18	*Sarotherodon occidentalis*		Cichlidae	demersal	34.5 TL	2	native		
19	*Tilapia brevimanus*		Cichlidae	demersal	30.3 TL	2.2	native		
20	*Tilapia buttikoferi*		Cichlidae	benthopelagic	37.6 TL	2.1	native		
21	*Tilapia coffea*		Cichlidae	demersal	16.1 TL	2.3	endemic		

No.	Species	Name	Family	Habitat	Length (cm)	Trophic Level	Status	IUCN	Migration Behaviour
22	*Tilapia guineensis*	Guinean tilapia	Cichlidae	benthopelagic	36.6 TL	2.8	native		
23	*Tilapia zillii*	Redbelly tilapia	Cichlidae	benthopelagic	48.8 TL	2	native		potamodrom
24	*Tylochromis intermedius*		Cichlidae	benthopelagic	28.1 TL	2.6	native		
25	*Tylochromis jentinki*		Cichlidae	benthopelagic	32.9 TL	2.7	native		
26	*Tylochromis leonensis*		Cichlidae	benthopelagic	26.7 TL	2.6	native		
27	*Clarias buettikoferi*		Clariidae	demersal	19.2 TL	3.3	native		
28	*Clarias laeviceps laeviceps*	Catfish	Clariidae	demersal	31.7 TL	3.4	native		
29	*Clarias salae*		Clariidae	demersal	50.8 TL	3.4	native		
30	*Heterobranchus isopterus*		Clariidae	demersal	90.0 TL	3.6	native		potamodrom
31	*Heterobranchus longifilis*	Sampa	Clariidae	demersal	183.0 TL	3.7	native		potamodrom
32	*Chrysichthys johnelsi*		Claroteidae	demersal	40.3 TL	3	native		
33	*Chrysichthys maurus*		Claroteidae	demersal	62.2 TL	2.7	native		potamodrom
34	*Chrysichthys nigrodigitatus*	Bagrid catfish	Claroteidae	demersal	79.3 TL	2.6	native		potamodrom
35	*Barbus ablabes*		Cyprinidae	benthopelagic	11.7 TL	2.5	native		potamodrom
36	*Barbus aliciae*		Cyprinidae	pelagic	8.5 TL	2.9	native		
37	*Barbus eburneensis*		Cyprinidae	benthopelagic	9.0 TL	2.9	native	VU	
38	*Barbus huguenyi*		Cyprinidae	pelagic	5.3 TL	3	native	EN	
39	*Barbus lauzannei*		Cyprinidae	benthopelagic	13.2 TL	2.9	native	EN	
40	*Barbus macrops*	Blackstripe barb	Cyprinidae	benthopelagic	12.0 TL	3	native		potamodrom
41	*Barbus parawaldroni*		Cyprinidae	benthopelagic	28.1 TL	2.9	native		
42	*Barbus sacratus*		Cyprinidae	benthopelagic	31.2 TL	2.9	native		
43	*Labeo curriei*		Cyprinidae	benthopelagic	19.5 TL	2.4	native	CR	
44	*Raiamas steindachneri*		Cyprinidae	demersal	15.3 TL	2.9	native		
45	*Nannocharax fasciatus*		Distichodontidae	pelagic	8.1 TL	3.5	native		potamodrom
46	*Neolebias unifasciatus*		Distichodontidae	pelagic	5.1 TL	3.5	native		
47	*Eleotris daganensis*		Eleotridae	demersal	12.1 TL	3.5	native		
48	*Eleotris vittata*		Eleotridae	demersal	26.5 TL	3.7	native		amphidrom
49	*Kribia nana*		Eleotridae	demersal	4.9 TL	3.3	native		
50	*Awaous lateristriga*	West African freshwater goby	Gobiidae	demersal	26.4 TL	2.2	native		amphidrom

No.	Species	Name	Family	Habitat	Length (cm)	Trophic Level	Status	IUCN	Migration Behaviour
51	*Periophthalmus barbarous*	Atlantic mudskipper	Gobiidae	reef-associated	25.0 TL	3.2	native		amphidrom
52	*Hepsetus odoe*	Kafue pike	Hepsetidae	demersal	70.0 TL	4.5	native		potamodrom
53	*Lates niloticus*	Nile perch	Latidae	demersal	200.0 TL	4.5	native		potamodrom
54	*Malapterurus punctatus*		Malapteruridae	benthopelagic	26.2 TL	3.3	native		
55	*Malapterurus stiassnyae*		Malapteruridae	benthopelagic	36.6 TL	3.4	native		
56	*Mastacembelus liberiensis*		Mastacembelidae	benthopelagic	44.9 TL	3.6	native		
57	*Chiloglanis occidentalis*		Mochokidae	benthopelagic	6.2 TL	3.2	native		
58	*Chiloglanis occidentalis*		Mochokidae	benthopelagic	6.2 TL	3.2	native		
59	*Synodontis waterloti*		Mochokidae	benthopelagic	18.5 TL	2.5	native		
60	*Brienomyrus brachyistius*		Mormyridae	benthopelagic	15.1 TL	2.8	native		
61	*Hippopotamyrus paugyi*		Mormyridae	demersal	30.5 TL	3.2	native		
62	*Isichthys henryi*		Mormyridae	demersal	35.0 TL	3.2	native		
63	*Marcusenius thomasi*		Mormyridae	demersal	24.4 TL	2.5	native		
64	*Marcusenius ussheri*		Mormyridae	demersal	37.2 TL	3.1	native		potamodrom
65	*Mormyrops anguilloides*	Cornish jack	Mormyridae	demersal	150.0 TL	3.6	native		potamodrom
66	*Mormyrops breviceps*		Mormyridae	demersal	79.3 TL	3.3	native		
67	*Mormyrus tapirus*		Mormyridae	demersal	52.5 TL	3.2	native		
68	*Petrocephalus pellegrini*		Mormyridae	demersal	11.1 TL	3.1	native		
69	*Petrocephalus tenuicauda*		Mormyridae	demersal	13.8 TL	3.2	native		
70	*Callopanchax monroviae*		Nothobranchiidae	benthopelagic	8.0 TL	3.3	native	VU	territorial
71	*Callopanchax occidentalis*	Golden pheasant panchax	Nothobranchiidae	benthopelagic	8.0 TL	3.3	native		territorial
72	*Epiplatys annulatus*	Banded panchax	Nothobranchiidae	benthopelagic	4.0 TL	3.3	native		territorial
73	*Epiplatys barmoiensis*		Nothobranchiidae	benthopelagic	7.0 TL	3.3	native		territorial
74	*Epiplatys dageti dageti*	Redchin panchax	Nothobranchiidae	benthopelagic	6.0 TL	3.2	native		
75	*Epiplatys fasciolatus*		Nothobranchiidae	benthopelagic	9.0 TL	3.3	native		territorial
76	*Epiplatys lamottei*	Redspotted panchax	Nothobranchiidae	benthopelagic	7.0 TL	3.3	native	VU	territorial
77	*Epiplatys maeseni*		Nothobranchiidae	benthopelagic	6.0 TL	3.2	Misiden-tification		territorial
78	*Epiplatys olbrechtsi olbrechtsi*		Nothobranchiidae	benthopelagic	8.0 TL	3.3	native		territorial
79	*Epiplatys roloffi*		Nothobranchiidae	benthopelagic	6.0 TL	3.2	native	EN	territorial

No.	Species	Name	Family	Habitat	Length (cm)	Trophic Level	Status	IUCN	Migration Behaviour
80	*Epiplatys ruhkopfi*		Nothobranchiidae	benthopelagic	7.5 TL	3.3	native	CR	territorial
81	*Nimbapanchax leucopterygius*		Nothobranchiidae	pelagic			native		
82	*Nimbapanchax viridis*		Nothobranchiidae	benthopelagic	7.0 TL	3.2	native	VU	territorial
83	*Scriptaphyosemion bertholdi*	Berthold’s killi	Nothobranchiidae	benthopelagic	5.5 TL	3.2	native	EN	territorial
84	*Scriptaphyosemion brueningi*	Bruening’s killi	Nothobranchiidae	benthopelagic	6.0 TL	3.2	native	EN	territorial
85	*Scriptaphyosemion liberiense*		Nothobranchiidae	benthopelagic	6.0 TL	3.2	native		territorial
86	*Papyrocranus afer*	Reticulate knifefish	Notopteridae	demersal	80.0 TL	3.6	native		
87	*Aplocheilichthys spilauchen*	Banded lampeye	Poeciliidae	benthopelagic	7.0 TL	3.4	native		territorial
88	*Poropanchax normani*	Norman’s lampeye	Poeciliidae	benthopelagic	4.0 TL	3.3	native		territorial
89	*Rhexipanchax nimbaensis*	Mt. Nimba lampeye	Poeciliidae	benthopelagic	4.5 TL	3.1	native	VU	territorial
90	*Polypterus palmas buettikoferi*		Polypteridae	demersal	43.1 TL	3.4	native		
91	*Polypterus palmas palmas*	Shortfin bichir	Polypteridae	demersal	30.0 TL	2.9	native		
92	*Schilbe mandibularis*		Schilbeidae	demersal	50.0 TL	3.4	native		potamodrom

Source: Fishbase

A11.1: Fisheries Leaders Contacted in the Project Area

Table 30-11: Village group fisheries leaders and contacts.

Surnames and given names	Quality	Nber of fishers censed in the village	Village name	Contact (N° mobile phone)
Morris Swaray	Town chief	22	Zanna town (Clay Ashland), right side, down stream	0777125376
Fredrick A. Brown	Teacher	108	Banee town	0777304485
Mrs Bandu Koroma	Chair lady	Idem	Banee town	Idem
Lasana Kroma	Contact	Idem	Idem	0777156358
Emmett Johnston	Contact	49	Fofee (Lousiana)	0776001673
Georges Jones	Leader	35	Geeto town	0777752451
Jackson Kennedy	Leader	21	Vanyi town	0776829950
Sarah Mulba	Women leader	+17	Idem	Idem
Rolland Brigges	Town chief		Borbor town	0776145363
Molley Fofee	Town chief	Idem	Fofee	0777379363
James Carter		29	White palms	0776135526
Samuel Ford	Town chief	66	Harrisburg 1	0777006461
Sarah Swaray	Women leader	Idem	Harrisburg 1	0776203015
Aloysius Sewerd		104	Raymond camp	0777906356
Alphonsus Dreks	Leader	100	Mullsburg/Arringthon	C/O Sam Y. Garwoloquoi, phone 0777899165

A11.2: Lists of Fishermen Visited and Interviewed During the Study

Village: **Vanyi town** Date: 15/02/2012 Hour start 11h50 end 14 h00

N°	Surname and given names	Age or birth year	Matrimonial statut/Nber children	Study level/starting fishing activity or fish farming or fish marketing	Main gear (line, net, cast net, etc.)	Contact and observations phone contact, quality, other info)
	WOMEN					
01	Ehen koto	30	M/7	7 Primary	Net	0777113095
02	Bindu	34	M/4	1 Primary	Net	
03	Messassaki	32	M/3	Illiterate	Net	
04	Sarah Mulba	43	M/5	2 Primary	Net	0770548054
05	Sarah Maley	37	M/4	Illiterate	CastNet +Gillnet	
06	Maasa Vany	24	M/5	Illiterate	Net	8886787879
07	Beatrice Wama	34	M/5	Illiterate	Net	
08	Kema Moloba	40	M/7	Illiterate	Net	
09	Limou Benson	33	M/6	Illiterate	Net	
10	Louise Pensiu	28	M/5	Illiterate	Net	
11	Louise Fopwa	34	M/9	Illiterate	Net	Abs; potential leader
12	Fatu Aamma	25	M/3	7 Primary	Net	
13	Assta Tamma	20	M/1	2 Primary	Net	
14	Somo Uoo	27	M/5	5Primary	Net	
15	Asstu Saki	39	M/8	Illiterate	Net	
16	Fatu kennedy	28	M/3	2 Primary	Net	
17	Fanta Tamma	27	M/4	1Primary	Net	
	MEN					
18	J.Fayiah Varney	49	M/9	O level teacher	Net	
19	Edwain Maller	66	M/4	Illiterate	Net	
20	Konah Zeiglah	36	M/6	Illiterate	Net	
21	Edmond P.Sorka	33	M/6	1Primary	Net	
22	Daniel Fortspa	32	M/3	3Primary	Net	
23	James Fortspah	44	M/10	3Primary	Net	
24	Mosses Flomo	39	M/4	4 Primary	Net	
25	James lartey	34	M/7	4 Primary	Net	
26	George Hunter	44	M/5	6 Primary	Net	

27	Joseph Nathanaeil	33	M/4	4 Primary	Net	
28	Gabriel Domah	30	M/4	Secondry 9	Net (leader)	0777701108
29	Mosses Fortspah	30	M/4	Secondry 2	Net	
30	Jackson Lim kennedy	29	M/3	Secondry 10	Net	0776829950
31	Jospeh kolie	44	M/5	2 Primary		
32	James kollie	27	M/4	2 Primary		
33	J. witty Ezeiglah	28	M/3	2 Primary		
34	Jessy Soorkai	29	M/1	10	Net	
35	Sameson Sabah	26	M/3	6	Net	088661041
36	War Kolli	23	M/1			
37	Anthony Kenndy	42	M/2			
38	Bossy kennedy	22	M/2	7	Net	
39	Old Frombog	42	M/3			
40	Kekuioh Frombog	30	M/3			

Village : **Millsbury/Zakama main gate.**Date: 16/02/2012 Hour start 14h30 End:16h15

N°	Surname and given names	Age or birth year	Matrimonial statut/Nber children	Study level/startin fishing activity or fish farming or fish marketing	Main gear (line, net cast…)	Contact and observations, phone nber, quality, other info)
01	James Gronavoloquoi	33	M/5	High School	Net	0777165418
02	Lincoln Hoggord	42	M/3	High School	Net	0777301770
03	Samuel Yenkor	72	M/3	Illiterate	Net	
04	Reabel Yenkor	42	M/3	Illiterate	Net	Mrs sam
05	Thomas Johnson	51	M/2	High School	Line	0776414675
06	Graybuo Gaononkomes	32	M/5	High School	Net	Mrs james
07	David Gaononkomes	49	M/13	High School	Net	0777157154
08	Old Diggs	34	M/5	High School	Net	
09	Junior Woods	31	M/1	High School	Line	
10	David Pewce	20		High School	Line	
11	Jackson Sumo	18		High School	Net	
12	James Dartus	18		Illiterate	Line	2007
13	Godler Kenndy	18		Illiterate	Line	6
14	Alfred Kollie	23	B/1	High School	Net	
15	Daniel Y. Mullah	66	M/4	High School	Line	1964
16	Bestman Kenned	39	M/5	Illiterate	Line	
17	Kakula Firba	31	M/4	Illiterate	Net	
18	David Firboy	31	M/2	Illiterate	Net	0777826178
19	Thomas Koker	55	M/8	High School	Line	0776891584
20	Herry Japan	75	M/2	Illiterate	Line	
21	Youguoi kowu	25	M/1	High School	Net	
22	Alphonso Diggs	32	M/5	High School	Net	0776262155
23	Koiwu Zakama	44	M/4	High School	Net	
24	Konmaze Kuwu	38	M/5	10		077143049
25	Simeon Hoggod	30				Abs
26	Papay gibadarwu	31	M/3	5 Primary	Net	077273511
27	Jyouguoi Gaflor	32	M/3	9 Primary	Cast	0776378266
28	Forday damtus	43	M/3	8Primary		0776078710
29	Joseph Obie	38	M/1	7Primary		0776054401
30	Solomon Obie	33		Abs		
31	Abrahm Gabomdah	35				
32	Jerw wright	35	M/14	5 Primary		077137066
33	Arther Morris	62	M/3	2 Primary		
34	Mose Moore	39	M/1			
35	Mose Kolubah	23	M/3	6		
36	Forkpah kolubah	28	Abs			
37	Momo Hoggod	38	M/2			
38	Samuel Gbanjarh	21	M/2	7		
39	James Wilson	30	M/3			
40	Peter Fiomo	33	M/3			

Village : **Arrighton-Gate town** Date: 16/02/2012 Hour start 14h15 End:

N°	Surname and given names	Age or birth year	Matrimonial statut/Nber children	Study level/startin fishing activity or fish farming or fish marketing	Main gear (line, net cast…)	Contact and observations phone nber, quality, other info)
01	Korpo zakama	42	M/6	ABC	Net	0776445551
02	Mary Morres	45	M/5	ABC	Net	
03	Rose Clemens	38	M/5	ABC	Fishing farmer	-
04	Konah Morris	49	M/6	ABC	Line/net/basket	
05	Lorpu Sumo	40	M/6	ABC	Line/net/basket	

06	Rebbeca Killeu	33	M/1	ABC	Line/net/basket	
07	Pallahn Sumo	37	M/4	ABC	Line/net/basket	0776612512
08	Satta Clemen	65	M/11	ABC	Line/net/basket	
09	Kebbeh Hossard	37	M/4	ABC	Line/net/basket	
10	Kebbeh Kollie	25	M/3	ABC	Line/net/basket	
11	Tumu Wrin	40	M/4	ABC	Line/net/basket	
12	James Victoria Hossard	27	M/1	ABC	Line/net/basket	
13	Saran Hossard	40	M/4	ABC	Line/net/basket	
14	Confort Jimmy	36	M/5	ABC	Line/net/basket	
15	Ganmai Kenneh	41	M/2	ABC	Line/net/basket	
16	Cathrine Wright	26	M/1	ABC	Line/net/basket	
17	Rosephine	25	M/1	ABC	Line/net/basket	
18	Musu Vamer	24	M/1	ABC	Line/net/basket	
19	Mama Fiomo	48	M/4	ABC	Line/net/basket	
20	Siah Zakama	28	M/4	ABC	Line/net/basket	
21	EBUM Kioh	29	M/2	ABC	Line/net/basket	
22	Konah	38	M/6	ABC	Line/net/basket	
23	Rose Mulban	16	M/4	ABC	Line/net/basket	
24	Kebbeh sumo	24	M/1	ABC	Line/net/basket	
25	Fatu Wright	34	M/4	ABC	Line/net/basket	
26	Konto Gayflor	39	M/4	ABC	Line/net/basket	
27	Konto Kolubah	38	M/1	ABC	Line/net/basket	
28	Garmai Kolubah	28	M/2	ABC	Line/net/basket	
29	Garmai Gbabanwu	28	M/2	ABC	Line/net/basket	
30	Kiubo Garwoloquoi	39	M/13	ABC	Line/net/basket	
31	Esther Diggs	38	M/3	ABC	Line/net/basket	
32	Louise Diggs	41	M/2	ABC	Line/net/basket	
33	Maitta Wright	42	M/3	ABC	Line/net/basket	
34	Orthu Obie	39	M/5	ABC	Line/net/basket	
35	Noimi Obie	30	M/2	ABC	Line/net/basket	
36	Hawa Obie	49	M/5	ABC	Line/net/basket	
37	Cecilia Obie	50	M/6	ABC	Line/net/basket	
38	Musu Hill	50	M/2	ABC	Line/net/basket	
39	Meta Wright	27	M/3	ABC	Line/net/basket	
40	Yamga Sumo	33	M/4	ABC	Line/net/basket	
41	Kannah Sumo	49	M/4	ABC	Line/net/basket	
42	Godma Will	39	M/1	ABC	Line/net/basket	
43	Bastty Kamah	24	M/4	ABC	Line/net/basket	
44	Babay kenneh	64	M/5	ABC	Line/net/basket	
45	Kiubo Sumo	40	M/5	ABC	Line/net/basket	
46	Jenneh Wright	65	M/20	ABC	Line/net/basket	
47	Esther Sackeq	20	M/2	ABC	Line/net/basket	
48	Junior Gbagarwu					
49	Bestman Kenndy					
50	John Obie					
51	Arthur Clemens					
52	William Wright					
53	Joseph Clemens					
54	Gballah Clemens					
55	David Pewee					
56	James Kesselee					
57	David Mulbah					
58	Jackson Sumo					

Village : **Geeto-town** Date: 17/02/2012 Hour start 10h15 End:12h00
GPS 06°2994 N' 10°3397 W'

N°	Surname and given names	Age or birth year	Matrimonial statut/Nber children	Study level/startin fishing activity or fish farming or fish marketing	Main gear (line, net cast…)	Contact and observations phone nber, quality, other info)
01	George R. janes	40	M/6	9 grade	Net	0777752451
02	Orsteen sodai	33	M/1	11 grade	Net + Line	0880378297
03	Zubah sirleas	42	M/1	ABC	Hook	Fished dam
04	Musu Sackie	60	B/5	ABC	Net	Town leader
05	SANOE sACKIE	46	B/3	ABC	NET	
06	Botoe Gbassay	25	M/2	ABC	Line	8886787879
07	Sabah Zazay	39	M/4	10 grade	Line	
08	Esther Saah	24	M/3	ABC	Net	
09	Aason Sokpah	27	M/5			
10	Zolu Watson	45	M/2	3 grade	Net + Line	
11	Ealhman waxton	42	M/3	3 grade	Hook	

12	Fatu Sunday	33	M/6	ABC	Net	
13	Doris fiomo	43	M/6	3 grade	Net	
14	Dapa Kallah	41	M/5	ABC	Net	
15	Moses Lamah	39	M/9	ABC	Line	
16	Varney waxton	34	M/6	Abs	Net	
17	Fatu Johson	39	M/1	Abs	Net	
18	Decontee Soydee	28	M/2		Net	
19	Varney Dulih	27	M/6	6 grade	Net	0777952337
20	Abraham Garf	31	M/4	7 grade	Net + Line	
21	Morta Jones	31	M/2	6 grade	Net +Line	Mrs jones
22	Fomata Ganet	45	M/3	ABC	Net	
23	Joseph Gwlah	44	M/5	10 grade	Net + Line	07776368086
24	Rancy Delgol	28	M/3	3 grade	Net	0776645516
25	George kondu	67	M/6	3grade	Net + Line	077005031
26	Tennie Robert	60	M/4	ABC	Basket	
27	Mamie Morris (Mrs)	46	M/3	ABC	Net	
28	Fain Sunday	48	M/4	ABC	Line	
29	Rebecca Dumah	32	M/6	1 grade	Net	
30	Fatu Ballah	74	M/10	ABC	Net	
31	Mama Kollie	43	M/2	10 grade	Net	
32	Annie sanda	48	M/2	ABC	Net	
33	Musu Liesia	42	M/3	ABC	Net	
34	Kabah Mamolu	22	M/1	ABC	Net	
35	Yowo sackie	45	M/3	ABC	Net	
36	Humu jones	38	M/6	3 grade	Net	
37	Kpannah momolu	29	M/6	2 grade	Net	

Village : **Harrisburg /JosephRicks town** Date: 17/02/2012 Hour start 15H15 End:16h40

N°	Surname and given names	Age or birth year	Matrimonial statut/Nber children	Study level/startin fishing activity or fish farming or fish marketing	Main gear (line, net cast…)	Contact and observations phone nber, quality, other info)
01	Mrs Meatta Gooding	45	M/5	Abs		0886750113
02	Ehen Carter	39	M/8	4th		0777968861
03	Mrs Ehen Gooding	18	M/1	10th Abs	Net	
04	John Banan	50	M/9	4th Abs	Net	
05	John Blatch	30	M/2	6th Abs	-	077175957
06	Wilmot gooding	62	M/9	9th		0886974400
07	Augustine Tarnue	46	M/6	M		0776762322
08	Bandu Kancce	25	M/4	6th		
09	Carthi Sackie	40	M/6			
10	Viola Mcgee	20	M/2	4th Abs		077805303
11	Matta ¨Paye	30	M/4			0776746228
12	Sengbah Morris	62	M/7	Abs		077822235
13	Zoe Cooke		M/4	Abs		
14	Wiolmot Gooding	42	M/2	11 Abs		
15	Gbaleh Smart	49	M/9	Abs		
16	Henry Smart	22	M/8	6		06545683
17	Thomas Thompson	22		11 Abs		0776686031
18	Hawa Smart	20		6 Abs		0777384628
19	Abraham Armah	29	M/3	9Abs		077741886
20	Joseph blackie	20	M/2	5 th Abs		
21	Joseph Johnson	27	M/1	3		
22	Evans Gray Jr	28	M/1	11		0776760951
23	Wile Gooding	30	M/2	10		077013052
24	Pricella Johnon	33	M/8	4 th		0777946144
25	James weah weah	30	M/5	12		077926862
26	Famatta kessey	30	M/3	5 Primary		077273511
27	Lydia Daniel	34	M/3	9 Primary		0776378266
28	Emmanuel Kennedy	70	M/3	8Primary		0776078710
29	Mrs Bonoper Nimmo	60	M/4	4 th		0776054401
30	Abraham Johnson	60	M/2	5 th		
31	Mrs Korto Torpah	26	M/12			0777325094
32	Kerpoo Torpah	40	M/12			
33	Stanley Michel	48	M/14	2 th		0777325094
34	Cora ricks	45 Abs	M/6	12		0776641088
35	Abraham Torpah	41	M/3	5 th		0886274289
36	Christian Napah	24	M/2	7th		
37	Abranham kertuio	31	M/2	10 th		077804603
38	Mumma Dukuly	30	M/4	4 th		
39	Mary Harris(mrs harris)	45	M/5	6 th		077723158

40	Philip Bass	30	M/4	7th		
41	Roseline Sickie	23	M/4	8 th		
42	Leelia Harris	23	M/2			
43	Alexander Harris	52	M/4	12 th		077127158
44	Ibou sarwary	53				
45	Kadafi Jallo	30	M/1			0761131570
46	Diaoura touré	42	M/3			076009481
47	Habakkuk Nuewoo	32	M/3	10th		077185493
48	Mapue stwart	40	M/3	8th		
49	Patrick Sumo	23	M/1	9th		
50	Hevricha Borkai	35	M/5	ABC		
51	Alie Kerkula	36	M/4	12		0773220122
52	Angeline k.Sumo	30	M/3	12		0777792341
53	Emma Holder	33	M/4	7th		
54	Samuel Ford		M/6	10th		

Village : **Harrisburg/**JosephRicks town, continue. Date: 17/02/2012 Hour start ? End:18h20

N°	Surname and given names	Age or birth year	Matrimonial statut/Nber children	Study level/startin fishing activity or fish farming or fish marketing	Main gear (line, net cast…)	Contact and observations phone nber, quality, other info)
01	George Zola	45	M/3	3		
02	John Hiu	50	M/8	4th		077754551
03	Bormah Harris	42	M/1		Net	0776591232
04	Tenna Banda	72	M/9	8	Net	
05	Alfred Ford	48	M/2	ABC	-	
06	Jartu Bando	38	M/9	7th		
07	Emmanuel Port	25	M/6	4th		077203686
08	Elizabeth Weeks	50	M/4	5th		0226845769
09	Mammie Kennedy	37	M/6	5		077804603
10	Victorial Tarnue	36	M/2	6th		
11	Emily Flomo	36	M/4	5 th		077006461

Village : **Raymond Camp** Date: 17/02/2012 Hour start 17h15 End:18h00

N°	Surname and given names	Age or birth year	Matrimonial statut/Nber children	Study level/startin fishing activity or fish farming or fish marketing	Main gear (line, net cast…)	Contact and observations phone nber, quality, other info)
01	Harrison K. Sumo	62	M/2	10 TH	Line	077725 21 33
02	J. Rolland F. Albert	50	M/6	High School	Line	0776030746
03	Fahn Dennis	53	M/4	illiterate	Line	Town cheaf
04	James Torkpa	71	M/3	illiterate	Line	-
05	Korpor M.Albert	45	M/5	Elementary	Net	0777764404
06	Frank Gooding	44	M/6	HSG Certificate	Cast	0777207891
07	Nowah Flomo	64	M/5	illiterate	Net	Women Learder
08	John Gbanjahsr	72	M/9	illiterate	Net	
09	Daniel Kollie	50	M/6	illiterate	Net	
10	Nowahks Sumo	58	M/4	illiterate	Net	
11	Turmuh Sumo	49	M/4	6grade	Net	
12	Rebecca Goodling	37	M/6	HA degree	Net	0777963123
13	Samuel kpadeak	50	M/7	-	line	0777297438
14	Larsee Kpadeak	42	M/7	C Citi	Net	0776387344
15	George Bass	50	M/5	High School	Net	0777947876
16	Paul S.L. Harris	32	M/3	Graduate	Line	0777206715
17	Henry Flomo	30	M/4	-grade	Net	076314483
18	Abraham Flomo	30	M/5	9grade	Net	0777252381
19	Nathanael S. Koto	31	M/4	High School	Net	0777991130
20	Amma Koto	29	M/3	7grade	Net	0776113037
21	Sualiho Sheriff	27	M/1	-	Line	
22	Sisgo Clinton	31	M/7	6grade	Net	077405120
23	Alphonso Zoryar	29	M/2	7grade	Net	
24	Lucy Johnson	48	No -5	illiterate	Net	0776832077
25	Daniel kollie	55	M/5	illiterate	Net	0777854235
26	James kollie	38	M/9	Elementary	Net	
27	Alyosius Seword	44	M/6	Junior High	Net	
28	Mrs Jartu Cooper	38	M/4			
29	Yassah kollie	40	M/9	illiterate	Net	
30	Kabbeh Johnson (Abs)	37	M/3	illiterate	Net	
31	Cecilia Seword	42	No-3	Elementary	Net	
32	Baby Dukuly	29	No-3	illiterate	Net	
33	Yarmah Wea weah	50	No-5	illiterate	Net	

34	David Wee (Abs)	65	M/7	illiterate	Net	
35	Musu wee	55	M/7	illiterate	Net	
36	Asobe Grwoloyuis (Abs)	19	No	Junior High	Line	
37	Alice Garwded (Abs)	23	No-2	Junior High	Line	
38	Matthew clourke	48	M/2	Junior High	Line	0777754635
39	Morris shemen (Abs)	20	M/1	Junior High	Line	
40	Junior Sumo	20	M/2	illiterate	Line	
41	Gabriel Seword	18	No	illiterate	Line	
42	Moses sumo	38	M/5	illiterate	Net	
43	James Tokpah	68	No-2	illiterate	Line	
44	Old Leady Diggs	30	M/4	illiterate	Net	0777371446
45	Anthony Miller	19	No	Junior high	Net	0777371446
46	Patrick Clinton	23		Junior high	Net	
47	Rita Beah	18	No- 1	elementary	Line	
48	Satta Kennedy	18	M/1	Junior high	Line	0776989881
49	Esther K. Johnson	45	M/6	illiterate	Net	0777859859
50	Famatta Flomo	19	No-1	elementary	Line	
51	Jeedy Johnson	18	No	Junior high	Net	
52	Garmah franklin	58	No-5	illiterate	Net	
53	Ruth Franklin	20	No-2	High School	Net	
54	Johnson Gayflor	42	No-3	High School	Net	
55	Ruth Clinton	33	M/4	Junior high	Net	
56	Gairmah Getoga	27	M/3	elementary	Net	
57	Mary Diggs	50	No-1	illiterate	Net	
58	Eveline Sirleaf	26	M/3	elementary	Net	
59	Nowoh Gataga	39	No-4	elementary	Net	
60	John Gbanjoh	29	M/3	Junior high	Net	0776135808
61	Alex Miller	23	M/2	illiterate	Net	
62	Lucky boy Gbenjeh	26	M/3	illiterate	Net	
63	Ellen Hayes	35	M/4	elementary	Net	
64	Nowah Sumo	35	No-5	illiterate	Net	
65	Lorpu Flomo	68	No-12	illiterate	Net	
66	Mumia Harris	69	M/2	illiterate	Net	
67	Nowah Barker	53	No-8	illiterate	Net	
68	Evon Kerkola	52	M/5	illiterate	Net	
69	Abraham Sumo	18	No	elementary	Net	
70	Daniel Barker	59	M/10	illiterate	Line	
71	Josiah Diggs	45	M/4	teacher	Line	
72	Mamia Bass	40	M/5	illiterate	Net	077794787876
73	James Flomo	68	M/5	illiterate	Net	
74	Reta bass	50	No-	illiterate	Net	
75	Isaac dukaly	30	M/3	illiterate	Net	
76	Esther Mortor	40	No-6	illiterate	Net	
77	James A. Herris	53	M/4	Teacher	Net	
78	Oretha Miller	50	No-2	illiterate	Net	
79	Victory Tokpah	31	M/5	illiterate	Net	
80	David Freeman	36	No-	Teacher	Net	
81	Reta Sir leaf	24	M/3	elementary	Net	
82	Hawa Padmore	32	M/4	illiterate	Net	
83	Kpimie Manamee	22	No-	illiterate	Net	
84	Tumue Sumo	48	M/5	illiterate	Net	
85	John sumo	46	M/5	illiterate		
86	Robert Norris	40	M/3	illiterate	Net	
87	James Dukuly	26	M/3	Teacher	Net	
88	Moses Sacckie	53	M/2	illiterate	Net	
89	Mumia Clinton	26	M/5	illiterate	Net	
90	Madia Wea-weah	22	M/4	illiterate	-	
91	Fatu kollie	25	M/2	illiterate		
92	Elizabeath suah	37	M/4	High School		
93	Sarah Dennis	52	M/4	illiterate		
94	Musu Johnson	48	M/1	illiterate		
95	Roselin Clinton	18	M/1	Student		
96	Moses K. Sumo	34	M/4	illiterate		
97	Samuel Gbanjoh	24	M/2	illiterate		
98	Patrical Moses	32	M/3	Junior High		
99	Garmah Gataga	60	No-8			
100	Cecilia Mortor	44	M/5	illiterate		
101	Cenue Mortor	45	M/5	illiterate		
102	Helena Nathanael	20	M/1	illiterate		
103	Junior Flomo	22	No-	illiterate		
104	Moses Sumo Jr	18	No-	illiterate		

105	Prince S. Nunu	25				
106	Daniel Ford	17				
107	Aaron MONEYTOIL	15		Student		
108	Esther B. johnson	48	M/2	illiterate		
109	Mamie Daniel	39	M/3	Student		
110	Miatta Coke	40	M/5	illiterate		
111	Beatrice Diggs	40	No-4	Student		
112	Nency Gataga	50	M/2	illiterate		
113	James K. Sumo	40	M/6	Student		
114	Lemue Harris	17		Student		
115	Sarah Kollie	48	M/48	illiterate		
116	Roy kollie	52	M/7	illiterate		
117	Isaac Ricks	51	M/2	illiterate		
118	Isaac Verfee	34	M/4	illiterate		
119	Mulbah Zayzay	21		Student		
120	Peter Flomo	27	M/3	Student		
121	Daniel Barker	20	M/1	Student		
122	Janetta Dukuly	20		Student		
123	Joseph T. Johnson	50	M/7	Nurse		
124	Prince Robertson	18		Student		
125	Charles Goodlin	16		Student		
126	Attoh Clemens	32	M/10	Nurse		
127	Mary Sayon	58	No-5	llliterate		
128	Meliklee Paye	38	M/5	Nurse		

Village : **White Plains** Date: 20/02/2012 Hour start 10h45 End:12h45

N°	Surname and given names	Age or birth year	Matrimonial statut/Nber children	Study level/startin fishing activity or fish farming or fish marketing	Main gear (line, net cast…)	Contact and observations phone nber, quality, other info)
01	James Coker	44	M/5	9	Net	0776135326
02	Arthur Carter	48	M/2	12	Net	077608153
03	David Kpalah	47	M/3	20		077176930
04	Hannah Flomo	25	M/2	10	Hook	
05	John Kpalah	50	M/5	13	Hook	088077787583
06	Wisdom Flomo	36	M/5	11		0880675011
07	Annie Kollie	45	M/10	10	Net	0776370813
08	Watta Kollie	58	M/13	10	Net	0886325838
09	Richard monge	48	abs			
10	Mary Douweeh	40	Abs			
11	Labah Railay	43	M/6	10	Net	0776319850
12	Justice	40	Abs			
13	Bendu Kollie	28	Abs			
14	Abraham Grogae	43	Abs			
15	Panneh Harrie	48	Abs			
16	Nora Grangaw	4(	Abs	ABC		
17	Kpainsua Kolleh	50	M/7	10 Abs		
18	Rabbar kolan	38				
19	Ester Brown	45	M/6	ABC	net	
20	Mane Geaga	30	M/7	ABC	Handnet	
21	Joseph Carter	47	M/5	6	Hook	
22	Hawrane Robenks	52	M/4	20	Handnet	0776937529
23	Banda seimo	45	M/7	10	Hand net	07795022
24	Patricea Changebath	28	M/4	8		0880675011
25	Zoo washinyton	47	M/7	5	net	
26	William Mcgill	61	M/4		Dive+ Gun	
27	Kapweh kollie	50	M/7		Hook	
28	Augustine Kpameh	37	M/4		Hook	077991217
29	Michel Gayah	27	M/2		Net	
30	Lunneh Sumo	24	M/2		Net	076747678
31	Mulbah J. Q. Sumo	57	M/7		Hook	0777950077

Village :**Lousiana/ Fofee** Date: 20/02/2012 Hour start 13h30 End:14h35

N°	Surname and given names	Age or birth year	Matrimonial statut/Nber children	Study level/startin fishing activity or fish farming or fish marketing	Main gear (line, net cast…)	Contact and observations phone nber, quality, other info)
01	Molley Fofee	45	M/6		Line	0777379363
02	Henry Clarke	34	M/3		Line	
03	Emmtlen J.	35	M/3		Line	0776001613
04	Moses Padmeome	29	M/3		Line	077770412

05	Alfred Mulbah	36	M/8		Line	
06	Catherine Fofee	34	M/4		Net	
07	Manee Togbah	35	M/4		Net	
08	Massa Dixon	18	M/1		Net	
09	Timay Sumo	37	M/1		Net	
10	Fatta Kamara	34	M/6		Net	
11	Kpamah Mulbulm	31	M/8		Net	
12	Helena Cole	32	M/3		Net	
13	Robert Fofee	37	M/1		Net	
14	Joseph Kamera	19	M/2		Net	
15	Mary Toybad	39	M/3		Net	
16	Mane Stremon	29	M/3		Net	
17	Kamah Kalie	26	M/3		Net	
18	Jefforson Bram	34	M/2		Net	
19	Jusu Dixon	44	M/1		Net	
20	John Kollie	22	M/3		Net	
21	Fayah Bono	29	M/4		Net	
22	John Viapa	35	M/3		Net	
23	Hawa kiazulu	39	M/3		Net	
24	Lovette Bono	19	No-	6 th	Net	
25	Cathrine Tokpah	18	M/1	6 th	Net	0888666544
26	Mary padmoore	40	M/2 Abs		Net	
27	Joe R. B. Perry	25	M/6 Abs		Net	0777635726
28	Manie Kollie	25	M/3		Net	
29	Satta kerkulah	30	M/3		Net	0776695408
30	Isaac Klleh	39	M/3		Net	077773134
31	Mary kollie	40	M/7	ABC	Net	
32	Ojuku Dallon	25	M/1 Abs		Net	
33	Manie perry	29	M/6 Abs	ABC	Net	
34	Moses Kerkulah	37	M/7	ABC	Net	0777913455
35	Rebecca Moore	33	M/3 Abs		Net	
36	Johnny Moore	36	M/3 Abs	67th	Net	
37	Wenned Mcgee	24	M/3		Net	
38	Vennery Fofee	29	M/1 Abs		Net	
39	Sunday wessay	36	M/ Abs		Net	
40	Emmanuel Kamara	25	M/3 Abs		Net	
41	Prince massaguio	24	M/3 Abs		Net	
42	Ernest Zolue	28	M/2		Net	0880751064
43	Manie Samuel	20	M/2 Abs		Net	
44	Alice Gboyah	24	M/7	ABC	Net	
45	William Tolbert	40	M/5	8th	Net	077544537
46	Bendu Fofee	70	M/4		Net	
47	Vivian Houbelt	23	M/2	8 th	Net	
48	Kanah kerkulah	65	M/7		Net	
49	Tete Broun	23	M/2			
50	Watta Sirleaf	65				
51	Rachel Fick	35				
52	Moyo Faith	22	M/3			
53	Korto Tokpah	65				

Village: **Banee Town** Date: 21/02/2012 Hour start 10h00 End: ?

N°	Surname and given names	Age or birth year	Matrimonial statut/Nber children	Study level/startin fishing activity or fish farming or fish marketing	Main gear (line, net cast…)	Contact and observations phone nber, quality, other info)
01	Klomah lassana	58	M/8	1930 market	Net	07776686365
02	Mathew Solsar	53	M/6	1967 market	Line	08804442918
03	Fajuma kloma	84	M/17	1972 market	Net	
04	Ousma keita	40	M/6	2005 market	Net + Line	
05	Johnny kolah	48	M/6	1960 market	line	
06	Manna Boika	50	M/9	1970 market	Net	
07	Jinny Carter	49	M/4	1990 market	Net	
08	Betty Fordy	75	M/9	1930 market	Net	
09	Fordy jah	59	M/9	1952market	Net	
10	Lassana Konah	28	M/3	1988 market	Net	077156358
11	Fatu Quit	38	M/6	1989 market	Net	
12	Varney Gbalay	55	M/7	1975market	Net	
13	Abu Baka	45	M/3	1979 market	Line	
14	Frank David	28	M/3	1997 market	Net	
15	James Darka	37	M/4	1991 market	Net	
16	David sumo	56	M/4	1972 market	Line	

17	Zinnah Sunday	49	M/5	1985 market	Line	
18	Edward Johnson	47	M/5	2001 market	Line	
19	David Dixon	38	M/4	1981market	Net	
20	Levi haggard	59	M/4	1970 market	Net	
21	Varnney Damah	56	M/5	1969market	Net	
22	Elijah T. Freeman	31	M/2	1996 market	Net	0777128107
23	Fredrick brown	41	M/4	1989 market	Net	0777304485
24	Jackson Robert	36	M/4	2000market	Net	
25	Robert Graham	69	M/8	1960 market	Net	
26	Joseph F. Johnson	45	M/6	1980 market	Net	
27	Tenny Kromah	42	M/6	1979 market	Net	
28	Fatu Kromah	41	M/4	1979 market	Net	
29	Fortto kromah	52	M/5	1968 market	Net	
30	Joseph Seabeyor	32	M/9	1978 market	Net	
31	Bandi loyar	35	M/8	1977 market	Net	
32	Fatu keita	45	M/6	2000 market	Net	
33	Sawo kamara	50	M/5	1990 market	Net	
34	Boika Dukuly	40	M/5	1960 market	Net	
35	Vanney Dukuly	75	M/7	1975 market	Net	
36	Famata Dukuly	65	M/8	1940 market	Net	
37	Lenna Domah	64	M/8	1935 market	Net	
38	Kamah William	28	M/5	1955market	Net	
39	Satta white	40	M/4	1998 market	Net	
40	Maima white	19	M/1	1979 market	Net	
41	Massa White	18	M/1	2009 market	Net	
42	Sanah Freeman	30	M/1	2010 market	Net	
43	Mama Brown	32	M/2	2009 market	Net	
44	Jesse Boika	45	M/6	2000 market	Net	
45	Ellen G.Mayor	40	M/2	2000market	Net	
46	Jartu Boika	40	M/5	1999 market	Net	
47	Jartu Bomah	27	M/4	1999 market	Net	
48	Doris Fuller	28	M/3	2000 market	Net	
49	Mamie Fordy	34	M/2	2001 market	Net	0777340785
50	Bandu konah	47	M/3	1996 market	Net	
51	Roseline Gray	41	M/1	1992 market	Net	
52	Fatu Wilson	59	M/5	1990market	Net	
53	Hawah Stephane	45	M/2	1969market	Net	
54	Watta Dukuly	40	M/5	1975market	Net	
55	Satta Staward	34	M/4	1980 market	Net	
56	Jennet Sumo	49	M/4	1990 market	Net	
57	Bandu Haggaard	39	M/5	1992 market	Net	
58	Augustine Kpeh	34	M/3	19398market	Net	
59	Charlie haggarg	40	M/4	1999 market	Net	
60	Zennah Bandi	49	M/4	1999market	Net	
61	Hawah Doma	48	M/4	1979 market	Net	
62	John Gola	60	M/6	1991 market	Net	
63	Betty Graham	48	M/6	1947 market	Net	
64	Hawa Haggard	45	M/4	1945 market	Net	
65	Massa Konah	58	M/6	1940 market	Net	
66	Neomi Dixon	27	M/4	1941 market	Net	
67	Musu Wilson	52	M/5	2004 market	Net	

Village: **Banee Town** Date: 21/02/2012 Hour start 11h15 End: 14h45

N°	Surname and given names	Age or birth year	Matrimonial statut/Nber children	Study level/starting fishing activity or fish farming or fish marketing	Main gear (line, net cast…)	Contact and observations phone nber, quality, other info)
01	Sumo Migard	45	M/4	No market	Net	
02	Massa Migard	26	M/4	No market	Net	
03	Junior out	20		No market	Net	
04	Banda sumo	30	M/3	No market	Net	
05	Amula Kromah	30	M/4	No market	line	
06	Sinoe Japhan	41	M/7	No market	Line	
07	Zinnah Kona	22	M/2	No market	Net	
08	Fieggand Bois	56	M/	No market	Net	
09	Mama Dixon	28	M/4	No market	Net	
10	Moses Jacks	42	M/6	No market	Net	
11	Fama Zinneh	32	M/4	No market	Net	
12	Blama Kamara	20		No market	Net	
13	Nathanston Dixon	58		No market	Line	

14	Zoe Fordy	25	M/3	No market	Net	
15	Jennet Fordy	21	M/3	No market	Net	
16	Memah gbalay	75	M/4	No market	Line	
17	Ester Graham	40		No market	Line	
18	Johamah Graham	41	M/8	No market	Line	
19	Papa Graham	31	M/3	No market	Net	
20	Sinoe Hoggard	30	M/4	No market	Net	
21	Musa gola	43	M/8	No market		
22	Lalieah	23	M/4	No market	Net	
23	Sinoe Boika	35	M/4	No market	Net	

Village: Zanna **Clay Ashland** Date: 21/02/2012 Hour start 14h00 End: 18h00

N°	Surname and given names	Age or birth year	Matrimonial statut/Nber children	Study level/startin fishing activity or fish farming or fish marketing	Main gear (line, net cast…)	Contact and observations phone nber, quality, other info)
01	James Clarke	40	M/7	School	Net	0886314707
02	Momoh kamara	29	M/5		Net	0777200592
03	Morris Sularay	55	5		Net	0777125376
04	Lewis white	39	M/4	School	Net	0776073392
05	Wragbo junior	43	M/6	School	lNet	
06	Judu kenneh	46	M/7		Net	0880273388
07	David Karo	39	M/3		Net	Fish commander
08	Amdu kamara	54	M/10		Net	
09	William Kabeht	44	M/3	School	Net	0886913321
10	Emmanuel Tegbor	31	M/4	School	Net	
11	Masa kamara	45	M/10			
12	Bendu Konneh	34	6			
13	Hawah William	34	3			
14	Confort Konneh	41	M/4	School		
15	Princess Krbeht	15				
16	Satta Konneh	75	M/8			
17	Mattannie Tollie	55				
18	Kronnah Donnie	76	M/5			
19	Bendu Thomas	75				
20	Fatu Clark	39	M/9			
21	Evelyn Gibson	39	M/6	School		
22	Deborah Sunday	18	M/2	School		
23	Masa Dukuly	32	M/4			
24	Methan sularay	40	M/4			

ANNEX 12: PROTECTED AREAS

No entries in this Annex

ANNEX 13: SETTLEMENTAND POPULATION

A13.1: Socio-Economy

Basic Indicators

The socio-economic indicators from the latest UNDP Human Development Report (HDR), 2011 show an improvement in some sectors from the 2008 indicators for Liberia in general. According to the HDR Liberia is ranked 182 on the Human Development Index (HDI) with a value of 0.329, thus falling in the Low Human Development category, but this is an improvement from 2010 ranking by one place. Population has grown, and with it the number of people living below the national poverty line has decreased. However, the health indicators show a deteriorating situation with an increase of people with infectious diseases and government spending on health as a percentage of GDP also going down. Government spending on the education sector has increased, albeit the constant percentage of student enrolment at the different levels of education. The HDI index trend for Liberia has been 0.453 in 1995, 0.459 in 2000 to the present 0.483.

9.7% of the population is vulnerable to poverty while 57.5% are vulnerable to severe poverty. The poor who are deprived of environmental services are as follows: 33.5% are deprived of clean water, 78.9% of the population don't have access to improved sanitation, while 83.9% have no access to modern fuels. For the years 2000-2009, the proportion of the population living below the national poverty line was 63.8%. This should have improved now with the return of a number of Liberians from the USA and the beginning of a semblance to democracy.

Table 30-12: Socio-economic indicators

Social Indicators	2011	2010	Economic Indicators	2011	2010
HDI	0.329	0.325	Goss National Income per capita PPP$	265	
Population in millions (2011)	4.1		GDP in USD in billions		1.0
Average annual population growth, %, 2010-2015	2.6		GDP per capita in USD		246.9
Population below national poverty line, %, 2000-09		63.8	GDP per capita, PPP in USD, (2009)		396
Population in severe poverty , %, 2007		57.5	% Average annual Growth rate GDP per capita , (1970-2008)		-2.0
Health: (2009)					
Life expectancy at birth (Years)	56.8				
HIV prevalence (% ages15-24), 2009, Female HIV prevalence (% ages15-24), 2009, Male		0.7 0.3			
Incidence of TB per 100,000, (2009)		288.0			
Population under 5 suffering from stunting, 2000-9 Pop under 5 suffering from wasting, 2000-09		39.4 20.4			
Infant mortality rate per 1,000 live births – under 5 mortality rate, 2009		112			
Adult mortality rate per 1,000 people, 2009, Fema. Adult mortality rate per 1,000 , 2009, Male		337 389			
Undernourished % of total population , 2007		33	% of total health expenditure, public, 2009		39.7

Deaths due to malaria per million people		444.7	Commitment to health, per capita PPP USD		29.4
Maternal mortality ratio, number live births/100,00	990		Govt spending on health % of GDP		13.2
Education: (2010)					
Mean years of schooling (years)	3.9				
Expected years of schooling (years)	11.0				
Tertiary enrolment ratio(%), 2001-09, Gross	..	17.4			
Adult literacy rate (% ages 15 and older)	59.1				
Education enrolment (%)					
Primary enrolment ratio (%)	90.6				
Secondary enrolment ratio (%), 2001-2009	..	38.0	Govt spending on education % of GDP		13.2
Water and Sanitation: (2008)					
Access to improved sanitation (%) Urban (2008) Rural (2008)		17 25 45.1			
Access to improved water (%) Urban (2008) Rural (2008)		79 51			
			Imports and Exports: (2008)		
			Imports of goods & services (% of GDP)		173
			Export of goods & services (% of GDP)		31
			Overseas Development Assistance: (2009)		
			ODA received in USD (millions)		513.02
			Per capita		133.7
			Per cent of GDP		78.3
			Net direct investment inflows (% of GDP)		24.9
			Debt service as percent of GNI		8.7
Internally displaced persons (2010), thousands		23.0	Remittance inflows (% of GDP), 2009		6.2
			Energy Consumption:		
			Traditional fuel consumption (% of total energy requirements)	..	..
			Energy consumption per capita, kilowatt-hours	..	..
Gender Related Development Index:			Energy Sources:		
Population with at least secondary ed, %, Female		15.7	Total primary energy supply (Mt of oil equiv.)	..	
Population with at least secondary ed,, %, Male		39.2	Coal %	..	
			Oil %	..	
Labour force participation rate (%), 2009, Female		66.6	Natural gas %	..	
Labour force participation rate (%), 2009, Male		75.8	Hydro, solar, wind, geothermal %	..	
			Biomass %	..	
Seats in Parliament held by women (% female)	13.8		Nuclear %	..	

Source: UNDP Human Development Report, 2011 , “Sustainability and Equity: A better Future for All” New York, USA, 2011, website: http://hdr.undp.org/en/reports/global/hdr2011/ and earlier years (2009-2010) and the World Bank’s website for indicators: http://www.app.collinsindicate.com/worldbankatlas-global/en

A13.2: Data Profile for Liberia

Table 30-13: Data Profile for Liberia

	2000	2005	2008	2009	2010
World view					
Population, total (millions)	2.85	3.18	3.66	3.84	3.99
Population growth (annual %)	4.9	2.9	5.1	4.7	4.0
Surface area (sq. km) (thousands)	111.4	111.4	111.4	111.4	111.4
Poverty headcount ratio at national poverty line (% of population)	..	..	..	..	..
GNI, Atlas method (current US$) (billions)	0.38	0.41	0.65	0.74	0.78
GNI per capita, Atlas method (current US$)	140	130	180	190	200
GNI, PPP (current international $) (billions)	0.83	0.85	1.18	1.31	1.36
GNI per capita, PPP (current international $)	290	270	320	340	340
People					
Income share held by lowest 20%	..	..	..	..	..
Life expectancy at birth, total (years)	46	52	55	55	56
Fertility rate, total (births per woman)	5.8	5.6	5.4	5.3	5.2
Adolescent fertility rate (births per 1,000 women ages 15-19)	149	144	139	135	131
Contraceptive prevalence (% of women ages 15-49)	10	..	..	..	..
Births attended by skilled health staff (% of total)	51	..	..	..	..
Mortality rate, under-5 (per 1,000 live births)	169	132	114	109	103
Malnutrition prevalence, weight for age (% of children under 5)	23	..	..	..	..
Immunization, measles (% of children ages 12-23 months)	63	63	64	64	64
Primary completion rate, total (% of relevant age group)	..	..	62	..	..
Ratio of girls to boys in primary and secondary education (%)	73	..	..	..	..
Prevalence of HIV, total (% of population ages 15-49)	3.3	2.2	1.6	1.5	..
Environment					
Forest area (sq. km) (thousands)	46.3	44.8	..	..	43.3
Agricultural land (% of land area)	26.9	26.9	27.1	27.1	..
Annual freshwater withdrawals, total (% of internal resources)	0.1	..	..	0.1	..
Improved water source (% of population with access)	61	67	..	..	73
Improved sanitation facilities (% of population with access)	12	15	..	..	18
Energy use (kg of oil equivalent per capita)	..	..	..	..	..
CO2 emissions (metric tons per capita)	0.2	0.2	0.2	..	..
Electric power consumption (kWh per capita)	..	..	..	..	..
Economy					
GDP (current US$) (billions)	0.56	0.53	0.84	0.88	0.99
GDP growth (annual %)	25.7	5.3	7.1	4.6	5.5
Inflation, GDP deflator (annual %)	-1.3	13.8	10.4	7.8	11.3
Agriculture, value added (% of GDP)	72	66	61	..	..
Industry, value added (% of GDP)	12	16	17	..	..
Services, etc., value added (% of GDP)	16	18	22	..	..
Exports of goods and services (% of GDP)	21	38	31	..	..
Imports of goods and services (% of GDP)	26	52	173	..	..
Gross capital formation (% of GDP)	..	16	20	..	..
Revenue, excluding grants (% of GDP)	..	0.3	0.4	..	..
Cash surplus/deficit (% of GDP)	..	0.0	0.0	..	..

States and markets					
Time required to start a business (days)	..	..	31	20	20
Market capitalization of listed companies (% of GDP)	..	..	..	..	..
Military expenditure (% of GDP)	..	1.5	0.5	0.8	..
Mobile cellular subscriptions (per 100 people)	0	5	23	28	39
Internet users (per 100 people)	0.0	..	0.5	0.5	7.0
Roads, paved (% of total roads)	6	..	..	..	..
High-technology exports (% of manufactured exports)	..	..	..	..	..
Global links					
Merchandise trade (% of GDP)	177.8	83.2	125.3	79.6	94.4
Net barter terms of trade index (2000 = 100)	100	114	120	111	147
External debt stocks, total (DOD, current US$) (millions)	2,792	3,898	3,128	1,656	228
Total debt service (% of exports of goods, services and income)	..	0.3	119.6	13.5	1.3
Net migration (thousands)	453	-73	..	..	300
Workers' remittances and compensation of employees, received (current US$) (millions)	..	32	58	25	27
Foreign direct investment, net inflows (BoP, current US$) (millions)	21	83	395	218	453
Net official development assistance and official aid received (current US$) (millions)	67	222	1,251	513	1,423

Source: World Development Indicators database

A13.3: Household Questionnaire

Socio-economic Profiles of Communities Affected Within the Project Impact Zone (PIZ)

Data of Interview: ___________ Interviewer: ________________

District:_______________ Village/Town:____________ Household No.:______

Instruction: Please clearly print the appropriate answer(s) by filling in the blank(s) or by checking the corresponding box or numbers to the best of the respondent's knowledge. Please be sure not to skip any box or blank.

1. Personal Data

a.

	Name of Household Members	Age	Sex		Educational Attainment (Check √ one)					Relationship to the Respondent	Occupation	Marital Status (Check √ one)				Religion			Vulner-able Gr.
			Female	Male	Non-formal Education	Elem (Grades 1-6)	Junior Hi (Grades 7-9)	Senior High (Grades 10-12)	Tertiary Educ & Higher			Single	Married	Widow/Widower	Divorced	Christian	Muslin	Others (specify)	Specify
i.																			
ii.																			
iii.																			
iv.																			
v.																			
vi.																			
vii.																			

Use additional sheet if necessary.

Are there any vulnerable people in your HH?
Vulnerable Group: This includes:

Female HH Head, widows, the very sick, handicapped, elderly (80 years old +), blind, etc.

b. Let the respondent state his/her birthplace. ________________________________

c. Which ethnic origin does the respondent belong?
☐ Kpelle ☐ Bassa ☐ Luma Others, pls specify _________________________

d. Which local dialect does the respondent household speak most?
☐ Kpelle ☐ Bassa ☐ Luma Others, pls specify _________________________

e. eDoes the respondent's household have access to school?
Yes ☐ No ☐

f. If yes, let the respondent describe the school level and the estimated walking time from the respondent's house.

School Level	Walking Time from Respondent's House (Please check one)		
	< 15 min	16-30 min	> 30 min
Kindergarten			
Elementary			
Junior High			
Senior High			

2. Data on Land and Resettlement

a. Is the respondent originally from the PIZ?
Yes ☐ No ☐

b. If no, how long has the respondent been residing in the PIZ?
< 5 years ☐ 6 – 10 years ☐ 11-20 years ☐ 21-40 years ☐ 41-60years ☐

c. Where has the respondent lived before? _____________________

d. Has the respondent been resettled before in relation to the hydro power plant? Yes N☐ ☐

e. If yes, state where you were resettled: _____________________

f. If no, let the respondent state why he/she settled in the reservoir area?
(i) For fishing
(ii) For farming
(iii) For charcoal making
(iv) Others (pls. specify)_____________________

g. g. In which year did the respondent settle in the reservoir area? _______

h. h. Does the respondent have access to farmland? Yes ☐ No ☐

i. If yes, let the respondent choose his/her approximate land size.
< 1 acre ☐ 1 – 4 acre ☐ 5 - 8 acre ☐ > 8 acre ☐

j. What type of land tenure system does the respondent's land belongs?
Customary ☐ Statutory ☐ Other types: (Pls. specify)_______________________

k. What processes did the respondent go through to acquire land?
____
____

l. Besides the current respondent's residence, does the respondent have land outside the PIZ?
Yes ☐ No ☐

m. If yes, is the respondent's land a
Commercial ☐ or a Farmland ☐

n. If yes, what is the size of the land?
< 1 acre ☐ 1 – 4 acre ☐ 5 - 8 acre ☐ > 8 acre ☐

o. Does the respondent have a title deed?
Yes ☐ No ☐

p. If the respondent has to move/relocate☐at would be☐ preferential ☐ling place?
Arthington City ☐ Clay Island Millsburg Harrisburg Others_____________

q. What could the respondent say would be the deciding factors for relocation due to rehabilitation of the HPP? Let the respondent prioritize by selecting 4 out of the ten factors below:
Family ☐ Money ☐ Children's education ☐
Food/Farming ☐ Job relocation ☐ Marriage ☐
Better shelter ☐ Safety ☐ Hospitable climate ☐
Other: Please specify ____

r. What type of irrigation is used on the land?
Rainfed ☐ Pump ☐ Channel ☐ Others: Specify___________________

3. Health, Water and Sanitation and Waste

a. Let the respondent state the common health problem☐ithin the household.
Malaria ☐ Typhoid fever
Diarrhea ☐ Whooping cough ☐
HIV/AIDS ☐ Pneumonia ☐
Rheumatism ☐ Others, pls. specify __________________________

b. Let the respondent state where his/her household go for treatment when sick.
Health Post ☐ Clinic ☐ Hospital ☐ Herbalist ☐ Others _____________

c. Let the respondent state what is the walking time from her/his house to the nearest health facility.
< 15 min ☐ 16-30 min ☐ > 30 min ☐

d. Does the respondent gather plants/herbs? Yes ☐ No ☐

e. If yes, where does the respondent gather herbs/plants?
Forest ☐ Bush ☐ Mountains ☐ Other, specify__________________

f. Let the respondent state the source of water the household use for domestic use.
Own hand pump ☐ Deep well ☐ Stream ☐
Neighbour's hand pump ☐ Public pump ☐ River/creek ☐

g. During dry season, does water run out of the respondent's main water source?
Yes ☐ No ☐

h. If yes, where does the respondent get water?
Buy water ☐ Water tank brought to HH ☐ Others: __________

i. Let the respondent state what is the walking time from her/his house to the nearest water source.
< 15 min ☐ 16-30 min ☐ > 30 min ☐

j. Let the respondent state the type of toilet facilities the household use.
Pit ☐ Water shed ☐ Public latrine ☐ In the bush ☐

k. Let the respondent state the manner how the household dispose of their garbage.
Compost pit ☐ Burn waste ☐ Throw anywhere ☐ Others, pls specify ________

4. Household's Assets

a. Allow the respondent to check the items listed below that is owned by her family within their household.

Generator ☐ Radio ☐ Bicycle ☐
Cell phone ☐ Motorcycle ☐ TV ☐
Motor vehicle (car, truck, tractor, etc.) ☐
Power saw ☐ Sugar cane mill ☐
Dinning ☐ Living room set ☐ Tables and chairs ☐
Beds ☐ Others, pls specify ____________________

5. Agricultural Output/Livestock

a. Let the respondent complete the table below with regard to the type of crop cultivated in the last farming year or last 12 months?

Estimated Land area (acre)	Type of food cop	Ave. harvest/yr (lbs)	Home consumption (lbs)	Selling volume (lbs)	Unit price $LD
	Rice				
	Cassava				
	Vegetables				
	Corn				
	Peanuts				
	Sweet potatoes				
	Others (pls specify)				

b. Are the food crops grown enough for the respondent household's consumption the whole year around?
Yes ☐ No ☐

c. If no, let the respondent say specifically how the household supplement for food insufficiency? (What does the HH do if there is not enough food? How does the HH survive?)
1.____________________
2.____________________
3.____________________

d. Allow the respondent to indicate the kinds of tree/cash crops his/her household owns and the estimated lbs/harvest/yr?

Cash/Tree Crop	Respondent's House harvest crop/yr (Please check one)					
	0-50 lbs	Value $LD	51-100 lbs	Value $LD	Over 101 lbs	Value $LD
Sugar cane						
Coffee						
Cocoa						
Rubber						
Others (pls specify)						

e. How many livestock does the respondent's household have?

Animal Type	**Number**
Chicken	
Duck	
Goat	
Pig	
Sheep	
Cattle	
Rabbit	
Guinea fowl	
Others, specify	

6. Fishing and Hunting

a. Does any member of the respondent's household fish in the river? Yes ☐ No ☐

b. If yes, how much fish is caught? State the average weekly catch. ________ lbs

c. How much of the respondent's HH catch is intended for selling? ________ lbs

d. How much of the respondent's HH catch is intended for household consumption? ________ lbs

e. Does any member of the respondent's household hunt in the nearby forest? Yes ☐ No ☐

f. If yes, how much meat is caught? State the average weekly catch. ________ lbs

g. How much of the respondent's HH catch is intended for selling? ________ lbs

h. How much of the respondent's HH catch is intended for household consumption? ________ lbs

i. Let the respondent name at least three (3) dominant animals caught during the hunting spree.

1. ___________________ 2. ____________________ 3. ____________________

7. Energy

a. What is the respondent's main energy source for cooking?
Firewood ☐ Charcoal ☐ LPG ☐ Electricity ☐

b. What is the respondent's main energy source for lighting?
Candle ☐ Kerosene lamp ☐ Flashlight ☐
Electricity ☐ 'Jackle Lantern" ☐

8. Household Income and Expenditure

a. Is any member of the respondent's household gainfully employed?
Yes ☐ No ☐

b. Let the respondent state her/his household main source of income.
Petty trading ☐ Rubber farm ☐ Hired labor ☐ Employed ☐
Farming/gardening ☐ Remittance ☐ Others (pls. specify) ________________

c. Please indicate the monthly income bracket in which the respondent falls by checking the corresponding choices below.
LD$ 1,000 and less ☐ 1, 100-3,000 ☐ 3,100-5,000 ☐ More than 5,000 ☐

d. How many of the other household members earn a monthly income?
One ☐ Two ☐ Three ☐ Others, ___________

e. Please indicate the monthly income bracket in which the respondent's household (other than respondent) falls by checking the corresponding choices below.
LD$ 1,000 and less ☐ 1, 100-3,000 ☐ 3,100-5,000 ☐ More than 5,000 ☐

f. Does the household get money from other sources?
Yes ☐ No ☐

g. If yes, let the respondent state other source of income by checking the choice/s below:
Abroad ☐ Pension ☐ Remittance ☐ Others (specify) ☐

h. If yes, let the respondent state the amount per year. ___________LD______

i. On average, let the respondent state the average monthly household expenditure on the following:

Item	Amount (LD)
Food	
Energy	
Education	
Health	
Clothing	
Transport	
Farm tools	
House repairs	
Household assets	
Social events	
Others (specify)	

j. Let the respondent state the total expenditure of the household per month. _______________

9. Household's opinion of the Mt. Coffee Hydro Power Plant within the Project Impact Zone

What do you see as benefits/advantages or problems/disadvantages with the rehabilitation/revival of the Hydro?

Advantages/Benefits	Disadvantages/Problems

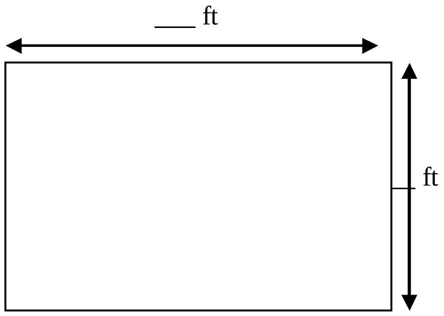
A13.4: Household Questionnaire – Size of Structures

Socio-economic Profiles of Communities Affected
Within the Project Impact Zone (PIZ)

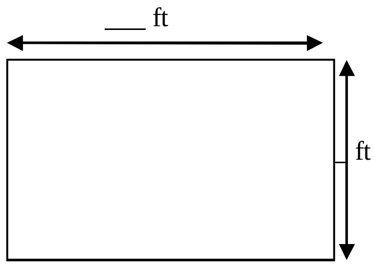
Data of Interview: ___________ Interviewer: ________________

District: _______________ Village/Town:____________ Household No.:______

Information about the Respondent's House



Respondent's House



Respondent's Kitchen

a. What is the status of the respondent's house?
Owner ☐ Renting ☐ Caretaker ☐ Others (Pls specify) _______________

b. How many rooms are occupied by the respondent's household? ___ no. of rooms

c. What is the physical condition of the respondent's house structure?
In good condition ☐ Partially damaged ☐ Temporary structure (good) ☐
Temporary structure (bad) ☐ Uncompleted structure ☐ Poor structure ☐

d. Where is the kitchen/cooking area? Inside the house ☐ Outside the house ☐

e. Main material of the floor
Mud ☐ Concrete ☐ Ceramic tiles ☐
Sand ☐ Wooden ☐ Others, pls specify ________________

f. Main material used for roof
Thatch ☐ Concrete ☐ Asbestos ☐
Mat ☐ Metal sheets/zinc ☐ Others, pls specify _________________

g. Main material used for wall structure
Mud and stick ☐ Cement blocks ☐ Plank ☐ Mat ☐ Bamboo ☐
Concrete ☐ Baked bricks ☐ Thatch ☐ Zinc round ☐

h. Main material used for window structure
Plank ☐ Decorative blocks ☐ Others, pls. specify _____________________
Zinc ☐ Bamboo ☐

ANNEX 14: LAND USE

A14.1: Field Measurement in the Reservoir Area of Mount Coffee HPP

Table 30-14: Field measurement in the reservoir area of Mount Coffee HPP

FIELD MEASUREMENT PER HOUSE HOLD IN THE MC HPP PROJECT AREA								
		,.			GPS RECORDINGS			
No:	***NAME OF HH FARMER***	***Crop***	***# of trees***	***Farm size [Ha]***	***Elevation [m]***	***N***	***W***	***Community***
1	J. Roland Albert	Plantain mix with vegetables		2.5	20 m	06º29.520	10º38.924	Raymond Camp
2	Hannah Hunder	oil palm	800	1.2	24m	06º29.499	10º38.363	Raymond Camp
3	Rebecca Bukuly	Banna& pineapple		0.9	22m	06º29.443	10º38.887	Raymond Camp
4	Lucy Johnson -1	Banana		0.11	31m	06º29.420	10º38.922	Raymond Camp
5	Lucy Johnson -2	Oil palm	75	0.2	31m	06º29.420	10º38.922	Raymond Camp
6	Matthew Clarke	Rubber	250	0.5	79m	06*29.615	10.38.234	Raymond Camp
7	Zoe Johnson -1	mix vegetables		0.2	28m	06º29.420	10º38.895	Raymond Camp
8	Zoe Johnson -2	plantain		0.25	28m	06º29.420	10º38.895	Raymond Camp
9	sisco clinton -1	Rubber	52	1	29 m	06º29.417	10º38.884	Raymond Camp
10	sisco clinton -2	oil palm	15	0.1	29 m	06º29.417	10º38.884	Raymond Camp
11	James Reynes-1	pineapple		0.15	29 m	06º29.404	10º38.853	Raymond Camp
12	James Reynes-2	sugar cane		0.22	29 m	06º29.404	10º38.853	Raymond Camp
13	Daniel Barker -1	Coffee		0.025	49 m	06º29.387	10º38.877	Raymond Camp
14	Thomas Johnson -1	Banana		0.2	40m	06*29.381	10*38.378	Raymond Camp
15	Thomas Johnson -2	Oil palm	30	0.16	40m	06*29.381	10*38.378	Raymond Camp
16	Joseph T. Johnson	Plantain Sugar Cane		0.29	41 m	06*29.360	10*38.850	Raymond Camp,
17	Kammue Martor	Rubber	900	1.63	68m	06*29.586	10*38.231	Raymond Camp
18	Garmai Franklin	Corn and Banana		0.27				Raymond Camp
19	Johnson Gayflor	pineapple and Cassava		0.14				Raymond Camp
20	Daniel Barker -2	Rubber	1000	1.5				Raymond Camp
21	David Zayzay	Rubber	700	1.27				Raymond Camp

FIELD MEASUREMENT PER HOUSE HOLD IN THE MC HPP PROJECT AREA								
		,.			GPS RECORDINGS			
No:	***NAME OF HH FARMER***	***Crop***	***# of trees***	***Farm size [Ha]***	***Elevation [m]***	***N***	***W***	***Community***
22	Alphonso Zoryou	Rubber	600	1.09				Raymond Camp
23	Herry Flomo -1	Rubber	700	1.27				Raymond Camp
24	Herry Flomo -2	Corn, bitter ball and pepper		0.34	54 m	06*29.893	10*38.247	Raymond Camp
25	Sisco clinton -2	Rubber	900	1.63				Raymond Camp
26	Samuel Rufus	Sugar cane		1.13	52 m			Raymond Camp
27	Harrison K. Sumo	sugar cane		0.22	66 m			Raymond Camp
28	Mark Clemens	Sugar Cane		0.9	56m			Raymond Camp
29	James Y. Flomo	Cocoa and Corn		0.25				Raymond Camp
30	Fatou Barker	Corn, bitter ball and pepper		0.35	39 m			Raymond Camp
31	James Togbah	Sugar cane and banana		0.9	51 M			Raymond Camp
32	Joseph Kelleyan	Sugar cane and Plantain		0.21	61 m			Raymond Camp
33	Siya Saah	Sugar cane		2	26 m	06*29.425	10*38.988	Raymond Camp
34	Frank Goodliong	Sugar cane and Rubber	260	0.5	52 m			Raymond Camp
35	Thomas F. Johnson -1	Rubber	900	1.6	53 m	06*30.021	010*39.262	Buzzel Quarter
36	Thomas F. Johnson -2	Sugar cane		0.5	53 m	06*30.021	010*39.262	Buzzel Quarter
37	George A. Bass-1	Rubber	1000	1.81				Buzzel Quarter
38	Moses Konnah	Rubber	3750	6.8	51	06*29.954	010*39.420	Buzzel Quarter
39	Samuel Gbanjah-1	Rubber	1800	3.27	50 m	06*29.964	010*39.590	Buzzel Quarter
40	Moses Sisco	Rubber	1000	1.8	50 m	06*29.775	010*39.527	Buzzel Quarter
41	Samuel Gbanjah -2	plantain and corn		0.9	43 m	06*29.732	010*39.434	Buzzel Quarter
42	Fatu Johnson	corn		0.34	48 m	06*29.829	010*39.391	Buzzel Quarter
43	Daniel Kollie	Banana and cocoa		0.9	49 m	06*29.829	010*39.350	Buzzel Quarter

FIELD MEASUREMENT PER HOUSE HOLD IN THE MC HPP PROJECT AREA								
		,.			GPS RECORDINGS			
No:	***NAME OF HH FARMER***	***Crop***	***# of trees***	***Farm size [Ha]***	***Elevation [m]***	***N***	***W***	***Community***
44	Samuel Gbanjah -3	Cocoa		1.36	47 m	06*29.916	010*39.221	Buzzel Quarter
45	Abraham Gbanjah-1	Plantain		0.68	50 m	06*29.898	010*39.207	Buzzel Quarter
46	Robert Kerkulah	plantain		0.7	47 m	06*29.904	010*39.757	Buzzel Quarter
47	Abraham Gbanjah -2	cassava		0.68	52 m	06*29.798	010*39.212	Buzzel Quarter
48	David Wee	Plantain		0.9	25 m	06+29.799	010*39.211	Buzzel Quarter
49	Zupon Zupon	Banana		0.68	44 m	06*30.340	10*39.161	voinjama
50	Moses K. Sumo	pepper and bitter		0.9	37 m	06*30.486	10*38.893	voinjama
51	Maryee Franklin	pepper and corn		0.92	37 m	06*30.458	10*38.809	voinjama
52	David Bono	pepper and egg-plant		1.5	39 m	06.30.458	10*38.809	voinjama
53	Saturday Kerkulah	pepper		0.9	40 m	06*30.458	10*38.808	voinjama
54	Old lady Diggs-1	Banana		0.45	41 m	06.30.408	10*38.821	voinjama
55	Old lady Diggs-2	pepper		0.45	47 m			voinjama
56	John Sumo	pepper		0.45	45 m	06*30.437	10*38.861	voinjama
57	Joseph Goll	Rubber	1000	1.8	17 m			Varney Town
58	Syverster Clemens	Rubber	2000	3.6	51 m	06º31.312	10º37.315	Varney Town
59	Jackson Kennedy	Rubber and cassava	700	1.5				Varney Town
60	Momo Risks	rubber	250	0.45	15 m			Varney Town
61	Edwin Mallet	Rubber	1000	1.8	19 m	06º31.663	10º36.052	Varney Town
62	Mary Fineboy	Banana		0.45	20 m	06º31.715	10º36.176	Varney Town
63	Joseph Kollie	Rubber	1400	1.36	31 m	06º31.144	10º36.494	Varney Town
64	Konah Zeiglah	plantain		0.65	25 m	06º31.394	10º36.878	Varney Town
65	Anthony Kennedy	Planrtain		0.9	26 m	06º31.312	10º36.485	Varney Town

FIELD MEASUREMENT PER HOUSE HOLD IN THE MC HPP PROJECT AREA								
		,.			GPS RECORDINGS			
No:	***NAME OF HH FARMER***	***Crop***	***# of trees***	***Farm size [Ha]***	***Elevation [m]***	***N***	***W***	***Community***
66	Philip Koto	cassava		0.6	24 m	06º31.410	10º36.359	Varney Town
67	Fatou thompson	Rubber	374	0.68	31 m	06º31.270	10º36.426	Weaduo
68	Oldman Fineboy	Rubber	374	0.68	28 m	06º31.287	10º36.438	Weaduo
69	Bendu Koto	Rubber	500	0.9	29 m	06º31.152	10º36.382	Weaduo
70	Flomo Morris	Rubber	400	0.72	29m	06º31.133	10º36.405	Weaduo
71	Gabriel Domah	Plantain		0.45	30 m	06º31.112	10º36.435	Weaduo
72	Meimah Ricks	Cocoa		1.6	32 m	06º31.084	10º36.482	weaduo
73	Edwin Mallet -2	plantain		0.9	24 m	06º31.362	10º36.932	Weaduo
74	Daniel Norris	plantain		0.45	22 m	06º31.312	10º37.017	Weaduo
75	Ousma Massaly	cassava		0.45	47 m	06º31.677	10º35.664	Gbally Village
76	Abraham Keita	cassava and plantain		0.68	29m	06º31.687	10º35.672	Gbally Village
77	Varney Dukuly-1	cassava		0.22	33m	06º31.662	10º35.731	Gbally Village
78	Zinah Thompson	Rubber	75	0.13	46m	06º31.858	10º35.88	Gbally Village
79	Varney Dukuly -2	Cocoa		0.34	44m	06º31.862	10º35.924	Gbally Village
80	Gbally Domah	rubber	80	0.14	47m	06º31.809	10º35.937	Gbally Village
81	Fatumata Keita	corn		0.34	33 m	06º31.603	10º35.804	Gbally Village
82	Famata Fuller	Rubber	150	0.27	33 m	06º31.594	10º35.792	Gbally Village
83	Varney Dukuly	Rubber	750	1.35	43 m	06º31.733	10º35.881	Gbally Village
84	Fajumah Kromah	Rubber	500	1.1	63	06*32.084	010*36.711	Gbandi
85	Elijah Freeman	rubber	1500	2.72				Gbandi
86	Embulah Kromah	Rubber	800	1.45	64	06*31.844	010*36.875	Gbandi
87	Zinnah Stevens	Rubber	250	0.45	66	06*31.755	010*36.982	Gbandi

FIELD MEASUREMENT PER HOUSE HOLD IN THE MC HPP PROJECT AREA								
		,.			**GPS RECORDINGS**			
No:	***NAME OF HH FARMER***	***Crop***	***# of trees***	***Farm size [Ha]***	***Elevation [m]***	***N***	***W***	***Community***
88	Joseph Obit	Rubber	400	0.75	72	06*31.667	010*37.090	Gbandi
89	Sonnoe Japan	Rubber	200	0.36	67	06*31.659	010*37.167	Gbandi
90	Johny Kolleh	Rubber	1000	1.8	67	06*31.542	010*37.174	Gbandi
91	Varney Domah	cassava		0.45	63	06*31.424	010*37.355	Gbandi
92	James Boakai	pepper, bitter ball		0.75	63	06.31*424	010*37.401	Gbandi
93	Jimmy Carter -1	rubber	880	1.6	66	06*31.511	010*37.477	Gbandi
94	Wilmot Clarke	Rubber	150	0.27	47	06*29.916	010*39.221	Gbandi
95	Biomah Johnson	Bitter ball and pepper		0.42	64	06*31.979	010*37.511	Gbandi
96	Lasanah Konnah	Rice and Plantain		1.6	42	06*31.339	10*37.766	Markai
97	Lasanah kromah	rubber	1500	2.7	35	06*31.276	010*37.860	Markai
98	Jimmy Carter -2	Plantain		1.2	36	06*31.243	010*37.962	Markai
99	Zinnah Konnah	Plantain		0.45				Markai
100	Bendu Konnah	Corn and pepper		0.86				Markai
101	Massa Konnah	Rubber	200	0.36				Markai
102	Abu Boakai	Rubber	320	0.58				Markai
103	Daniel Huggar	Rubber	1000	1.8				Sarah Town
104	Lafy Huggar	Rubber	700	1.27	35	06*31.145	010*38.604	Sarah Town
105	Momo Huggar	Rubber	2000	3.6	22	06*31.149	010*38.661	Sarah Town
106	Cruzer Huggar	Cassava and rice		1.5	30	06*31.187	010.38.416	Sarah Town
107	Vick Huggar	Rubber	400	0.75				Sarah Town
108	Yassah Flomo	pepper and plantain		1.5				Sarah Town
109	James williams	rubber	250	0.45				Sarah Town

FIELD MEASUREMENT PER HOUSE HOLD IN THE MC HPP PROJECT AREA								
		,.			GPS RECORDINGS			
No:	***NAME OF HH FARMER***	***Crop***	***# of trees***	***Farm size [Ha]***	***Elevation [m]***	***N***	***W***	***Community***
110	Lincoln Huggar	Cassava		0.5	43	06*31.144	010*38.694	Sarah Town
111	Bessy Kamara	corn and cassava		0.46				Sarah Town
112	Irene Korfeh	corn		0.2				Sarah Town
113	Pallah Sumo	corn and pepper		0.22	34	06*30.816	010*38.865	Zakama Field
114	Yewullie Sumo	Plantain and cassava		0.68	48	06*30.766.	010*38.830	Zakama Field
115	Faith Huggar	Rubber	100	0.18	36	06*30.858	010*38.902	Zakama Field
116	Bestman Kennedy	Plantain		0.45				Zakama Field
117	Mulbah Zakama	Plantain		0.22				Zakama Field
118	Beyan Sumo	cassava		0.9				Zakama Field
119	Micheal Huggar	Rubber	150	0.27				Zakama Field
120	Gbanjah Huggar	cassava		0.52				Zakama Field
121	Arthur Clemens	rubber	125	0.02				Zakama Field
122	Rose Clemens, Kopo Zakama,Arthur Morris,mary Moore,Siah Fallah,Sebeh Sumo,Rebecca Toghah,David Brownell koto Gayflor	Group vegetable (corn, pepper, grain, okra etc) farm along the St Paul river bank close to the dam control gate		2				Zakama Field
123	Gbassay Padmore	Sugar cane		0.45				James A. Mulbah's Town
124	Borbor Garmen	Sugar cane		0.34				James A. Mulbah's Town
125	Jonah Sieh	Rubber	500	0.9				James A. Mulbah's Town
126	George Padmore-1	Rubber	1200	2.18				James A. Mulbah's Town
127	George Padmore-2	sugar cane		0.5				James A. Mulbah's Town
128	John Doufoah	Rubber intercropped with sugar cane	600	1.09				James A. Mulbah's Town
129	Gbartor Paypay	cocoa		0.45				James A. Mulbah's Town

FIELD MEASUREMENT PER HOUSE HOLD IN THE MC HPP PROJECT AREA								
		,.			GPS RECORDINGS			
No:	***NAME OF HH FARMER***	***Crop***	***# of trees***	***Farm size [Ha]***	***Elevation [m]***	***N***	***W***	***Community***
130	Nowah Padmore	Rubber intercropped with sugar cane	500	0.9				James A. Mulbah's Town
131	Augustine Yankaba	Rubber intercropped with sugar cane	800	1.45				James A. Mulbah's Town
132	Amos Kollie	Rubber intercropped with sugar cane	400	0.72				James A. Mulbah's Town
133	William Flomo	Rubber intercropped with sugar cane	200	0.36				James A. Mulbah's Town
134	Rufus Borkpateh	Rubber	700	1.27				James A. Mulbah's Town
135	Yatta Flomo	cassava		0.52				James A. Mulbah's Town
136	Amos Sieh	Rubber	400	0.72				James A. Mulbah's Town
137	Jestina Dorglas -1	Rubber	1000	1.8				James A. Mulbah's Town
138	Jestina Dorglas-2	pepper		0.45				James A. Mulbah's Town
139	J. Barclay Gleekeh	Rubber intercropped with sugar cane	700	1.27				James A. Mulbah's Town
140	Mary Kollie	Rubber	400	0.72				James A. Mulbah's Town
141	William Padmore	Rubber intercropped with sugar cane	600	1.09				James A. Mulbah's Town
142	Esther Myers	sugar cane		0.5				James A. Mulbah's Town
143	David Belleh	Rubber and Sugar cane	1000	1.8				James A. Mulbah's Town
144	Amos and Morris -1	Rubber	3300	6				James A. Mulbah's Town
145	Amos and Morris -2	Sugar cane		2.72				James A. Mulbah's Town
146	Amos and Morris -3	Banana		0.5				James A. Mulbah's Town
147	Okaso Padmore	Sugar cane		0.45				James A. Mulbah's Town
148	Joseph Monroe -1	sugar cane		0.2				James A. Mulbah's Town
149	Joseph Monroe -2	Rubber	2000	3.6				James A. Mulbah's Town
150	Momo Kollie	Rubber intercropped with cassava	500	0.9				James A. Mulbah's Town
151	Siafa Sameh	cassava	1000	1.8				James A. Mulbah's Town

FIELD MEASUREMENT PER HOUSE HOLD IN THE MC HPP PROJECT AREA								
		,.			GPS RECORDINGS			
No:	***NAME OF HH FARMER***	***Crop***	***# of trees***	***Farm size [Ha]***	***Elevation [m]***	***N***	***W***	***Community***
152	James Porkpa -1	Rubber and cassava	2000	3.6				James A. Mulbah's Town
153	George Singbeh -1	Rubber	1000	1.8				James A. Mulbah's Town
154	George Singbeh -2	Corn and Plantain		0.9				James A. Mulbah's Town
155	Edwin Monroe	Rubber and pepper inter-cropped	250	0.45				James A. Mulbah's Town
156	Fred Lartey	Rubber	300	0.36				James A. Mulbah's Town
157	Esther Kollie	pepper and bitter ball		0.22				James A. Mulbah's Town
158	Amos Komil	Rubber	2000	3.6				James A. Mulbah's Town
159	James M. Kollie-1	Rubber	1000	1.8				James A. Mulbah's Town
160	James N. Kollie -2	pepper and bitter ball		1.3				James A. Mulbah's Town
161	Moses Flomo	cassava and Rubber intercropped	750	1.63				James A. Mulbah's Town
162	Daniel Porkpah	Rubber	1000	1.8				James A. Mulbah's Town
163	Konnah Campbell	Rubber and cassava	200	0.36				James A. Mulbah's Town
164	Samuel konnah	Rubber and cassava	400	0.72				James A. Mulbah's Town
165	Moses Porkpah	Rubber and cassava	150	0.27				James A. Mulbah's Town
166	John paypay	Rubber and plantain	500	0.9				James A. Mulbah's Town
167	Foday Somah	Cassava inter-cropped with pineapple		0.3				James A. Mulbah's Town
168	Moses kerkulah	rubber	500	0.9				James A. Mulbah's Town
169	Varney Massaquio	Rubber	1000	1.8				James A. Mulbah's Town
170	Foloklah Padmore	Rubber	500	0.9				James A. Mulbah's Town
171	Henry Mulbah	cassava		0.42				James A. Mulbah's Town
172	George Singbeh	rubber	1000	1.8				James A. Mulbah's Town
173	Hawa Momo -1	oil palm	300	0.45				James A. Mulbah's Town

FIELD MEASUREMENT PER HOUSE HOLD IN THE MC HPP PROJECT AREA								
		,.			GPS RECORDINGS			
No:	***NAME OF HH FARMER***	***Crop***	***# of trees***	***Farm size [Ha]***	***Elevation [m]***	***N***	***W***	***Community***
174	Hawa Momo -2	rubber	500	0.9				James A. Mulbah's Town
175	Peter Sokan	Rubber and cassava	500	0.9				James A. Mulbah's Town
176	Richard M. Flomo	Rubber	500	0.9	41	06*29.852	010*37.274	Wonekai
177	Paul Harris	Rubber	400	0.72	31	06*29.851	010*37.908	Wonekai
178	Annie Gatagah	Rubber	200	0.36	48	06*30.026	010*38.011	Wonekai
179	James K. Sumo	Rubber	600	1.09	47	06*29.711	010*38.104	Wonekai
180	James Davies	cocoa		0.45				Wonekai
181	Andrew Tengbeh	Plantain and cassava		1.6	55	06*30.149	06*29.907	Wonekai
182	Moses Sumo	rubber	600	1.09				Wonekai
183	Augustine Dixon	cassava		0.6	40	06*29968	010*38.273	Wonekai
184	Alphonso Brown	cassava		0.9	42	06*29.993	010*38.274	Wonekai
185	Princess Albert	plantain		0.25	42	06.29.857	010*38.544	Wonekai
186	Sam Flomo	pineapple		0.3	25	06*29.907	010*38.618	Wonekai
187	Alphonso Ricks	Rubber	1000	1.8				Borbor Town
188	Asata Sackie	plantain		0.45				Borbor Town
189	George Hunder	plantain		0.48				Borbor Town
190	Matthew Sackie	plantain		0.5				Borbor Town
191	Steven Togbah	plantain		0.45				Borbor Town
192	Wilson Sackie	plantain		0.45				Borbor Town
193	Tommy Uray -1	Rubber	1200	3	39	29N325255	721676	Benben Town
194	Tommy Uray -2	Sugar cane		1				Benben Town
195	Fatu Uray	Rubber and cassava	1000	1.5	38	29N324222	721405	Benben Town

FIELD MEASUREMENT PER HOUSE HOLD IN THE MC HPP PROJECT AREA								
		,.			GPS RECORDINGS			
No:	***NAME OF HH FARMER***	***Crop***	***# of trees***	***Farm size [Ha]***	***Elevation [m]***	***N***	***W***	***Community***
196	Musu Pewee	pepper and bitter ball		0.5				Benben Town
197	Mama Binda	Rubber	950	1.5	29	29N0324371		
198	Mama Binda	Sugar cane		0.6				Benben Town
199	Ruth Kolubah	vegetable		0.2				Benben Town
200	Everline Borkpotah	vegetable		0.25				Benben Town
201	Martha Shilling	Cassava and Banana		0.6				Benben Town
202	Grace Cloulo	Plantain		0.2				Benben Town
203	Jusu Massaquio	plantian		0.5				Benben Town
204	Mohemeh Sold	Cassava		0.3				Benben Town
205	Kahgomah Seabul	Banana		0.4	48	29N6325015	721737	Benben Town
206	Esther Yassiah -1	plantain		0.2	42	29N0324945	721759	Benben Town
207	Esther Yassiah-2	Rubber	401	0.8	42	29N0324945	721759	Benben Town
208	Mamie Binda	Cassava and plantain		0.5	41	29N0324202	721487	Benben Town
209	Peter Sackie	pepper		0.2	38	29N0324266	721345	Benben Town
210	Moses porkpah	vegetable		0.2				Benben Town
211	James Sumo	vegetable		0.32				Benben Town
212	Annie Steward	pineapple		0.21				Benben Town
213	Ahaba Sackie	Cassava		0.3	38	29N0324007	721333	Benben Town
214	Emmanuel Kolubah	Rubber	860	1.5				Benben Town
215	Joseph Sumo	Rubber	50	0.35	37	29N0324856	7223514	Sumo Village
216	David Sumo	Rubber and Vegetable	750	2	43	324779	2364	Sumo Village
217	Janet Sumo	Rubber	400	0.5				Sumo Village

FIELD MEASUREMENT PER HOUSE HOLD IN THE MC HPP PROJECT AREA								
		,.			GPS RECORDINGS			
No:	***NAME OF HH FARMER***	***Crop***	***# of trees***	***Farm size [Ha]***	***Elevation [m]***	***N***	***W***	***Community***
218	Yamah Sumo	vegetable and Rubber	300	0.4				Sumo Village
219	Famah Zinnah	Rubber and Vegetable	500	1.5				Sumo Village
220	Johny Matthew	Rubber	500	1				Sumo Village
221	John Sumo	Rubber	375	0.5				Sumo Village
222	Gbanjah Zinnah	Rubber	320	0.9				Sumo Village
223	Quayee Kabbah	Cocoa		1.5				Sumo Village
224	Morris Kerkulah	pineapple		0.25				Sumo Village
225	Joseph Secadayor	rubber	100	0.3				Sumo Village
226	Hannah Konnah	Rubber	500	1.2				Sumo Village
227	Hawa Blackey	Rubber	452	1				Sumo Village
228	Hawa Momo	Rubber	250	0.5				Sumo Village
229	Biomah Kollie	Rubber	650	1.5				Sumo Village
230	Hannah Binda	Rubber	155	0.5				Sumo Village
231	James Paye	Sugar Cane		1.2				Sumo Village

A14.2: Participants of Community Meeting and FGDs' Held Concerning Agriculture

Women Group (Raymond Camp) Date: February 16, 2012

No.	NAME OF PARTICIPANT	GENDER	OCCUPATION	NAME OF SETTLMENT
1	Lucy Johnson	Female	Small Business/Farmer	Raymond Camp
2	Dasee kpadia	Female	Farmer	Raymond Camp
3	Kpaine Manamee	Female	Farmer	Raymond Camp
4	Cecelia Mator	Female	Farmer	Raymond Camp
5	Martha N. Laywhyee	Female	Farmer	Raymond Camp
6	Kou Laywhyee	Female	Farmer	Raymond Camp
7	Easy Laywhyee	Female	Farmer	Raymond Camp
8	Celecia Seward	Female	Small Business	Raymond Camp
9	Mary Tengbe	Female	Farmer	Raymond Camp
10	Kopo Albert	Female	Farmer	Raymond Camp
11	Yamah Zayzay	Female	Farmer	Raymond Camp
12	Esther Johnson	Female	Farmer	Raymond Camp
13	Oretha Varney	Female	Farmer	Raymond Camp
14	Siya Saah	Female	Small Business/ Farmer	Raymond Camp
15	Noah Flomo	Female	Farmer	Raymond Camp

Youth Group (Raymond Camp). Date: February 16, 2012

No.	NAME OF PARTICIPANT	GENDER	OCCUPATION	NAME OF SETTLMENT
1	Nathaniel Koto	Male	Youth Leader/Farmer	Raymond Camp
2	Alphonso Zoryou	Male	Farmer	Raymond Camp
3	Sisco D. Clington	Male	Fisherman/farmer	Raymond Camp
4	Henry Flomo	Male	Fisherman/farmer	Raymond Camp
5	Paul S. Harris	Male	Fisherman/farmer	Raymond Camp
6	Saleo Sheriff	Male	Farmer	Raymond Camp
7	Josiah Diggs	Male	Farmer	Raymond Camp
8	Samuel Rufus	Male	Farmer	Raymond Camp

COMMUNITY LEADERS (Raymond Camp) Date: February 16, 2012

No.	NAME OF PARTICIPANT	GENDER	OCCUPATION	NAME OF SETTLMENT
1	Sam Gawoloquio	Male	Asst. Commissioner	Raymond Camp
2	Samuel T. Miller	Male	District Commissioner	Raymond Camp
3	Romed G. Saye	Male	Teacher	Raymond Camp
4	Frank Goodling	Male	Farmer	Raymond Camp
5	J. Roland Albert	Male	Farmer	Raymond Camp
6	Mathew Clarke	Male	Farmer	Raymond Camp
7	Daniel Barker	Male	Farmer	Raymond Camp
8	David Wee	Male	Farmer	Raymond Camp
9	Abraham Flomo	Male	Farmer	Raymond Camp

Meeting with a sample size of people from Gbally Village Date: March 10, 2012

No.	NAME OF PARTICIPANT	GENDER	OCCUPATION	NAME OF SETTLMENT
1	Famata Fuller	Female	Business/Farmer/Founder	Gbally Village
2	Ousma Massaly	Male	Village Chief/Farmer	Gbally Village
3	Momo Ricks	Male	Farmer	Gbally Village
4	Doris Fuller	Female	Farmer	Gbally Village
5	Edwin Johnson	Male	Farmer	Gbally Village
6	Massa Dukuly	Female	Farmer	Gbally Village
7	Massa McGill	Female	Farmer	Gbally Village
8	Orether Clay	Female	Farmer	Gbally Village
9	Varney Dukuly	Male	Farmer	Gbally Village
10	Wata Dukuly	Female	Female	Gbally Village
11	Fatumato Keita	Male	Farmer	Gbally Village

Varney Town Date: February 18, 2012

No.	NAME OF PARTICIPANT	GENDER	OCCUPATION	NAME OF SETTLMENT
1	Jackson Kennedy	Male	Town Chief/Farmer	Varney Town
2	Harllie Varney	Male	Farmer	Varney Town
3	Edwin Mallet	Male	Farmer	Varney Town
4	Joseph Kollie	Male	Farmer	Varney Town
5	Zoe Kollie	Female	Farmer	Varney Town
6	Edward D. Sackie	Male	Farmer	Varney Town
7	Joseph Goll	Male	Farmer	Varney Town
8	Gabriel Domah	Male	Farmer	Varney Town
9	Philip Koto	Male	Farmer	Varney Town
10	Joseph Collins	Male	Farmer	Varney Town
11	Bendu Koto	Female	Farmer	Varney Town
12	Yan Kollie	Female	Farmer	Varney Town
13	Zinnah Thompson	Male	Farmer	Varney Town
14	Mary Fineboy	Female	Farmer	Varney Town
15	Gbellay Goyah	Male	Farmer	Varney Town
16	Anthony Kennedy	Male	Farmer	Varney Town

Settlement: Gbandi Town Date: March 11, 2012

No.	NAME OF PARTICIPANT	GENDER	OCCUPATION	NAME OF SETTLMENT
1	Lasannah Kromah	Male	Town Chief	Gbandi
2	Fajumah Kromah	Male	Farmer	Gbandi
3	Varney Gbellay	Male	Farmer	Gbandi
4	Varney Domah	Male	Farmer	Gbandi
5	James Boakai	Male	Farmer	Gbandi
6	Ellen Rugus	Female	Farmer	Gbandi
7	Federick Brown	Male	Farmer	Gbandi

Community Meetings

Settlement: Buzzel Quarter Date: February 17, 2012

No.	NAME OF PARTICIPANT	GENDER	OCCUPATION	NAME OF SETTLMENT
1	Robert Kerkulah	Male	Town Chief/farmer	Buzzel Quarter
2	Thomas F. Johnson	Male	Farmer	Buzzel Quarter
3	Samuel Gbanjah	Male	Farmer	Buzzel Quarter
4	George A. Bass	Male	Farmer	Buzzel Quarter
5	Mohameh Barig	Male	Farmer	Buzzel Quarter
6	David Kerkulah	Male	Farmer	Buzzel Quarter
7	Henry Wilson	Male	Farmer	Buzzel Quarter
8	Gbanyan Zennah	Male	Farmer	Buzzel Quarter
9	Maway Mulbah	Female	Farmer	Buzzel Quarter
10	Jarlu Kerkulah	Male	Farmer	Buzzel Quarter
11	Abraham O. Gbanjah	Male	Farmer	Buzzel Quarter
12	Jefferson Brown	Male	Farmer	Buzzel Quarter
13	Charles Konnah	Male	Farmer	Buzzel Quarter

James Daniel Town (Women Group) February 18, 2012

No.	NAME OF PARTICIPANT	GENDER	OCCUPATION	NAME OF SETTLMENT
1	Cora Ricks	Female	Leader/Farmer	James Daniel Town
2	Sarah Swaray	Female	Small Business	James Daniel Town
3	Angeline K. Sumo	Female	Farmer	James Daniel Town
4	Heritha Boakai	Female	Farmer	James Daniel Town
5	Mary Miller	Female	Farmer	James Daniel Town
6	Elizabeth Gono	Female	Farmer	James Daniel Town
7	Eva Fineboy	Female	Farmer	James Daniel Town
8	Mammie Diggs	Female	Farmer	James Daniel Town
9	Lela Harris	Female	Farmer	James Daniel Town
10	Koto kerkulah	Female	Farmer	James Daniel Town
11	Kemah kerkulah	Female	Farmer	James Daniel Town
12	Kpana Port	Female	Farmer	James Daniel Town
13	Mawee Sirleaf	Female	Farmer	James Daniel Town
14	Tete Bono	Female	Farmer	James Daniel Town
15	Orether Kepa	Female	Farmer	James Daniel Town
16	Elizabeth Clington	Female	Farmer	James Daniel Town

Settlement: James Daniel Town (Community Leaders) February 18, 2012

No.	NAME OF PARTICIPANT	GENDER	OCCUPATION	NAME OF SETTLMENT
1	Will Goodling	Male	Elder/farmer	James Daniel Town
2	Wilmot Goodling	Male	Farmer	James Daniel Town
3	Samuel Clington	Male	Farmer	James Daniel Town
4	James Weaweah	Male	Farmer	James Daniel Town
5	C. Swaray	Male	Town Chief	James Daniel Town
6	Teanapu Mitchell	Female	Farmer	James Daniel Town

Community Meeting
Settlement: Sumo Village Date: March 10, 2012

No.	NAME OF PARTICIPANT	GENDER	OCCUPATION	NAME OF SETTLMENT
1	David Sumo	Male	Village Chief	Sumo village
2	Joseph Sumo	Male	Farmer	Sumo village
3	Janet Sumo	Female	Farmer	Sumo village
4	Yamah Sumo	Female	Farmer	Sumo village
5	Famah Zinnah	Female	Farmer	Sumo village
6	Johnny Matthew	Male	Farmer	Sumo village
7	John Sumo	Male	Farmer	Sumo village

Settlement: James Mulbah Town Date: March 13, 2012

No.	NAME OF PARTICIPANT	GENDER	OCCUPATION	NAME OF SETTLMENT
1	Forpka Sackie	Male	Town Chief	James Mulbah Town
2	Amos Tealeh	Male	Farmer	James Mulbah Town
3	Joseph Monroe	Male	Farmer	James Mulbah Town
4	Rufus Porkpateh	Male	Farmer	James Mulbah Town
5	Konnah Campbell	Female	Farmer	James Mulbah Town
6	Forday Sumo	Male	Farmer	James Mulbah Town
7	John Paypay	Male	Farmer	James Mulbah Town
8	Gbassy Padmore	Male	Farmer	James Mulbah Town
9	James M. Kollie	Male	Farmer	James Mulbah Town
10	William Flomo	Male	Farmer	James Mulbah Town
11	Kebbeh Garneh	female	Farmer	James Mulbah Town
12	Yatta Flomo	Female	Farmer	James Mulbah Town
13	Fatu Tealeh	Female	Farmer	James Mulbah Town
14	Gleekeh Padmore	Female	Farmer	James Mulbah Town
15	Augustine Yangaba	Male	Farmer	James Mulbah Town
16	David Belleh	Male	Farmer	James Mulbah Town

Settlement: Voinjama Date: February 17, 2012

No.	NAME OF PARTICIPANT	GENDER	OCCUPATION	NAME OF SETTLMENT
1	Prince E. Guanue,	Male	Farmer	Voinjama
2	David Garwoloquoi	Male	Farmer	Voinjama
3	Benjamin Kolubah	Male	Farmer	Voinjama
4	Moses Kolubah	Male	Farmer	Voinjama
5	Sackie Diggs	Male	Farmer	Voinjama
6	David Mulbah	Male	Farmer	Voinjama
7	KanzeeKowu	Male	Farmer	Voinjama
8	Mary Diggs	Female	Farmer	Voinjama

Settlement: Markai Date: March 12, 2012

No.	NAME OF PARTICIPANT	GENDER	OCCUPATION	NAME OF SETTLMENT
1	Lasannah Konnah	Male	Town Chief / Farmer	Markai
2	Varney Gbally	Male	Farmer	Markai
3	Benu Konnah	Male	Farmer	Markai
4	Zinnah Konnah	Male	Farmer	Markai
5	Jimmy Carter	Male	Farmer	Markai
6	Massa Konnah	Male	Farmer	Markai
7	Johnny Kolleh	Male	Farmer	Markai
8	John Otoo	Male	Farmer	Markai
9	Sarah	Female	Farmer	Markai

Sarah Town Date: March 12, 2012

No.	NAME OF PARTICIPANT	GENDER	OCCUPATION	NAME OF SETTLMENT
1	Daniel Hoggar	Male	Town Chief	Sarah Town
2	Lafy Huggar	Male	Farmer	Sarah Town
3	Momo Huggar	Male	Fisherman/farmer	Sarah Town
4	Cruzer Huggar	Male	Elder/ founder	Sarah Town
5	Vick Huggar	Female	Farmer	Sarah Town
6	James Wilson	Male	Farmer	Sarah Town
7	Lincoln Huggar	Male	Farmer	Sarah Town
8	Bessy Kamara	Female	Farmer	Sarah Town
9	Irene Korfeh	Female	Farmer	Sarah Town

Settlement: Benben Town March 14, 2012

No.	NAME OF PARTICIPANT	GENDER	OCCUPATION	NAME OF SETTLMENT
1	Tommy Uray	Female	Town chief /farmer	Benben Town
2	James Yarsiah	Male	Farmer	Benben Town
3	Esther Yarsiah	Female	Farmer	Benben Town
4	Joseph Yarsiah	Male	Farmer	Benben Town
5	Neomi Tenwah	Female	Farmer	Benben Town
6	Peter Yarsiah	Male	Farmer	Benben Town
7	Robert Mulbah	Male	Farmer	Benben Town
8	Mark Johnson	Male	Farmer	Benben Town
10	Momo Dagoseh	Male	Farmer	Benben Town
11	Alex Tommy	Male	Farmer	Benben Town
12	David Weah	Male	Farmer	Benben Town
13	Boima Dukuly	Male	Farmer	Benben Town
14	Timonthy Flomo	Male	Farmer	Benben Town
15	Yatta Dagoseh	Female	Farmer	Benben Town
16	Richard Daniel	Male	Farmer	Benben Town
17	Jimmy Tandai	Male	Farmer	Benben Town
18	Moses Pewee	Male	Farmer	Benben Town
19	Zie Dahn	Male	Farmer	Benben Town
20	Sekou Harris	Male	Farmer	Benben Town

21	Junior Duo	Male	Farmer	Benben Town
22	Morris Dukuly	Male	Farmer	Benben Town
23	Nacy Flomo	Female	Farmer	Benben Town
24	Alfred Massaquoi	Male	Farmer	Benben Town

Settlement: Zakama Date: March 13, 2012

No.	NAME OF PARTICIPANT	GENDER	OCCUPATION	NAME OF SETTLMENT
1	Gbanjah Huggard	Male	Farmer	Zakama Town
2	Kiowu Zakama	Male	Farmer	Zakama Town
3	Arthur Clement	Male	Farmer	Zakama Town
4	Beyan Sumo	Male	Farmer	Zakama Town
5	Ballah Sumo	Male	Farmer	Zakama Town
6	Katrient Wright	Female	Farmer	Zakama Town
7	David Brownell/Rose Clement	Male	Farmer	Zakama Town
8	Marry More	female	Farmer	Zakama Town
9	Bestmen Kennedy	Male	Farmer	Zakama Town
10	Siah Fallah	Female	Farmer	Zakama Town
11	Rebecca Togbah	Female	Farmer	Zakama Town
12	Arthur Morris	Male	Farmer	Zakama Town
13	Yeawulie Sumo	Male	Farmer	Zakama Town
14	Kopu Zakama	Female	Farmer	Zakama Town
15	Siah Zakama	Female	Farmer	Zakama Town

Settlement : Wonukai Date: February 17, 2012

No.	NAME OF PARTICIPANT	GENDER	OCCUPATION	NAME OF SETTLMENT
1	Richard Flomo	Male	Farmer	Wonukai
2	Paul Harris	Male	Farmer	Wonukai
3	Annie Gatagate	Female	Farmer	Wonukai
4	James K. Sumo	Male	Farmer	Wonukai
5	James Davies	Male	Village chief/ farmer	Wonukai
6	Andrew Tengbeh	Male	Farmer	Wonukai
7	Moses F. Sumo	Male	Farmer	Wonukai
8	Alponso Brown	Male	Farmer	Wonukai
9	Sam Flomo	Male	Farmer	Wonukai
10	Mammie Harris	Female	Farmer	Wonukai

Settlement : Borbor Town Date:

No.	NAME OF PARTICIPANT	GENDER	OCCUPATION	NAME OF SETTLMENT
1	Roland Bridges	male	Town Chief	Borbor
2	Sylvester Clemen	male	Farmer	Borbor
3	Alphonso Ricks	male	Farmer	Borbor
4	Asata Sackie	male	Farmer	Borbor
6	George Hunder	male	Farmer	Borbor
7	Matthew Sackie	male	Farmer	Borbor
8	Steven Togbah	male	Farmer	Borbor
9	Wilson Sackie	male	Farmer	Borbor

ANNEX 15: INFRASTRUCTURE

No entries in this Annex

ANNEX 16: WATER SUPPLY

No entries in this Annex

ANNEX 17: PUBLIC HEALTH

A17.1: List of Persons Met and Interviewed

Name	**Institution and function**	**Contact**
WATAKU Z. KORTIMAI	ENVIRONMENTAL ENGENIEER/MOHSW	0886532431
BENJAMIN C. SOKO	COORDINATOR, WASTE MAGANEMENT/MOHSW	0886520911
NEMO J. KAMARU	ENVIRONMENTAL HEALTH SUPERVISOR, CHT, MONTSERRADO	0880546440
ROWENA B. STANLEY	NURSE, NYEHN HEALTH CENTER	0886878776
AMOS D. CARTER	OIC, WHITE PLAINS CLINIC	0886570385
ATTOLO G. CLEMENS	DISPENSER, WHITE PLAINS CLINIC	0777889983
TAMBA K. HENNEH	ADMINISTRATOR, PEACELAND MEDICAL AND LABORATORY CLINIC, KINGSVILLE	0886852479
JACKSON S. KOTIO	LABORATORY TECHNICIAN, PEACELAND MEDICAL AND LABORATORY CLINIC, KINGSVILLE	0886113588
GEORGE T.BOAKAI	BENSONVILLE HOSPITAL/OIC	0886483210
LUCIUS BOLLEY	BENSONVILLE HOSPITAL /ADMINISTRATION	0886895309
JAMES KPANGBOI	BENSONVILLE HOSPITAL /ACCOUNTANT	08886345485
ALBERTHER KORTIE	BENSONVILLE HOSPITAL /CM	0886409838
RICHARD TOBY	BENSONVILLE HOSPITAL /EPI SUP.	0886411779
JAMES SUMOIWNO	CROZIERVILLE CLINIC/OIC	0886439794
KEBBEH FRANKLIN	CROZIERVILLE CLINIC /CM	0886582719
AGNES NAMA	HERRIBURY CLINIC /CM	0777778459
MENIKILI PAGE	HERRIBURY CLINIC /OIC	0776109432
KARTINA LAYWEH	CAREYSBURY CLINIC/ RN	0880510329
WILLING TUBOGAR	CAREYSBURY CLINIC / OIC	08886581620
CELESTINE SELAY	ARTHINGTON CLINIC/ OIC	0777860251
DEBBIE KWASHIE	ARTHINGTON CLINIC CM	0777276520
COMFORT VARGBELEE	ARTHINGTON CLINIC /PA	0776834048
SAM DANMA WILLIAMS	BROMELY CLINIC/ RN	0880444609
SARAH BORVAH	BROMELY CLINIC /CM	0886691888
RITA GARTEI	A.F.RUSSELL CLINIC/ OIC	0886525480
NETTIE GONSAH	A.F.RUSSELL CLINIC /CM	0886686068
LEOCA	BLAMACEE CLINIC/ OIC	0886769726
BENITOR	BLAMACEE CLINIC / CM	0886939203
ZINNAH FULLY	BLAMACEE CLINIC / VACINATOR	0886315926
DONS DEYTON	ST.PETERS CLINIC/ OIC	088063264
MIATTA KAMARA	ST.PETERS CLINIC /HEAD NURSE	0880732531
SANDIA ASGONG	ST.PETERS CLINIC/ CM	NO NUMBER
EDWIN SENGA	WONJAH SMITH CLINIC/ OIC	0886821921

ANNEX 18: CULTURAL HERITAGE

No entries in this Annex

ANNEX 19: MAIN IMPACTS

No entries in this Annex

ANNEX 20: MITIGATION MEASURES

No entries in this Annex

ANNEX 21: PROVISIONAL ESMP

No entries in this Annex

ANNEX 22: RESETTLEMENT PLANNING

No entries in this Annex

ANNEX 23: PUBLIC PARTICIPATION

A23.1: Meetings Held

Table 30-15: Meetings Held

Date	Persons met	Institution, contact	Met by	Main Topics / Observations

2011-11-14	Mr. Joseph T. Mayah,
	Deputy CEO
	
	Mr. Matthew F. Konai
	Acting Manager CPD
	
	Mr. Arthur S. Johnson
	Engineer CPD
		Liberian Electricity Corporation (LEC)
		Tel. 06-511941
		Liberian Electricity Corporation (LEC)
		
		Liberian Electricity Corporation (LEC)
			Dr. Robert Zwahlen
			Ms. Britta Lammers
			Ms. Imelda Yhr
				• Introduction of LEC and Pöyry
				• Main aims have been to start the collection of material and information concerning Mount Coffee HPP
				• Pöyry delivered the list of required data
				• Information received:
				  • Technical and Financial Feasibility Study for the Reconstruction and Expansion of the Mount Coffee Hydropower Facility in Liberia (2008).
				  • St. Paul river Hydroelectric Development: Feasibility Study 1982 Volume 1 to4
				• More information will be available from Stanley Consultants Inc.
				• Discussing options for start of assignment (awaiting finalisation of contract)
				• Office will be made available in Monrovia.
				• Arranged site visit for November 15th, 2011, with Deputy COE of LEC and Acting Manger CPD.
				• Arranged meeting with Ministry of Land, Mines and Energy

2011-11-14	Mr. Beauford O. Weeks Assistant Minister for Energy Mr. Joseph T. Mayah, Deputy CEO	Ministry of Land, Mines and Energy Tel. 06-514005 Liberian Electricity Corporation (LEC) Tel. 06-511941	Dr. Robert Zwahlen Ms. Britta Lammers Ms. Imelda Yhr	• Discussion on availability of maps for the Project area. (what is available within the Cartographic Service Center) • Discussion on capacity building within the Ministry • Hydrological stations are not yet existing

Date	Persons met	Institution, contact	Met by	Main Topics / Observations
2011-11-16	Mr. Nathaniel T. Blama Deputy Executive Director Ms. Lilian S. Bemah Administration Assistant / Chief of Staff Mr. Edward G. Wingbah Assistant Manager/ Coordination Department Compensation Mr. Varney L. Cownen Assistant Manager / Enforcement Department Compensation	Environmental Protection Agency Liberia Mr. Blama: 0886 518 635 0777 518 635 natpolo2000@yahoo.com nattbs@gmail.com	Dr. Robert Zwahlen Ms. Britta Lammers Ms. Imelda Yhr	• Discussion on the EPA process, which contains two Steps. • Application: The Project Component has to inform EPA who will carry out the ESIA and RAP. EPA has to approve the Company. • Accreditation: After Pöyry has been approved, Pöyry is obliged to take in an independent local accredited ESIA Evaluator in the Team. EPA will provide Pöyry with the list of accredited ESIA Evaluator after the Approval of Pöyry, which will probably take up to two weeks. Pöyry will have to communicate the person chosen as ESIA Evaluator to EPA • Discussion on legislation and laws. Each sector has own guidelines. • The generic ESIA guidelines will be submitted to Pöyry after they have been approved.
2011-11-23	Mr. Joseph T. Mayah, Deputy CEO Mr. Matthew F. Konai Acting Manager CPD	Liberian Electricity Corporation (LEC) Tel. 06-511941	Ms. Britta Lammers	• Discussion on how to follow up the Application
2011-11-30	Mr. Joseph T. Mayah, Deputy CEO Mr. Matthew F. Konai Acting Manager CPD	Liberian Electricity Corporation (LEC) Tel. 06-511941	Ms. Britta Lammers Ms. Imelda Yhr	• Information on the Application Letter, which has been received by LEC.
2012-01-13	Mr. Matthew F. Konai Acting Manager CPD	Liberian Electricity Corporation (LEC) Tel: 0880326485 Tel: 0777091960	Dr. Robert Zwahlen Mr. Alan Edwards	• Robert Zwahlen introduced Alan Edwards • Alan Edwards introduced himself and outlined his background, expertise and experience • Alan Edwards outlined his intention to inspect the Mount Coffee HPP, Power Intake, Spillway and Embankments, the White Plains water treatment facility, the OHTL corridor between Mount Coffee HPP and Bushrod substation and the Bushrod substation • Discussion on the EPA progress

Date	Persons met	Institution, contact	Met by	Main Topics / Observations
2012-01-18	Mr. Matthew F. Konai Acting Manager CPD Mr. Boakai J. Paegar Chief of Office Staff / MD Office Mr. Nortu A. Jappah Jr Managing Director Mr. Elmos B. Glay Deputy Managing Director for Technical Services	Liberian Electricity Corporation (LEC) Tel: 0880326485 Tel: 0777091960 Liberian Water and Sewage Company (LWSC) Tel: 0886219531 Liberian Water and Sewage Company (LWSC) Tel: 0886750777 Liberian Water and Sewage Company (LWSC) Tel: 0886550962	Mr. Alan Edwards Mr. Alan Edwards Mr. Alan Edwards (telephone conversation) Mr. Alan Edwards (telephone conversation)	• Visit to Bushrod substation and inspection of the 10MVA subsection of the substation • Mr Konai exhibits, the project office • Discussion with regard to obtaining permission to visit and inspect the White Plaines Water Treatment works and the feasibility of reconnecting the former raw water pipe to the facility • Discussion pertaining to above request • Discussion pertaining to above request
2012-01-19	Mr. Matthew F. Konai Acting Manager CPD	Liberian Electricity Corporation (LEC) Tel: 0880326485 Tel: 0777091960	Mr. Alan Edwards	• Mr Konai accompanied Mr Alan Edwards for the duration of the visit to both the White Plains water treatment facility and Mount Coffee HPP, Powerhouse, Embankments and Spillway
2012-01-19	Mr. Elmos B. Glay Deputy Managing Director for Technical Services Mr. Horatio D. Bernard Operations Engineer Mr. Patrick N. Sandike Water Engineer Mr Elias Blidi Operator	Liberian Water and Sewage Company (LWSC) – at White Plains Water Treatment Facility Tel: 0886550962 Email:elmosbglay@lwsc.gov.lr Tel: 0886707437 Email:horatio1031@yahoo.com Tel: 0886707437 Email:pnsandikie@yahoo.com	Mr. Alan Edwards	• Discussion pertaining to the feasibility of reconnecting the raw water supply piping with the White Plains water treatment facility • Discussions on availability of drawings for both old and new water treatment facilities, but in particular with regard to the former raw water supply from Mount Coffee HPP • Discussions on reinstating the power supply when Mount Coffee HPP is rehabilitated. • Mr Elias Blidi kindly gave a guided tour of the facility and Pöyry Energy AG is very grateful to him for sharing his knowledge

Date	Persons met	Institution, contact	Met by	Main Topics / Observations
2012-01-19	Mr. Prince V. Mambu Sr. Inspector General Mr. Morris Z. Balakai Mining Engineer, Director, Bureau of Economic Forecast & Concession Appraisal	Ministry of Lands, Mines & Energy Tel: 0886116371 Ministry of Lands, Mines & Energy Tel: 0886573786 Tel: 0777960230	Mr. Alan Edwards	• Discussion regarding availability of maps and environmental concerns
2012-01-25	Mr. Varney L. Conneh Assistant Manager (ESIA) Department of Compliance & Enforcement	Environmental Protection Agency Tel: 0886531029 Email:clvarney68@yahoo.com	Mr. Alan Edwards	• Collection of the EPA Accreditation Certificate
2012–02-10	Mr. Joseph T. Mayah, Deputy CEO Mr. Matthew F. Konai Acting Manager CPD	Liberian Electricity Corporation Tel: 06-511941 Liberian Electricity Corporation Tel: 0880326485 / 0777091960	Ms. Britta Lammers	• Organization of the next days, site visits
2012-02-13 9:00–10:15	Mr. Joseph T. Mayah, Deputy CEO Mr. Matthew F. Konai Acting Manager CPD	Liberian Electricity Corporation (LEC) Tel: 06-511941 Liberian Electricity Corporation (LEC) Tel: 0880326485 Tel: 0777091960	Ms. Britta Lammers Dr. Victor Pouomogne	• Britta Lammers introduced Victor Pouomogne • Victor Pouomogne introduced himself and outlined his background, expertise and experience • Victor Pouomogne outlined his plans for the next days of field work and the stakeholder he would like to get in touch to. • Discussion on the staff which should be trained by Pöyry. • The Pöyry office was presented, even when the sanitation still not in operation.

Date	Persons met	Institution, contact	Met by	Main Topics / Observations
2012-02-13 10:30–13:30	Ms Yamga Tokpa, officer in charge, D. Wisseh Kay, Head of research and statistics, George Weefar, Head of aquaculture and inland division, Nicolas Nepe. Field technician. Fisheries inspector	Bureau of National fisheries. Tel.: 886462335 Tel.: 0886561193 Tel.: 0886652587 Tel.:08806222771	Ms. Britta Lammers Dr. Victor Pouomogne	• No data; available for field trip, because need to learn. BSc from university. • Some statistics: Marine 10000-150000 tons/yr 2008. Fishing plan not yet, gclm ok. • Number of fishers unknown; 14 staff including 9 inspectors plus 5 supporting. 111 landing sites. • Comments from Georges: Chemical (ddt) + dynamites used by fishermen to catch fish
2012-02-14 Until 2012-02-22	Village group fisheries leaders and contacts Morris Swaray, Town chief Fredrick A. Brown, Teacher Mrs Bandu Koroma, Chair lady Lasana Kroma Emmett Johnston t Georges Jones, Leader Jackson Kennedy, Leader Sarah Mulba, Women leader Rolland Brigges, Town chief Molley Fofee, Town chief James Carter, Town chief Samuel Ford Sarah Swaray, Women leader Aloysius Sewerd Alphonsus Dreks, Leader	 Tel: 0777125376 Tel: 0777304485 Idem Tel: 0777156358 Tel: 0776001673 Tel: 0777752451 Tel: 0776829950 Idem Tel: 0776145363 Tel: 0777379363 Tel: 0776135526 Tel: 0777006461 Tel: 0776203015 Tel: 0777906356 C/O Sam Y. Garwoloquoi, phone 0777899165	Dr. Victor Pouomogne	• Visit of the project area several individual meetings and group meetings with fishermen and fisherwomen

Date	Persons met	Institution, contact	Met by	Main Topics / Observations
2012-02-23	Mass Meeting, 70 attendance Mr. Matthew F. Konai Acting Manager CPD	Raymonds camp Liberian Electricity Corporation (LEC) Tel: 0880326485 Tel: 0777091960	Ms. Britta Lammers Dr. Victor Pouomogne Mr. Albert J. Thompson Mr. Mitchell Kumbelay Mr. E-Blamo Robinson	• Introduction of the team which is carrying out the ESIA. • Explanation of ESIA • Description of the project • Definition of the project area • Current stage of the assessment • The involvement of the local population in the ESIA • Overall time schedule of the ESIA • Discussion about the project including suggestions, wishes and comments of the local population
2012-02-23	Daniel Glay, station manager, John B. Giddings, lab technician for the station	Liberia Water Corporation LWC, Tel: 0886550003 Tel: 0777794266	Ms. Britta Lammers Dr. Victor Pouomogne	• LWC for data and lab analysis
2012-02-24	Dr Wollor E.Topor, acting dean, Science college, David Y. Kenkpen, Biology dpt Timothy K. Kie, dpt of Biology, Chairman. Kwewon David, Forestry on-field expert, since 1964. facilitated by Mathew Konai (LEC)	University of Liberia, Sciences department. Tel: 0886875802. Email wollortopor@yahoo.com Tel: 0886466687. Email Alpinjoyker@yahoo.com Tel: 06806174 Email timothyk.kie@yahoo.com Tel: 05789701	Ms. Britta Lammers Dr. Victor Pouomogne	• The University of Liberia has 4 colleges including science, agriculture & forestry, teachers, engineering. • in 2011, 300 graduates in agri, and 1000 in Sciences. (BSc level). Afterwards no way of going higher in Liberia. • Where to receive data on biodiversity for Liberia, Montserrado county and the Project area

Date	Persons met	Institution, contact	Met by	Main Topics / Observations
2012-02-24	Dr Sizi Z. Subah; Deputy Minister Technical Services, Isaac Flowers	Ministry of Agriculture Tel: 777557104. sizizsubah@yahoo.com. , Tel: 0886513364. zeekif@yahoo.com	Ms. Britta Lammers Dr. Victor Pouomogne	• WAAFF in Africa is planning to develop MSc training in Fisheries. • Isaac Flowers, Minagri Consultant who was then in charge of the FAO program distributing fishing materials to fishermen: 2003. FAO emergency program, after the war, lasted 1 yr; 244,000 USD. St-Paul and St-Georges rivers benches.
2012–02-28	Beauford O.Weeks, I. Msc Assistant Minister for Energy	Ministry of Land Mines and Energy	Ms. Britta Lammers	• Discussion on the Scoping Report. • Main comment: We should focus on Mount Coffee and Via should be a next step
2012-02-29	J. Konie Merfee Training Coordinator Samuel S. Peter Programme Assistant	FAO 0886592153 0886544070 / 0776737523	Ms. Britta Lammers	• Which kind of studies have been carried out in the Project area and or near surrounding • 2003 Study on Fishery, providing fishing gears to the local population • 2004 study on farming
2012-03-01	Mr. Nathaniel T. Blama	Environmental Protection Agency Deputy Executive Director	Ms. Britta Lammers	• Are there any comments on the Scoping Report
2012–03-01	Alexander Peal	Retired director of Conservation International	Ms. Britta Lammers	• Gathering data on biodiversity.
2012-03-05	Mass Meeting, 69 attendance	Gbandi Town in Arthington	Ms. Britta Lammers Mr. Thomas Langer Mr. Albert J. Thompson Mr. Mitchell Kumbelay Mr. E-Blamo Robinson	• Introduction of the team which is carrying out the ESIA. • Explanation of ESIA • Description of the project • Definition of the project area • Current stage of the assessment • The involvement of the local population in the ESIA • Overall time schedule of the ESIA • Discussion about the project including suggestions, wishes and comments of the local population

Date	Persons met	Institution, contact	Met by	Main Topics / Observations
2012-03-06	Mr. Joseph T. Mayah, Deputy CEO Mr. Matthew F. Konai Acting Manager CPD	Liberian Electricity Corporation (LEC) Tel: 06-511941 Liberian Electricity Corporation (LEC) Tel: 0880326485 Tel: 0777091960	Ms. Britta Lammers Mr. Thomas Langer Dr. Sylvain Nkwenkeu	• Britta Lammers introduced Mr Thomas Langer and Dr Sylvain Nkwenkeu • Dr Sylvain Nkwenkeu outlined his plans for the next days of field work and the stakeholder he would like to get in touch to. • LEC started right away with facilitating the meeting with the Ministry of health • Discussion on the staff which should be trained by Pöyry. • Sanitation of the Pöyry office is still not working.
2012-03-06	Mr. Nathaniel T. Blama Mr. Varney Conneh	Environmental Protection Agency Deputy Executive Director Responsible for the ESIA	Ms. Britta Lammers Mr. Thomas Langer	• Introduction of Mr. Thomas Langer • Discussion on the scoping process in Liberia, an additional meeting has been scheduled with Thomas Langer to discuss comments on the Scoping report.
2012-03-09	Varney L. Conneh Assistant Manager (ESIA)	Environmental Protection Agency of Liberia (EPA) Tel: 0886 531 029 clvarney68@yahoo.com	Mr. Thomas Langer Mr. Wassim Hamdam	• Procedures for approval of Scoping report. Final versions of scoping report, project brief and application letter.
2012-03-09	Mr. Matthew F. Konai Acting Manager CPD	Liberian Electricity Corporation (LEC) Tel: 0880326485 Tel: 0777091960	Mr. Thomas Langer	• Airport visa received for Mr. Nolé Tsabang • General status of the project
2012-03-12	Wataku Z. Kortimai Environmental Engineer Benjamin C. Soko Coordinator, Waste Management Nemo J. Kamaru Environmental Health Supervisor	Ministry of Health & Social Welfare Tel: 0886 532 431 Tel: 0886 520 911 Tel: 0886 546 440	Dr. Sylvain Nkwenkeu Mr. Thomas Langer	• Consultation/ information of the Ministery of Health & Social Welfare on initial results of health survey.

Date	Persons met	Institution, contact	Met by	Main Topics / Observations
2012-03-12	Dr. Wollor E. Topor Acting Dean	University of Liberia, Sciences department Tel: 0886 875 802	Dr. Nolé Tsabang Mr. Thomas Langer	• Introduction Nolé Tsabang • Recommendation: biology student for field assistance.
2012-03-13	Dr. Wollor E. Topor Acting Dean	University of Liberia, Sciences department Tel: 0886 875 802	Dr. Nolé Tsabang Mr. Thomas Langer	• Introduction of biology student for field assistance.
2012-03-14	Mr. Sam Y, Garwoloquoi, Town Clerk	Raymonds Camp Tel: 0777 899 165	Dr. Nolé Tsabang Mr. Thomas Langer	• Visit of the power house and the vegetation in its surrounding areas • Meeting at Raymonds Camp
2012-03-19	Mr. Joseph T. Mayah Deputy CEO Mr. Matthew F. Konai Acting Manager CPD	Liberian Electricity Corporation (LEC) Tel: 0886-511941 Liberian Electricity Corporation (LEC) Tel: 0880326485 Tel: 0777091960	Ms. Imelda Yhr Mr. Thomas Langer	• Announced of Mrs. Imelda Yhr's presence in Liberia in April and May 2012. • Mr. Matthew F. Konai back from an assignment outside Liberia
2012-03-21	Dr. Wollor E. Topor Acting Dean	University of Liberia, Sciences department Tel: 0886 875 802	Ms. Imelda Yhr Mr. Thomas Langer	• Introduction: Mrs. Imelda Yhr / Wollor Topor • General review of the Questionnaire for the Resettlement Action Plan
2012-03-22	Mr. Elmos B. Glay Deputy Managing Director for Technical Services	Liberian Water and Sewage Company (LWSC) – Monrovia Tel: 0886 550 962 elmosbglay@lwsc.gov.lr	Mr. Thomas Langer	• Request for quantitative data on drinking water consumption of Monrovia. • Data to be e-mailed to Consultant.
2012-03-22	Mr. Matthew F. Konai Acting Manager CPD	Liberian Electricity Corporation (LEC) Tel: 0880326485 Tel: 0777091960	Mr. Thomas Langer	• General status of the project • Request to forward 10 copies of the final scoping report and the project brief to Environmental Protection Agency of Liberia.

Date	Persons met	Institution, contact	Met by	Main Topics / Observations
2012-03-22	Frank Goodlin, Teacher & Member of Community Development Committee Mr. Sam Y, Garwoloquoi, Town Clerk Mr. Goodrich Village Chief	Tel: 0777207891 Tel: 0777899165 Tel: 0777172116	Dr. Wollor E Topor Ms. Imelda Yhr	• Introduction of Dr. Wollor • General population in the various towns that could be affected, on both sides of the river. • Received a list of towns and populations • Trip to project site made to familiarise Dr. Wollor with extent of area, both sides of the river were covered (left and right banks).
2012-03-23	E. Blamo Robinson Media / Peacebuilding Project Officer Albert Thomson Agricultural expert	International Alert Tel: 0886 554 827 Tel: 0777 333 916/0886 852 641	Ms. Imelda Yhr	• Status of work carried out so far • Discussion on possible impacted houses in the reservoir area • Need to verify the findings on the ground
2012-03-23	Albert Thomson Agricultural expert Mitchel Kumbelay Forestry expert	Tel: 0777 333 916/0886 852 641 Tel: 0886 595 905	Dr. Nolé Tsabang	• Discussion on findings of biodiversity/vegetation survey • Consolidation of results
2012-03-23	Mr. Sam Garwoloquoi Mr. Goodrich LEC employee	Town Clerk Tel: 0777899165 0777172116	Dr. Wollor Topor Ms. Imelda Yhr	• RRA including KIS and Emic –story telling to get information on already covered settlements for the HH survey, so as to build up settlement profiles. Covered Wenekia, Shellen, Erik, Gbally, and Sumo
2012-03-31	Frank Goodlin, Teacher & Member of Community Development Committee Mr. Sam Y, Garwoloquoi, Town Clerk Village Chief	Tel: 0777207891 Tel: 0777899165	Ms. Imelda Yhr Dr. Wollor E. Topor	• Workshop on prepared HH questionnaire on how to ask and fill information • Amending questionnaire as advised by Community representatives • Ground truthing on information received from earlier findings on houses built in the reservoir. • Identifying equipment needed for the detailed survey.
2012-04-03	Mr. Mathew F. Konai Acting Manager CPD	Liberian Electricity Corporation Tel: 0880326485 Tel: 0777091960	Ms. Imelda Yhr	• Update on latest activities in the field and findings of houses in the reservoir. • Preliminary findings on houses, crops, trees and owners data emailed as requested. • Follow up on status of reports sent to LEC and EPA

Date	Persons met	Institution, contact	Met by	Main Topics / Observations
12-04-16	Ms. Kristin K. Stroup	Senior Project Manager, LEC 0888 997 336 kristin.stroup@mhi.mb.ca	Dr. Robert Zwahlen Ms. Britta Lammers	• Inquired about information on Liberia energy sector . • Received reports/data on energy policy and economy.
12-04-16	Mr. Varney L. Conneh	Responsible for EIA, EPA clvarney68@gmail.com clvarney68@yahoo.com	Dr. Robert Zwahlen Ms. Britta Lammers	• Inquired about status of approval for Scoping Report. • Received assurance that EPA will send a letter asap confirming that Scoping is complete and that next step can be done.
2012-04-17	Mr. Sam Garwoloquoi	Town Clerk Tel: 0777899165 0777172116	Ms Britta Lammers	• To visit all villages within the reservoir area and to take the GPS coordinated
2012-04-18	Mr. Sam Garwoloquoi	Town Clerk Tel: 0777899165 0777172116	Ms Britta Lammers	• To visit all villages within the reservoir area and to take the GPS coordinated
2012-04-23	Mr. Tommy Urey, Town Founder Mr. James Yaseqah Town Chief Mr. Arthur S. Johnson Engineer CPD	Benben Town	Ms. Imelda Yhr Dr. Wollor Topor Mr. Sam Garwoloquoi	• Introduction of HH survey • Soliciting information on the settlement's history and asking about the settlement's structures and population, their economic activities, and the infrastructure present in order to work out the settlement's profile. • The enumerator and his assistant were left at the site to to start their work the following day.
2012-04-23	Mr. Russell c. Brown Mr. Leel Wickremarachchi	Chief of Party +231 0 880 686 715 rbrown@winrocklessp.org Private Power Producer Specialist +231 880 729 702 lwickremarachchi@winrocklessp.com LESSP (Liberia Energy Sector Support Program Monrovia, Liberia	Dr. Robert Zwahlen	• Discusse options for the power sector in Liberia. • Received information about LESSP's projects (currently: 4 projects for renewable electricity production, 2 small hydro, 1 biofuel and one woodchips fired thermal plant.

Date	Persons met	Institution, contact	Met by	Main Topics / Observations
2012-04-26	Mr. Mathew F. Konai Acting Manager CPD	Liberian Electricity Corporation Tel: 0880326485 Tel: 0777091960	Dr. Robert Zwahlen Ms. Britta Lammers Ms. Imelda Yhr	• Short update of the present stage of the study • Receiving information on the CLSG Project
2012-06-26	Mr. Matthew F. Konai Acting Manager CPD Mr. Henry Abiodu Lewis Sr. Manager, Corporate Planning Dept.	Liberian Electricity Corporation (LEC) Tel. 06-511941 Liberian Electricity Corporation (LEC) Tel: 0886 997 239, +231-6997239 Email: Halewis3027@yahoo.com	Ms. Imelda Yhr	• Update on where we are in regard to survey and RAP. The following information was narrated to LEC: • So far 145 HH have been interviewed, believed these are the ones that have to relocate, especially the Benben settlement. • FGDs are next and these will be divided to cover those losing cash crops, fisheries, coal production. The aim is to identify new livelihood strategies. FGD with Benben settlers as these were relocated in the 60s and came back to settle in present area. We want to know why they came back and what lessons could be learned from this. • Public consultations will also be done to gauge out those who were resettled before and then came back. As for Benben to find out why they came back. • Gender and Vulnerable groups will also be identified if not captured in the questionnaire. Data gathered so far shows no vulnerable groups were noted. This is puzzling, so we need to go back on the ground and verify this. • River Water usage: This was asked in the HH questionnaire and needs to be verified through FGDs. • Pöyry learnt that our Contact Mr. Matthew Konai is going on leave until August 6th, so our new contact will be the Manager Mr. Henry Abiodu Lewis Sr.

Date	Persons met	Institution, contact	Met by	Main Topics / Observations
2012-07-02	Mr. Tommy Urey, Town Founder Benben population for FGDs	Benben Town	Dr. Wollor Topor Ms. Imelda Yhr Mr. Albert Thompson Mr. Blamo Robinson Mr. Sam Garwoloquog	• Focus Group Discussions in 3 groups – men, women and youth to solicit information on people's knowledge on MC HPP. • PAPs identify alternative livelihood strategies • Elaborate on where the PAPs would like to relocate • The expectations of PAPs on the project and how they think these can be met. • Confirm Number of HHs and Population in Benben • Confirm existing public facilities in the settlement
2012-07-10	Women and Men of likely affected settlements	Settlements of Wenekai, Erik, and Shellen Town	Dr. Wollor Topor Ms. Imelda Yhr Mr. Sam Garwoloquog	• Focus Group Discussions differently with men and women to solicit information on people's choice of livelihood strategies, confirm HH and population, take photos of houses, confirm existing common goods and choice of relocation sites.
2012-07-10	Ms. Kristin K. Stroup	Senior Project Manager, LEC 0888 997 336 kristin.stroup@mhi.mb.ca	Dr. Robert Zwahlen Ms. Britta Lammers Ms. Imelda Yhr	• Update on the current project status • Confirmation on time, date and location of Donor Meeting. • Received the present stage of the development of the PIU • We got information that training is envisaged for PIU staff. • Positions to be filled in the PIU
2012-07-17	Mr. Shahid Mohammed, CEO Mr. Joseph Mayah, Deputy CEO Ms. Kirstin K. Stroup, Admin Director	LEC LEC +231 886 511 941 tambamayah@yahoo.com LEC / PIU Mount Coffee HPP. +231 886 997 336, kirstin.stroup@mbi.mb.ca	Ms. Britta Lammers Ms. Imelda Yhr Dr. Wollor Topor Mr. Albert Thompson Mr. Wassim Hamdan	• Presentation of ESIA and RAP to donors, PIU and EPA • Long discussion on hydrology • Long discussion on fisheries and especially the spawning on the 4 km area. • Need for a topography survey to pinpoint exactly whether the identified settlements will actually be submerged.

Date	Persons met	Institution, contact	Met by	Main Topics / Observations
	Mr. Alan Ferguson, Environmental Assessment Consultant	PIU Mount Coffee HPP, Consultant alan@regionalconsulting.ca		
	Dr. Daniel Skambracks, Snr. Environment & Social Advisor, Kwf Competence for Env & Climate	Kfw Development Bank +49 69 7431-3819 Daniel.skambracks@kfw.de		
	Mr. Ralf Kynast, Snr Engineer	Kfw Development Bank +49 69 7431-9468 Ralf.kynast@kfw.de		
	Andre Collin, Snr Project Manager Sub-Saharan Africa, Energy, Transport, Telecommunication	Kfw Development Bank +49 69 7431-4247 andre.collin@kfw.de		
	Mr. Knut Gakkestad, Snr. Advisor, Gender and Governance, Energy Section	Norad +47 23 98 00 00/803 36 knut.gakkestad@norad.no		
	Hon. Anyaa Vohiri Executive Director	EPA +231886 514 013 Vohiri@yahoo.com		
	Mr. Varney L. Conneh Assisstant Manager (ESIA)	EPA, Department of Compliance &Enforcement +231 886 531 029 Elvarney68@yahoo.com		
	Mr. Edward G. Wingbah	EPA. Asst.;Mgt/Coordination Tel: 0886576150		

Date	Persons met	Institution, contact	Met by	Main Topics / Observations
2012-07-18	Village Chief, Benben Population and Tommy and Fatu Urey – founders of Town,	Benben Town	Donors KFW and Norad, PIU Administrative Dir. PIU Environ Consultant EPA, Asst.: Mgt/Coordination Ms. Britta Lammars Ms. Imelda Yhr Mr. J. Mayah, LEC	• Donors asked whether settlement had been told about the project. Interviewed The founder on why he came back to same site after he had been moved before e dam was first constructed. • Visited the mining pits/areas for gold and later donors asked population various socio-economic information.
2012-07-18	Population at Wenekai	Wenekai Settlement	Donors KFW and Norad, PIU Administrative Dir. PIU Environ Consultant Ms. Britta Lammers Ms. Imelda Yhr	• Visited village and walked to fields to verify need of making a topological survey • Met with few women, noted charcoal packing
2012-07-18	Mrs. Pray	Raymond Camp Clinic, Nurse	Donors KFW and Norad, PIU Administrative Dir. PIU Environ Consultant EPA, Asst.: Mgt/Coordination Ms. Britta Lammers Ms. Imelda Yhr	• Assess capacity of clinic and need for upgrading • Inspect status and solicit information on who comes there for treatment, what type of treatment, number of beds, number of staff, where medicine is available, etc.. • Only 2 beds in room for examination and same room used as store for milk for mother and child. Presence of water tanks to harvest rain water, clean clinic. 5 staff government employed 2 volunteers from community, no doctor at clinic. • Donors asked waiting patients some questions.
2012-07-19	Mr. Alan Ferguson, Environmental Assessment Consultant	PIU Mount Coffee HPP, Consultant alan@regionalconsulting.ca	Ms. Britta Lammers Ms. Imelda Yhr	• Would like to have life cycle of the 5 aquatic key species in the ESIA • Risk of no flow • Flood warning system • Flood storage capacity of existing vegetated reservoir • Recommend monitoring on fish and water quality

Date	Persons met	Institution, contact	Met by	Main Topics / Observations
2012-07-19	Kirstin K. Stroup, Admin Director Dr. Daniel Skambracks, Snr. Environment & Social Advisor, Kwf Competence for Env & Climate Mr. Ralf Kynast, Snr Engineer Andre Collin, Snr Project Manager Sub-Saharan Africa, Energy, Transport, Telecommunication Mr. Knut Gakkestad, Snr. Advisor, Gender and Governance, Energy Section Gregs G. Thomopulos Chairman of the Board Tshaka E. Dennis Vice President	LEC / PIU Mount Coffee HPP. +231 886 997 336, kirstin.stroup@mbi.mb.ca Kfw Development Bank +49 69 7431-3819 Daniel.skambracks@kfw.de Kfw Development Bank +49 69 7431-9468 Ralf.kynast@kfw.de Kfw Development Bank +49 69 7431-4247 andre.collin@kfw.de Norad +47 23 98 00 00/803 36 knut.gakkestad@norad.no Stanley Consultants +1 563 264 6645 thomopulosg@stanleygroup.com Stanley Consultants +231 886 247 168 dennistshaka@stanleygroup.com	Ms. Britta Lammers Ms. Imelda Yhr	• In general references of Stanley related to HPP in the last years • Related to environment the topographical map

Date	Persons met	Institution, contact	Met by	Main Topics / Observations
2012-07-20	Dr. Daniel Skambracks, Snr. Environment & Social Advisor, Kwf Competence for Env & Climate Mr. Alan Ferguson, Environmental Assessment Consultant	Kfw Development Bank +49 69 7431-3819 Daniel.skambracks@kfw.de PIU Mount Coffee HPP, Consultant alan@regionalconsulting.ca	Ms. Britta Lammers Mr. Wassim Hamdan	• General references of Earthtime related to ESIAs • Discussion on the ESIA of the transmission lines from Mount Coffee HPP to Monrovia. • Danger for Birds and Bird protection • EMP of the transmission line • EMP ESIA Rehabilitation Mount Coffee HPP

A23.2: Notice of Intent

Notice of Intent

Environmental & Social Impact Assessment Study and Resettlement Action Plan for West African Power Pool

Rehabilitation of 64 MW Mount Coffee Hydropower Project

The general public and all concerned or interested parties are hereby informed that West African Power Pool is preparing an Environmental and Social Impact Assessment (ESIA) and Resettlement Action Plan (RAP) for the rehabilitation of 64 MW Mount Coffee Hydropower Project in Liberia.

Members of the Economic Community of West African States (ECOWAS) founded the West African Power Pool (WAPP) organization in January 2006. The objective of the WAPP is to establish a regional electricity market in West Africa through the judicious development and realization of key priority infrastructure that would permit accessibility to economic energy resources, to all member states of the ECOWAS.

In order to further advance the implementation of the priority projects of the West African Power Pool (WAPP), WAPP Secretariat and WAPP Members are embarking on preparatory works for the Mount Coffee Hydropower Project, which consists of the rehabilitation of the existing or destroyed components of the power plant and civil works.

The West African Power Pool (WAPP) on behalf of Liberia Electricity Corporation (LEC), procured the services of Pöyry Energy Ltd., Switzerland, an international Consulting firm, to undertake the Environmental Social Impact Assessment of the Mount Coffee Hydropower Project and the preparation of the Environmental Impact Statement and Environmental and Social Management Plan for Mount Coffee Hydropower Project.

In keeping with Section 11 of the Environmental Protection and Management Law of the Republic of Liberia (2003), and the World Bank's Environmental Assessment (OP 4.01) Safeguard Policy and EU directives WAPP'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 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:

E. Blamo Robinson

Monrovia, Liberia

E-mail: uncleblamo@yahoo.com

Tel.: 0886554827

Your participation or input in this assessment will be highly appreciated in order to guide decision making relevant to the proposed project.

A23.3: Mass Meeting in Raymond Camp and List of Participants

The first mass meeting with local community dwellers in the Mount Coffee Hydro Power Project area took place at the Raymond Town Palaver Hut on Thursday, February 23, 2012. An estimated number of 70 persons attended the meeting. The meeting started with the introduction of the team interacting with the community residents e.g. Mitchell Kumbelay (Forestry Specialist), E. Blamo Robinson (Communication Specialist), Albert Thompson (Agriculture Specialist), Victor Pouomogne (Fishery Specialist) and Britta Lammers (Biodiversity Specialist and Deputy Team Leader). In addition it was explained to the population that additional experts will come to carry out their assessment (Socio-economist, Health Expert, Botanist, etc.)

Furthermore Mr Matthew F. Konai from Liberian Electricity Corporation participated.

An introduction to what the rehabilitation of the Mount Coffee Hydro project entails was given by Ms. Britta Lammers, the Deputy Manager of the Environmental and Social Impact Assessment for the rehabilitation of Mount Coffee. It was announced that an environmental and social impact assessment will be carried out for the purpose of gauging both positive and negative effects that the project could generate on the population and the environment in the project area.

Ms. Britta Lammers stated that since the dam broke down in August 1990 and the subsequent looting and vandalization of the facility, plans are afoot to rehabilitate the hydro power plant consisting of the dam, the powerhouse, the substation and the reservoir. Ms. Lammers told that the project area would be divided into different zones which include directly affected and indirectly affected areas. She announced a upcoming mass community meeting to collect first hand accurate data from the ground in order to effectively address the concerns, problems and other unforeseen circumstances that may have some bearing on the rehabilitation of the Mount Coffee Hydro Power Plant.

Following the brief summary of what the project is about and what is involved in the process of rehabilitating it, the communications expert E. Blamo Robinson chaired the next part of the meeting. Direct interaction with the community dwellers were commented. The communities had the opportunity of expressing their concerns regarding the rehabilitation work, putting forward suggestions that may help in mitigating some of the concerns and comments.

Concerns Raised

The local population expressed fears and concerns regarding the future rehabilitation of the hydro power plant i.e.:

- loosing their farm lands;
- displacement to areas that they may not desire;
- denial of access to their daily livelihood;
- reduced access to forest land.

Needs Required

- compensation for farmland and crops that will be affected by the hydro project;
- the inclusion of women in the work force for the rehabilitation of the plant;

- community residents be given preference for hiring of human resource for plant rehabilitation;
- electric power be provided for local communities/residents when the hydro plant becomes operational and streets lights be installed in the project area;
- skill and vocational training in electricity be provided to locals for empowerment and subsequent absorption into the LEC work force at Mount Coffee.
- status of clinic in the project area be raised to that of an health centre;
- junior high school in the area be elevated to senior high school with living quarters for staff;
- building materials be provided to assist the reconstruct of their residences;
- installation of pipe borne water pumps;
- construction of a detention facility to dissuade the frequent commission of crimes.
- Construction of community town hall in project area.

Action applauded

The rehabilitation of the Mount Coffee hydro power plant.

Before the community meeting ended, comment and suggestion forms were given to the deputy commissioner of the area for onward distribution to other community dwellers who couldn’t attend the meeting. The forms are expected to be collected in the shortest possible time.

Table 30-16: List of Participants in Raymon Camp

MASS COMMUNITIES MEETING IN RAYMON CAMP 23.02.2012

No.	(Mr.,Ms.,Mrs)	First Name	Family Name	Community, Position	Contact
1	MRS.	FATU	BARKER	RAYMON CAMP	0778697362
2	MR.	SAMUEL	KOLLIE	RAYMOND CAMP	NIL
3	MRS	DARSEE	KPADEAH	"	0777387344
4	MS	MADIE	DIGGS	"	0777374446
5	MR.	JOHN	GBARNYAN SR	"	0760760855
6	MRS	ESTHER	JOHNSON K.	"	0778571559
7	MR.	JAMES	HARRIS A.	"	0770328166
8	MRS.	MARTHA	LAWHYEA	"	0776308661
9	MR.	JAMES	GARNIOLOQUIA	VOIJAMA	07771654018
10	MR.	JOHN	GBARNYAN JR	RAYMOND CAMP	0777844108
11	MS	LUCY	JOHNSON	"	0776837077
12	MS	TENNEE	HOLDER	FIRE-POINT	07760899443
13	MR	DAVID	GARNIOLOQUIOR	VOIJAMA/CT	077715715
14	MS	REBECCA	DUKULY	RAYMOND CAMP	NIL
15	MR.	ESAU	JOHNSON	"	0768577688
16	MRS	KOPO	ALBERTS	"	07777644094
17	MR.	ROLAND	ALBERTS	RAYMOND CAMP	0777603074
18	MR.	DANIEL	KOLLIE	"	0777856235
19	MR.	JAMES	DUKULY JR	"	NIL
20	MS	GARMAI	FRANKLIN	"	NIL
21	MR.	SAMUEL	GBARYAN T.	BUZZEL QUARTER	NIL
22	MR.	ALYOSIUS	SEKPARD	RAYMOND CAMP	0779063556
23	MR.	FRANK	GOODLING	"	0777207891
24	MS	ESTHER	MULBAH	"	0777404498
25	MR	FAHN	DENNIS	RAYMOND-CT	0776758465
26	MS.	MARY	SAYON	RAYMOND CAMP	NIL
27	MR.	JAMES	FLOMO	"	NIL
28	MR.	JOHN	SONNIE	"	NIL
29	MR.	SAMUEL	KPADEAH	R-CAMP/PRINCIPAL	07777297438
30	MR.	ROBERT	ZAWUO K.	R. CAMP	0777306609
31	MRS.	KPANIE	MANAMEE	"	07769028447

No.	(Mr.,Ms.,Mrs)	First Name	Family Name	Community, Position	Contact
32	MRS	LAZANDAH	KROMAH	BANDA/G.CT	0777688665
33	MR.	DAVID	DICKSON	GBALASUA/CT	NIL
34	MRS	SIA	SAAH	RAYMOND CAMP	NIL
35	MRS.	LUCIA	SACKIE	"	NIL
36	MR.	FEDRICK	BROWN	BANDA/TEACHER	0773049805
37	MR.	DANIEL	BARKER D.	RAYMOND CAMP	076436124
38	MR.	AUGUSTINE	MARTOR	"	0777556752
39	MR.	DANIEL	BARKER	"	NIL
40	MS	SARAH	DENNIS	"	NIL
41	MS	TASSAH	KOLLIE	"	NIL
42	MR.	JOHN	CRAWFORD	"	07781608
43	MR.	JAMES	KOLLIE	"	0880403501
44	MR.	CHARLES	KONNAH	"	NIL
45	MR.	SISCO	CLINTON	"	077405720
46	MR.	ALPHONSO	ZORYOU	"	NIL
47	MR.	ABRAHAM	FLOMO	"	0777282381
48	MRS	GENEVA	MILLER	"	NIL
49	MS	ELIZABETH	SUA	"	077312588
50	MS.	MARGRETT	WILLIAMS	"	0777131762
51	MRS	DAVID	WEE	"	NIL
52	MS	CECELIA	SEWARD	"	NIL
53	MR.	WILMOT	GOODLING	1ST WARD	0886974400
54	MR.	KAKAKOLO	RICKS	"	0776845742
55	MR.	JOHN	GAYFLOR C.	RAYMOND CAMP	NIL
56	MR.	SAM	GAKOLOGBOR	"/ASST. COM.	0777899165
57	MS	JATU	KERKULAH	BUZZEL QUARTER	0770000101
58	MR.	JOHN	BIOMAH S.	RAYMOND CAMP	077615755
59	MR.	PAUL	HARRIS SL	"	077206715
60	MR.	ISAAC	RICKS	"	NIL
61	MR.	GEORGE	A. BASS	"	NIL
62	MR.	PATRICK	CLINTON	"	NIL

No.	(Mr.,Ms.,Mrs)	First Name	Family Name	Community, Position	Contact
63	Mr.	JOSEPH	TWEH	RAYMOND CAMP	NIL
64	MR.	DAVID	FREEMAN	//	0763755320
65	MR.	THOMAS	JOHNSON	//	NIL
66	MR.	ROBERT	KERKULAH	RAYMOND CAMP	NIL
67	Mr.	Suliaho	Sheriff	"	"
68	Mr.	Neneh	Bridges	Borbor Town	"
69	Mis	Mata	White	Raymond Camp	0778899165
70		Asobe	Garwologuoi	"	"
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A23.4: Mass Meeting in Arthington, Gbandi and List of Participants

The second mass meeting with local community dwellers in the Mount Coffee Hydro Project area took place on Monday March 5, 2012 at Arthington a township located upstream from the damaged hydro power plant based at Mount Coffee in the township of Harrisburg. The meeting was attended by the special assistant to the Mayor of Arthington City in Gbande Town located on the outskirts of Arthington, where public meetings of such nature are usually held. 69 Persons participated at the meeting. The township is home to about 14 ethnic groups in Liberia, namely: Gola, Kpelle, Belle, Lorma, Kissi, Gio, Mano, Bassa, Krahn, Mandingo, Vai, Grebo, Mende and Kru.

The meeting started with the introduction of the present team, Mitchell Kumbelay (Forestry Specialist), E. Blamo Robinson (Communication Specialist), Albert Thompson (Agriculture Specialist), Thomas Langer (ESIA Specialist) and Britta Lammers (Biodiversity Specialist and Deputy Team Leader). In addition it was explained to the population that additional experts will come to carry out their assessment (Socio-economist, Health Expert, Botanist, etc.) in the project area.

A short description of the project, the project area and the current stage of the project was given by Ms. Britta Lammers.

One of the main concerns was, that the population had heard that another river would be diverted into the St. Paul river. Therefore the people thought that the reservoir area would be larger than before and additional villages would have to be relocated. The consultant explained that the dam height and the full supply level of the reservoir would not change and as long these characteristics of the HPP are not changed the area the reservoir will stay the same as before the dam was broken.

The meeting with the locals of this township was crucial because some residents of this township who are engaged in farming activities along the St. Paul river bank will definitely be affected when the hydro power plant becomes operational following the completion of the rehabilitation work. Other locals who are involved in fishing in the St. Paul River and others depending on non timber forest products in forested areas of the Arthington township would be concerned about both the positive and negative effects that the rehabilitation and subsequent operation of the hydro plant would have on their daily livelihood, hence it became imperative to convene a community meeting in the township to consult with the locals.

Most of the women said they were involved in farming as their livelihood while some men indicated that they were actively engaged in farming, hunting and fishing.

Concerns expressed:

- Expansion of the reservoir may overflow their residential areas;
- Rehabilitation of dam will affect their farms located along the banks of the St. Paul River;
- High yields from fishing will be drastically reduced.
- More than five villages are said to be in the pathway of the reservoir over ten houses reported to be on the pathway of reservoir will be damaged.

Positive sentiments expressed:

- With the return and subsequent operation of the hydro plant, mosquito infested diseases would be drastically reduced.

Suggestions:

- Locals who are basically unskilled want inclusion in the work force that would be involved in the rehabilitation work of the hydro power plant;
- Clinics be established in the township;
- Bird nets to drive away intruders from farms;
- Schools be constructed in the township.

Table 30-17: List of Participants in Arthington

MASS COMMUNITIES MEETING HELD IN GBANDI

05.03.2012

No.	(Mr.,Ms.,Mrs)	First Name	Family Name	Community, Position	Contact
1	MR.	FREDRICK	BROWN	GBANDI/TEACHER	0773044?5 *
2	"	VARMUNAH	DUKULY	GBALLY VILLAGE	
3	Hon.	LASANAH	KROMAH	GBANDI/ASST. TC	
4	Bro.	Abue	Boakai	Bandi/	
5	Pst	Elijah T.	Freeman	Bandi/Pastor	077712807
6	Ms.	Sarah F	Freeman	Bandi/mother	
7	mr	Robert B.	Grahands	Vamasu/Elder	
8	mr	Forday	Jah	Bandi/T. chief	
9	Bro	Jimmy	Carter	Bandi/youth	
10	Bro.	Lienah	Hoggard.	Bandi/town	
11	Sis	Mama	Lotty	Bandi/town	
12		Roland	Albend	Harrisburd	0776030746
13	mr	Varney	Domah	Bandi/town	
14	Sis	Jesse	Boika	Bandi/town	
15	Sis	mamie	Fordy	Bandi/town	
16	Bro.	Ousma	Massaly	Gbally Village	
17	Bro.	Ambulah	Kromah	Bandi/y. Leader	077852974
18	Bro.	Sando	Jappah	Bandi	
19	Bro.	Lasanah	Konah	macca/T. chief	07715 6358
20	Sis	Mamah	Lackett	Bandi town	
21	Sis	Zoe	Fordy	Bandi town	
22	Sis	Jenneh	Fordy	Bandi town	
23	mr	Varney	Domah	Bandi/elder	
24	mr	Abue	Boakai	Bandi town	
25	Sis	mamie	fordy	Bandi town	
26	Sis	Jesse	Boakai	Bandi town	
27	Bro	Charge	Chain	Bandi	
28	Sis	Bendu	Hoggard	Bandi	
29	Sis	Bendu	Konah	macca	
30	ma.	Hellen	Rufus	Bandi	
31	ma.	Zinnah	Domah	Bandi	

No.	(Mr.,Ms.,Mrs)	First Name	Family Name	Community, Position	Contact
32	ma.	Konsa	Sumo	Zoetu-town	
33	Sis	Jartu	Domah	Bandi town	
34	Sis	Hawah	Steven	Bandi-town	
35	Sis	Fatu	Duria	Bandi town	
36	ma	Fatu	Wilson	Bandi town	
37	ma.	musu	Wilson	Bandi town	
38	Bro	mamah	Boakai	Village Village	
39	Bro.	Edwuah	Johnson	Gbally Village	
40	Bro	Freend	Gbakpa	Vamasu town	
41	Bro.	Friend	David	Bandi town	
42	mr.	David	Sumo	Sumo Town / T.chief	
43	mr.	moses	Jack	Boi town / T.chief	
44	ma.	Feiggard	Boi	Boi town / T.chief	
45	Bro.	Joseph	Obey	Georgia road	077605440
46	mr.	Zinaba	Johnson	Gballasua	
47	ma.	Ruth	Jack	Boi town	
48	ma.	Jenneh	Sumo	Sumo Town	
49	Sis	massa	Dukuly	Gbally Village	
50	Sis	Theresa	Flomo	Bandi town	
51	ma.	Tenneh	Kromah	Bandi town	
52	Sis	Jartu	Boakai	Gbally Village	
53	Sis	Theresa	Freeman	Bandi town	
54	Sis	Wattah	Dukuly	Gbally Village	
55	mr.	Sammie	Brown	Bandi-town	
56		Varney	Ryane	Bandi town	
57		Boamah	Johnson	Bandi town	
58		Zinnah	Sunday	Boi town	
59		Sumo	miccgill	Gbally Village	
60		Famatta	Fuller	" "	
61		Boikai	Dukuly	" "	
62		massa	Konah	massa town	

No.	(Mr.,Ms.,Mrs)	First Name	Family Name	Community, Position	Contact
63	Mr	Jonney	Kollah	Bacca town	
64	MR.	Alfred	Lackett	Boa town	
65	"	WILLIAM	WRIGHT	RAKAMA	0776786016
66	"	CLEMENT	WRIGHT	1940/COMMISSIONER	0777219982
67	"	JACKSON	ROBERT	HAWA TOWN/T.C.	0777305801
68	"	NAPPAY	DUKULY	LACKETT	0778979894
69	"	MOMO	BOA	MISSION TOWN/TC	07765437756
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A23.5: Comments and Suggestion Form

<table>
<tr><td colspan="2">Comments & Suggestions Form
Mt. Coffee Hydropower Project</td><td>№
(to be completed by LEC, POYRY)
Date of receiving the Form (LEC,POYRY</td></tr>
<tr><td>Name</td><td colspan="2"></td></tr>
<tr><td rowspan="3">Please tick and indicate the best way to contact you on the communication you are submitting</td><td colspan="2">❑ by post; please include your address:</td></tr>
<tr><td colspan="2">❑ by telephone; please include your phone number:</td></tr>
<tr><td colspan="2">❑ by e-mail; please include your e-mail address:</td></tr>
<tr><td>Please tick and indicate the type of your comment</td><td>❑ suggestion</td><td>❑complaint</td></tr>
<tr><td>What do you think this project will do to you? Please tell us.</td><td colspan="2"></td></tr>
<tr><td>When it is negative, how do you think we can solve it?</td><td colspan="2"></td></tr>
<tr><td>Signature:</td><td colspan="2"></td></tr>
<tr><td>Date of the communication form:</td><td colspan="2"></td></tr>
<tr><td></td><td colspan="2">Contact Information:
Please bring this paper to Mr. Sam Y. Garwoloquoi from Raymond Camp, Harrisburg</td></tr>
</table>

ANNEX 24: PROJECT ALTERNATIVES

No entries in this Annex

ANNEX 25: ECONOMIC EVALUATION

Annex 25.1: Economic Analysis: Discount rate 10%, Base construction cost, Base tariff, Sale of full production in year 5

Annex 25.2: Economic Analysis: Discount rate 10%, Base construction cost, Base tariff, Sale of full production in year 1

Annex 25.3: Economic Analysis: Discount rate 10%, Construction cost +25%, Base tariff, Sale of full production in 5 year

Annex 25.4: Economic Analysis: Discount rate 10%, Base construction cost, Tariff +25%, Sale of full production in year 5

Annex 25.5: Economic Analysis: Discount rate 12%, Base construction cost, Base tariff, Sale of full production in year 5

Annex 25.6: Economic Analysis: Discount rate 12%, Base construction cost, Base tariff, Sale of full production in year 1

Annex 25.7: Economic Analysis: Discount rate 12%, Construction cost +25%, Base tariff, Sale of full production in year 5

Annex 25.8: Economic Analysis: Discount rate 12%, Base construction cost, Tariff +25%, Sale of full production in year 5

Annex 25.9: Economic Analysis: Discount rate 8%, Base construction cost, Base tariff, Sale of full production in year 5

Annex 25.10: Economic Analysis: Discount rate 8%, Base construction cost, Base tariff, Sale of full production in year 1

Annex 25.11: Economic Analysis: Discount rate 8%, Construction cost +25%, Base tariff, Sale of full production in year 5

Annex 25.12: Economic Analysis: Discount rate 8%, Base construction cost, Tariff +25%, Sale of full production in year 5

Annex 6.1
Mount Coffee Hydropower Plant
Economic Analysis
Discount rate 10%, Base construction cost, Base tariff, Sale of full production in year 5

Parameters				Parameters		
Installed capacity		66	MW	Project cost Year -4	14.60%	
Average annual energy		357	GWh	Project cost Year -3	17.00%	
Sale	Year 1	80.00%		Project cost Year -2	37.90%	
Sale	Year 2	85.00%		Project cost Year -1	30.10%	
Sale	Year 3	90.00%		Project cost Year +1	0.40%	
Sale	Year 4	95.00%		Base tariff	14.25	US cts/kWh
Sale	Year 5	100.00%		Per cent Base Tariff	100.00%	
Base Project cost		164.1	Million $	Applied Tariff	14.25	US cts/kWh
Per cent Base Project cost		100.00%		Results		
Applied Project cost		164.1	Million $	Discount rate	10.00%	
Annual O & M cost	1%	1.641	Million $	Production costs	5.89	US cts/kWh
				Net Present Value	193.729	Million $
				Internal rate return	21.68%	

Year	Energy	Revenue	Proj cost	O & M	Tot cost	Rev-Cost	Energy	Tot cost
-4	0.0	0.0	23.959	0.0	23.959	-23.959		35.078
-3	0.0	0.0	27.897	0.0	27.897	-27.897		37.131
-2	0.0	0.0	62.194	0.0	62.194	-62.194		75.255
-1	0.0	0.0	49.394	0.0	49.394	-49.394		54.334
1	285.6	40.698	0.656	1.313	1.969	38.729	285.6	203.766
2	303.5	43.242		1.395	1.395	41.847	303.5	1.395
3	321.3	45.785		1.477	1.477	44.308	321.3	1.477
4	339.2	48.329		1.559	1.559	46.770	339.2	1.559
5	357.0	50.873		1.641	1.641	49.232	357.0	1.641
6	357.0	50.873		1.641	1.641	49.232	357.0	1.641
7	357.0	50.873		1.641	1.641	49.232	357.0	1.641
8	357.0	50.873		1.641	1.641	49.232	357.0	1.641
9	357.0	50.873		1.641	1.641	49.232	357.0	1.641
10	357.0	50.873		1.641	1.641	49.232	357.0	1.641
11	357.0	50.873		1.641	1.641	49.232	357.0	1.641
12	357.0	50.873		1.641	1.641	49.232	357.0	1.641
40	357.0	50.873		1.641	1.641	49.232	357.0	1.641
41	357.0	50.873		1.641	1.641	49.232	357.0	1.641
42	357.0	50.873		1.641	1.641	49.232	357.0	1.641
43	357.0	50.873		1.641	1.641	49.232	357.0	1.641
44	357.0	50.873		1.641	1.641	49.232	357.0	1.641
45	357.0	50.873		1.641	1.641	49.232	357.0	1.641
46	357.0	50.873		1.641	1.641	49.232	357.0	1.641
47	357.0	50.873		1.641	1.641	49.232	357.0	1.641
48	357.0	50.873		1.641	1.641	49.232	357.0	1.641
49	357.0	50.873		1.641	1.641	49.232	357.0	1.641
50	357.0	50.873		1.641	1.641	49.232	357.0	1.641
Sum	17'672	2'518.19	164.100	81.230	245.330	2'272.859	17'672	283.683
PV	2'316.4	330.084	125.708	10.648	136.355	193.729	3'391.4	199.637
								5.89

Annex 6.2
Mount Coffee Hydropower Plant
Economic Analysis
Discount rate 10%, Base construction cost, Base tariff, Full sale in year 1

Parameters				Parameters		
Installed capacity		66	MW	Project cost Year -4	14.60%	
Average annual energy		357	GWh	Project cost Year -3	17.00%	
Sale	Year 1	100.00%		Project cost Year -2	37.90%	
Sale	Year 2	100.00%		Project cost Year -1	30.10%	
Sale	Year 3	100.00%		Project cost Year +1	0.40%	
Sale	Year 4	100.00%		Base tariff	14.25	US cts/kWh
Sale	Year 5	100.00%		Per cent Base Tariff	100.00%	
Base Project cost		164.1	Million $	Applied Tariff	14.25	US cts/kWh
Per cent Base Project cost		100.00%		Results		
Applied Project cost		164.1	Million $	Discount rate	10.00%	
Annual O & M cost:	1%	1.641	Million $	Production costs	5.66	US cts/kWh
				Net Present Value	207.686	Million $
				Internal rate return	23.07%	

Year	Energy	Revenue	Proj cost	O & M	Tot cost	Rev-Cost	Energy	Tot cost
-4	0.0	0.0	23.959	0.0	23.959	-23.959		35.078
-3	0.0	0.0	27.897	0.0	27.897	-27.897		37.131
-2	0.0	0.0	62.194	0.0	62.194	-62.194		75.255
-1	0.0	0.0	49.394	0.0	49.394	-49.394		54.334
1	357.0	50.8725	0.656	1.641	2.297	48.575	357.0	204.094
2	357.0	50.873		1.641	1.641	49.232	357.0	1.641
3	357.0	50.873		1.641	1.641	49.232	357.0	1.641
4	357.0	50.873		1.641	1.641	49.232	357.0	1.641
5	357.0	50.873		1.641	1.641	49.232	357.0	1.641
6	357.0	50.873		1.641	1.641	49.232	357.0	1.641
7	357.0	50.873		1.641	1.641	49.232	357.0	1.641
8	357.0	50.873		1.641	1.641	49.232	357.0	1.641
9	357.0	50.873		1.641	1.641	49.232	357.0	1.641
10	357.0	50.873		1.641	1.641	49.232	357.0	1.641
11	357.0	50.873		1.641	1.641	49.232	357.0	1.641
12	357.0	50.873		1.641	1.641	49.232	357.0	1.641
40	357.0	50.873		1.641	1.641	49.232	357.0	1.641
41	357.0	50.873		1.641	1.641	49.232	357.0	1.641
42	357.0	50.873		1.641	1.641	49.232	357.0	1.641
43	357.0	50.873		1.641	1.641	49.232	357.0	1.641
44	357.0	50.873		1.641	1.641	49.232	357.0	1.641
45	357.0	50.873		1.641	1.641	49.232	357.0	1.641
46	357.0	50.873		1.641	1.641	49.232	357.0	1.641
47	357.0	50.873		1.641	1.641	49.232	357.0	1.641
48	357.0	50.873		1.641	1.641	49.232	357.0	1.641
49	357.0	50.873		1.641	1.641	49.232	357.0	1.641
50	357.0	50.873		1.641	1.641	49.232	357.0	1.641
Sum	17'850	2'543.63	164.100	82.050	246.150	2'297.475	17'850	284.503
PV	2'417.6	344.506	125.708	11.113	136.820	207.686	3'539.6	200.319
								5.66

Annex 6.3
Mount Coffee Hydropower Plant
Economic Analysis
Discount rate 10%, Construction cost +25%, Base tariff, Full sale in year 5

Parameters				Parameters		
Installed capacity		66	MW	Project cost Year -4	14.60%	
Average annual energy		357	GWh	Project cost Year -3	17.00%	
Sale	Year 1	80.00%		Project cost Year -2	37.90%	
Sale	Year 2	85.00%		Project cost Year -1	30.10%	
Sale	Year 3	90.00%		Project cost Year +1	0.40%	
Sale	Year 4	95.00%		Base tariff	14.25	US cts/kWh
Sale	Year 5	100.00%		Per cent Base Tariff	100.00%	
Base Project cost		164.1	Million $	Applied Tariff	14.25	US cts/kWh
Per cent Base Project cost		125.00%		Results		
Applied Project cost		205.125	Million $	Discount rate	10.00%	
Annual O & M cost	1%	2.051	Million $	Production costs	7.36	US cts/kWh
				Net Present Value	159.640	Million $
				Internal rate return	18.08%	

Year	Energy	Revenue	Proj cost	O & M	Tot cost	Rev-Cost	Energy	Tot cost
-4	0.0	0.0	29.948	0.0	29.948	-29.948		43.847
-3	0.0	0.0	34.871	0.0	34.871	-34.871		46.414
-2	0.0	0.0	77.742	0.0	77.742	-77.742		94.068
-1	0.0	0.0	61.743	0.0	61.743	-61.743		67.917
1	285.6	40.698	0.821	1.641	2.462	38.237	285.6	254.708
2	303.5	43.242		1.744	1.744	41.498	303.5	1.744
3	321.3	45.785		1.846	1.846	43.939	321.3	1.846
4	339.2	48.329		1.949	1.949	46.380	339.2	1.949
5	357.0	50.873		2.051	2.051	48.821	357.0	2.051
6	357.0	50.873		2.051	2.051	48.821	357.0	2.051
7	357.0	50.873		2.051	2.051	48.821	357.0	2.051
8	357.0	50.873		2.051	2.051	48.821	357.0	2.051
9	357.0	50.873		2.051	2.051	48.821	357.0	2.051
10	357.0	50.873		2.051	2.051	48.821	357.0	2.051
11	357.0	50.873		2.051	2.051	48.821	357.0	2.051
12	357.0	50.873		2.051	2.051	48.821	357.0	2.051
40	357.0	50.873		2.051	2.051	48.821	357.0	2.051
41	357.0	50.873		2.051	2.051	48.821	357.0	2.051
42	357.0	50.873		2.051	2.051	48.821	357.0	2.051
43	357.0	50.873		2.051	2.051	48.821	357.0	2.051
44	357.0	50.873		2.051	2.051	48.821	357.0	2.051
45	357.0	50.873		2.051	2.051	48.821	357.0	2.051
46	357.0	50.873		2.051	2.051	48.821	357.0	2.051
47	357.0	50.873		2.051	2.051	48.821	357.0	2.051
48	357.0	50.873		2.051	2.051	48.821	357.0	2.051
49	357.0	50.873		2.051	2.051	48.821	357.0	2.051
50	357.0	50.873		2.051	2.051	48.821	357.0	2.051
Sum	17'672	2'518.19	205.125	101.537	306.662	2'211.527	17'672	354.603
PV	2'316.4	330.084	157.134	13.309	170.444	159.640	3'391.4	249.547
								7.36

Annex 6.4
Mount Coffee Hydropower Plant
Economic Analysis
Discount rate 10%, Base construction cost, Tariff +25%, Full sale in year 5

Parameters				Parameters		
Installed capacity		66	MW	Project cost Year -4	14.60%	
Average annual energy		357	GWh	Project cost Year -3	17.00%	
Sale	Year 1	80.00%		Project cost Year -2	37.90%	
Sale	Year 2	85.00%		Project cost Year -1	30.10%	
Sale	Year 3	90.00%		Project cost Year +1	0.40%	
Sale	Year 4	95.00%		Base tariff	14.25	US cts/kWh
Sale	Year 5	100.00%		Per cent Base Tariff	121.05%	
Base Project cost		164.1	Million $	Applied Tariff	17.25	US cts/kWh
Per cent Base Project cost		100.00%		Results		
Applied Project cost		164.1	Million $	Discount rate	10.00%	
Annual O & M cost	1%	1.641	Million $	Production costs	5.89	US cts/kWh
				Net Present Value	263.221	Million $
				Internal rate return	25.18%	

Year	Energy	Revenue	Proj cost	O & M	Tot cost	Rev-Cost	Energy	Tot cost
-4	0.0	0.0	23.959	0.0	23.959	-23.959		35.078
-3	0.0	0.0	27.897	0.0	27.897	-27.897		37.131
-2	0.0	0.0	62.194	0.0	62.194	-62.194		75.255
-1	0.0	0.0	49.394	0.0	49.394	-49.394		54.334
1	285.6	49.26615	0.656	1.313	1.969	47.297	285.6	203.766
2	303.5	52.345		1.395	1.395	50.950	303.5	1.395
3	321.3	55.424		1.477	1.477	53.948	321.3	1.477
4	339.2	58.504		1.559	1.559	56.945	339.2	1.559
5	357.0	61.583		1.641	1.641	59.942	357.0	1.641
6	357.0	61.583		1.641	1.641	59.942	357.0	1.641
7	357.0	61.583		1.641	1.641	59.942	357.0	1.641
8	357.0	61.583		1.641	1.641	59.942	357.0	1.641
9	357.0	61.583		1.641	1.641	59.942	357.0	1.641
10	357.0	61.583		1.641	1.641	59.942	357.0	1.641
11	357.0	61.583		1.641	1.641	59.942	357.0	1.641
12	357.0	61.583		1.641	1.641	59.942	357.0	1.641
40	357.0	61.583		1.641	1.641	59.942	357.0	1.641
41	357.0	61.583		1.641	1.641	59.942	357.0	1.641
42	357.0	61.583		1.641	1.641	59.942	357.0	1.641
43	357.0	61.583		1.641	1.641	59.942	357.0	1.641
44	357.0	61.583		1.641	1.641	59.942	357.0	1.641
45	357.0	61.583		1.641	1.641	59.942	357.0	1.641
46	357.0	61.583		1.641	1.641	59.942	357.0	1.641
47	357.0	61.583		1.641	1.641	59.942	357.0	1.641
48	357.0	61.583		1.641	1.641	59.942	357.0	1.641
49	357.0	61.583		1.641	1.641	59.942	357.0	1.641
50	357.0	61.583		1.641	1.641	59.942	357.0	1.641
Sum	17'672	3'048.34	164.100	81.230	245.330	2'803.014	17'672	283.683
PV	2'316.4	399.577	125.708	10.648	136.355	263.221	3'391.4	199.637
								5.89

Annex 6.5
Mount Coffee Hydropower Plant
Economic Analysis
Discount rate 12%, Base construction cost, Base tariff, Full sale in year 5

Parameters				Parameters		
Installed capacity		66	MW	Project cost Year -4	14.60%	
Average annual energy		357	GWh	Project cost Year -3	17.00%	
Sale	Year 1	80.00%		Project cost Year -2	37.90%	
Sale	Year 2	85.00%		Project cost Year -1	30.10%	
Sale	Year 3	90.00%		Project cost Year +1	0.40%	
Sale	Year 4	95.00%		Base tariff	14.50	US cts/kWh
Sale	Year 5	100.00%		Per cent Base Tariff	100.00%	
Base Project cost		164.1	Million $	Applied Tariff	14.50	US cts/kWh
Per cent Base Project cost		100.00%		Results		
Applied Project cost		164.1	Million $	Discount rate	12.00%	
Annual O & M cost	1%	1.641	Million $	Production costs	7.13	US cts/kWh
				Net Present Value	132.098	Million $
				Internal rate return	21.99%	

Year	Energy	Revenue	Proj cost	O & M	Tot cost	Rev-Cost	Energy	Tot cost
-4	0.0	0.0	23.959	0.0	23.959	-23.959		37.699
-3	0.0	0.0	27.897	0.0	27.897	-27.897		39.193
-2	0.0	0.0	62.194	0.0	62.194	-62.194		78.016
-1	0.0	0.0	49.394	0.0	49.394	-49.394		55.321
1	285.6	41.412	0.656	1.313	1.969	39.443	285.6	212.199
2	303.5	44.000		1.395	1.395	42.605	303.5	1.395
3	321.3	46.589		1.477	1.477	45.112	321.3	1.477
4	339.2	49.177		1.559	1.559	47.618	339.2	1.559
5	357.0	51.765		1.641	1.641	50.124	357.0	1.641
6	357.0	51.765		1.641	1.641	50.124	357.0	1.641
7	357.0	51.765		1.641	1.641	50.124	357.0	1.641
8	357.0	51.765		1.641	1.641	50.124	357.0	1.641
9	357.0	51.765		1.641	1.641	50.124	357.0	1.641
10	357.0	51.765		1.641	1.641	50.124	357.0	1.641
11	357.0	51.765		1.641	1.641	50.124	357.0	1.641
12	357.0	51.765		1.641	1.641	50.124	357.0	1.641
40	357.0	51.765		1.641	1.641	50.124	357.0	1.641
41	357.0	51.765		1.641	1.641	50.124	357.0	1.641
42	357.0	51.765		1.641	1.641	50.124	357.0	1.641
43	357.0	51.765		1.641	1.641	50.124	357.0	1.641
44	357.0	51.765		1.641	1.641	50.124	357.0	1.641
45	357.0	51.765		1.641	1.641	50.124	357.0	1.641
46	357.0	51.765		1.641	1.641	50.124	357.0	1.641
47	357.0	51.765		1.641	1.641	50.124	357.0	1.641
48	357.0	51.765		1.641	1.641	50.124	357.0	1.641
49	357.0	51.765		1.641	1.641	50.124	357.0	1.641
50	357.0	51.765		1.641	1.641	50.124	357.0	1.641
Sum	17'672	2'562.37	164.100	81.230	245.330	2'317.038	17'672	292.116
PV	1'793.1	260.003	119.663	8.242	127.905	132.098	2'821.5	201.261
								7.13

Annex 6.6
Mount Coffee Hydropower Plant
Economic Analysis
Discount rate 12%, Base construction cost, Base tariff, Full sale in year 1

Parameters				Parameters		
Installed capacity		66	MW	Project cost Year -4	14.60%	
Average annual energy		357	GWh	Project cost Year -3	17.00%	
Sale	Year 1	100.00%		Project cost Year -2	37.90%	
Sale	Year 2	100.00%		Project cost Year -1	30.10%	
Sale	Year 3	100.00%		Project cost Year +1	0.40%	
Sale	Year 4	100.00%		Base tariff	14.50	US cts/kWh
Sale	Year 5	100.00%		Per cent Base Tariff	100.00%	
Base Project cost		164.1	Million $	Applied Tariff	14.50	US cts/kWh
Per cent Base Project cost		100.00%		Results		
Applied Project cost		164.1	Million $	Discount rate	12.00%	
Annual O & M cost	1%	1.641	Million $	Production costs	6.81	US cts/kWh
				Net Present Value	144.875	Million $
				Internal rate return	23.40%	

Year	Energy	Revenue	Proj cost	O & M	Tot cost	Rev-Cost	Energy	Tot cost
-4	0.0	0.0	23.959	0.0	23.959	-23.959		37.699
-3	0.0	0.0	27.897	0.0	27.897	-27.897		39.193
-2	0.0	0.0	62.194	0.0	62.194	-62.194		78.016
-1	0.0	0.0	49.394	0.0	49.394	-49.394		55.321
1	357.0	51.765	0.656	1.641	2.297	49.468	357.0	212.527
2	357.0	51.765		1.641	1.641	50.124	357.0	1.641
3	357.0	51.765		1.641	1.641	50.124	357.0	1.641
4	357.0	51.765		1.641	1.641	50.124	357.0	1.641
5	357.0	51.765		1.641	1.641	50.124	357.0	1.641
6	357.0	51.765		1.641	1.641	50.124	357.0	1.641
7	357.0	51.765		1.641	1.641	50.124	357.0	1.641
8	357.0	51.765		1.641	1.641	50.124	357.0	1.641
9	357.0	51.765		1.641	1.641	50.124	357.0	1.641
10	357.0	51.765		1.641	1.641	50.124	357.0	1.641
11	357.0	51.765		1.641	1.641	50.124	357.0	1.641
12	357.0	51.765		1.641	1.641	50.124	357.0	1.641
40	357.0	51.765		1.641	1.641	50.124	357.0	1.641
41	357.0	51.765		1.641	1.641	50.124	357.0	1.641
42	357.0	51.765		1.641	1.641	50.124	357.0	1.641
43	357.0	51.765		1.641	1.641	50.124	357.0	1.641
44	357.0	51.765		1.641	1.641	50.124	357.0	1.641
45	357.0	51.765		1.641	1.641	50.124	357.0	1.641
46	357.0	51.765		1.641	1.641	50.124	357.0	1.641
47	357.0	51.765		1.641	1.641	50.124	357.0	1.641
48	357.0	51.765		1.641	1.641	50.124	357.0	1.641
49	357.0	51.765		1.641	1.641	50.124	357.0	1.641
50	357.0	51.765		1.641	1.641	50.124	357.0	1.641
Sum	17'850	2'588.25	164.100	82.050	246.150	2'342.100	17'850	292.936
PV	1'884.1	273.198	119.663	8.661	128.323	144.875	2'964.7	201.919
								6.81

Annex 6.7
Mount Coffee Hydropower Plant
Economic Analysis
Discount rate 12%, Construction cost +25%, Base tariff, Full sale in year 5

Parameters				Parameters		
Installed capacity		66	MW	Project cost Year -4	14.60%	
Average annual energy		357	GWh	Project cost Year -3	17.00%	
Sale	Year 1	80.00%		Project cost Year -2	37.90%	
Sale	Year 2	85.00%		Project cost Year -1	30.10%	
Sale	Year 3	90.00%		Project cost Year +1	0.40%	
Sale	Year 4	95.00%		Base tariff	14.50	US cts/kWh
Sale	Year 5	100.00%		Per cent Base Tariff	100.00%	
Base Project cost		164.1	Million $	Applied Tariff	14.50	US cts/kWh
Per cent Base Project cost		125.00%		Results		
Applied Project cost		205.125	Million $	Discount rate	12.00%	
Annual O & M cost	1%	2.051	Million $	Production costs	8.92	US cts/kWh
				Net Present Value	100.121	Million $
				Internal rate return	18.35%	

Year	Energy	Revenue	Proj cost	O & M	Tot cost	Rev-Cost	Energy	Tot cost
-4	0.0	0.0	29.948	0.0	29.948	-29.948		47.124
-3	0.0	0.0	34.871	0.0	34.871	-34.871		48.992
-2	0.0	0.0	77.742	0.0	77.742	-77.742		97.520
-1	0.0	0.0	61.743	0.0	61.743	-61.743		69.152
1	285.6	41.412	0.821	1.641	2.462	38.951	285.6	265.249
2	303.5	44.000		1.744	1.744	42.257	303.5	1.744
3	321.3	46.589		1.846	1.846	44.742	321.3	1.846
4	339.2	49.177		1.949	1.949	47.228	339.2	1.949
5	357.0	51.765		2.051	2.051	49.714	357.0	2.051
6	357.0	51.765		2.051	2.051	49.714	357.0	2.051
7	357.0	51.765		2.051	2.051	49.714	357.0	2.051
8	357.0	51.765		2.051	2.051	49.714	357.0	2.051
9	357.0	51.765		2.051	2.051	49.714	357.0	2.051
10	357.0	51.765		2.051	2.051	49.714	357.0	2.051
11	357.0	51.765		2.051	2.051	49.714	357.0	2.051
12	357.0	51.765		2.051	2.051	49.714	357.0	2.051
40	357.0	51.765		2.051	2.051	49.714	357.0	2.051
41	357.0	51.765		2.051	2.051	49.714	357.0	2.051
42	357.0	51.765		2.051	2.051	49.714	357.0	2.051
43	357.0	51.765		2.051	2.051	49.714	357.0	2.051
44	357.0	51.765		2.051	2.051	49.714	357.0	2.051
45	357.0	51.765		2.051	2.051	49.714	357.0	2.051
46	357.0	51.765		2.051	2.051	49.714	357.0	2.051
47	357.0	51.765		2.051	2.051	49.714	357.0	2.051
48	357.0	51.765		2.051	2.051	49.714	357.0	2.051
49	357.0	51.765		2.051	2.051	49.714	357.0	2.051
50	357.0	51.765		2.051	2.051	49.714	357.0	2.051
Sum	17'672	2'562.37	205.125	101.537	306.662	2'255.706	17'672	365.145
PV	1'793.1	260.003	149.578	10.303	159.881	100.121	2'821.5	251.576
								8.92

Annex 6.8
Mount Coffee Hydropower Plant
Economic Analysis
Discount rate 12%, Base construction cost, Tariff +25%, Full sale of production in year 5

Parameters				Parameters		
Installed capacity		66	MW	Project cost Year -4	14.60%	
Average annual energy		357	GWh	Project cost Year -3	17.00%	
Sale	Year 1	80.00%		Project cost Year -2	37.90%	
Sale	Year 2	85.00%		Project cost Year -1	30.10%	
Sale	Year 3	90.00%		Project cost Year +1	0.40%	
Sale	Year 4	95.00%		Base tariff	14.50	US cts/kWh
Sale	Year 5	100.00%		Per cent Base Tariff	120.69%	
Base Project cost		164.1	Million $	Applied Tariff	17.50	US cts/kWh
Per cent Base Project cost		100.00%		Results		
Applied Project cost		164.1	Million $	Discount rate	12.00%	
Annual O & M cost	1%	1.641	Million $	Production costs	7.13	US cts/kWh
				Net Present Value	185.892	Million $
				Internal rate return	25.46%	

Year	Energy	Revenue	Proj cost	O & M	Tot cost	Rev-Cost	Energy	Tot cost
-4	0.0	0.0	23.959	0.0	23.959	-23.959		37.699
-3	0.0	0.0	27.897	0.0	27.897	-27.897		39.193
-2	0.0	0.0	62.194	0.0	62.194	-62.194		78.016
-1	0.0	0.0	49.394	0.0	49.394	-49.394		55.321
1	285.6	49.98014	0.656	1.313	1.969	48.011	285.6	212.199
2	303.5	53.104		1.395	1.395	51.709	303.5	1.395
3	321.3	56.228		1.477	1.477	54.751	321.3	1.477
4	339.2	59.351		1.559	1.559	57.792	339.2	1.559
5	357.0	62.475		1.641	1.641	60.834	357.0	1.641
6	357.0	62.475		1.641	1.641	60.834	357.0	1.641
7	357.0	62.475		1.641	1.641	60.834	357.0	1.641
8	357.0	62.475		1.641	1.641	60.834	357.0	1.641
9	357.0	62.475		1.641	1.641	60.834	357.0	1.641
10	357.0	62.475		1.641	1.641	60.834	357.0	1.641
11	357.0	62.475		1.641	1.641	60.834	357.0	1.641
12	357.0	62.475		1.641	1.641	60.834	357.0	1.641
40	357.0	62.475		1.641	1.641	60.834	357.0	1.641
41	357.0	62.475		1.641	1.641	60.834	357.0	1.641
42	357.0	62.475		1.641	1.641	60.834	357.0	1.641
43	357.0	62.475		1.641	1.641	60.834	357.0	1.641
44	357.0	62.475		1.641	1.641	60.834	357.0	1.641
45	357.0	62.475		1.641	1.641	60.834	357.0	1.641
46	357.0	62.475		1.641	1.641	60.834	357.0	1.641
47	357.0	62.475		1.641	1.641	60.834	357.0	1.641
48	357.0	62.475		1.641	1.641	60.834	357.0	1.641
49	357.0	62.475		1.641	1.641	60.834	357.0	1.641
50	357.0	62.475		1.641	1.641	60.834	357.0	1.641
Sum	17'672	3'092.52	164.100	81.230	245.330	2'847.192	17'672	292.116
PV	1'793.1	313.797	119.663	8.242	127.905	185.892	2'821.5	201.261
								7.13

Annex 6.9
Mount Coffee Hydropower Plant
Economic Analysis
Discount rate 8%, Base construction cost, Base tariff, Full sale in year 5

Parameters				Parameters		
Installed capacity		66	MW	Project cost Year -4	14.60%	
Average annual energy		357	GWh	Project cost Year -3	17.00%	
Sale	Year 1	80.00%		Project cost Year -2	37.90%	
Sale	Year 2	85.00%		Project cost Year -1	30.10%	
Sale	Year 3	90.00%		Project cost Year +1	0.40%	
Sale	Year 4	95.00%		Base tariff	14.00	US cts/kWh
Sale	Year 5	100.00%		Per cent Base Tariff	100.00%	
Base Project cost		164.1	Million $	Applied Tariff	14.00	US cts/kWh
Per cent Base Project cost		100.00%		Results		
Applied Project cost		164.1	Million $	Discount rate	8.00%	
Annual O & M cost	1%	1.641	Million $	Production costs	4.73	US cts/kWh
				Net Present Value	287.162	Million $
				Internal rate return	21.38%	

Year	Energy	Revenue	Proj cost	O & M	Tot cost	Rev-Cost	Energy	Tot cost
-4	0.0	0.0	23.959	0.0	23.959	-23.959		32.595
-3	0.0	0.0	27.897	0.0	27.897	-27.897		35.142
-2	0.0	0.0	62.194	0.0	62.194	-62.194		72.543
-1	0.0	0.0	49.394	0.0	49.394	-49.394		53.346
1	285.6	39.984	0.656	1.313	1.969	38.015	285.6	195.595
2	303.5	42.483		1.395	1.395	41.088	303.5	1.395
3	321.3	44.982		1.477	1.477	43.505	321.3	1.477
4	339.2	47.481		1.559	1.559	45.922	339.2	1.559
5	357.0	49.980		1.641	1.641	48.339	357.0	1.641
6	357.0	49.980		1.641	1.641	48.339	357.0	1.641
7	357.0	49.980		1.641	1.641	48.339	357.0	1.641
8	357.0	49.980		1.641	1.641	48.339	357.0	1.641
9	357.0	49.980		1.641	1.641	48.339	357.0	1.641
10	357.0	49.980		1.641	1.641	48.339	357.0	1.641
11	357.0	49.980		1.641	1.641	48.339	357.0	1.641
12	357.0	49.980		1.641	1.641	48.339	357.0	1.641
40	357.0	49.980		1.641	1.641	48.339	357.0	1.641
41	357.0	49.980		1.641	1.641	48.339	357.0	1.641
42	357.0	49.980		1.641	1.641	48.339	357.0	1.641
43	357.0	49.980		1.641	1.641	48.339	357.0	1.641
44	357.0	49.980		1.641	1.641	48.339	357.0	1.641
45	357.0	49.980		1.641	1.641	48.339	357.0	1.641
46	357.0	49.980		1.641	1.641	48.339	357.0	1.641
47	357.0	49.980		1.641	1.641	48.339	357.0	1.641
48	357.0	49.980		1.641	1.641	48.339	357.0	1.641
49	357.0	49.980		1.641	1.641	48.339	357.0	1.641
50	357.0	49.980		1.641	1.641	48.339	357.0	1.641
Sum	17'672	2'474.01	164.100	81.230	245.330	2'228.681	17'672	275.512
PV	3'097.3	433.625	132.225	14.237	146.463	287.162	4'213.9	199.261
								4.73

Annex 6.10
Mount Coffee Hydropower Plant
Economic analysis
Discount rate 8%, Base construction cost, Base tariff, Full sale in year 1

Parameters				Parameters		
Installed capacity		66	MW	Project cost Year -4	14.60%	
Average annual energy		357	GWh	Project cost Year -3	17.00%	
Sale	Year 1	100.00%		Project cost Year -2	37.90%	
Sale	Year 2	100.00%		Project cost Year -1	30.10%	
Sale	Year 3	100.00%		Project cost Year +1	0.40%	
Sale	Year 4	100.00%		Base tariff	14.00	US cts/kWh
Sale	Year 5	100.00%		Per cent Base Tariff	100.00%	
Base Project cost		164.1	Million $	Applied Tariff	14.00	US cts/kWh
Per cent Base Project cost		100.00%		Results		
Applied Project cost		164.1	Million $	Discount rate	8.00%	
Annual O & M cost	1%	1.641	Million $	Production costs	4.58	US cts/kWh
				Net Present Value	302.438	Million $
				Internal rate return	22.74%	

Year	Energy	Revenue	Proj cost	O & M	Tot cost	Rev-Cost	Energy	Tot cost
-4	0.0	0.0	23.959	0.0	23.959	-23.959		32.595
-3	0.0	0.0	27.897	0.0	27.897	-27.897		35.142
-2	0.0	0.0	62.194	0.0	62.194	-62.194		72.543
-1	0.0	0.0	49.394	0.0	49.394	-49.394		53.346
1	357.0	49.98	0.656	1.641	2.297	47.683	357.0	195.924
2	357.0	49.980		1.641	1.641	48.339	357.0	1.641
3	357.0	49.980		1.641	1.641	48.339	357.0	1.641
4	357.0	49.980		1.641	1.641	48.339	357.0	1.641
5	357.0	49.980		1.641	1.641	48.339	357.0	1.641
6	357.0	49.980		1.641	1.641	48.339	357.0	1.641
7	357.0	49.980		1.641	1.641	48.339	357.0	1.641
8	357.0	49.980		1.641	1.641	48.339	357.0	1.641
9	357.0	49.980		1.641	1.641	48.339	357.0	1.641
10	357.0	49.980		1.641	1.641	48.339	357.0	1.641
11	357.0	49.980		1.641	1.641	48.339	357.0	1.641
12	357.0	49.980		1.641	1.641	48.339	357.0	1.641
40	357.0	49.980		1.641	1.641	48.339	357.0	1.641
41	357.0	49.980		1.641	1.641	48.339	357.0	1.641
42	357.0	49.980		1.641	1.641	48.339	357.0	1.641
43	357.0	49.980		1.641	1.641	48.339	357.0	1.641
44	357.0	49.980		1.641	1.641	48.339	357.0	1.641
45	357.0	49.980		1.641	1.641	48.339	357.0	1.641
46	357.0	49.980		1.641	1.641	48.339	357.0	1.641
47	357.0	49.980		1.641	1.641	48.339	357.0	1.641
48	357.0	49.980		1.641	1.641	48.339	357.0	1.641
49	357.0	49.980		1.641	1.641	48.339	357.0	1.641
50	357.0	49.980		1.641	1.641	48.339	357.0	1.641
Sum	17'850	2'499.00	164.100	82.050	246.150	2'252.850	17'850	276.333
PV	3'210.1	449.419	132.225	14.756	146.981	302.438	4'367.4	199.966
								4.58

Annex 6.11
Mount Coffee Hydropower Plant
Economic Analysis
Discount rate 8%, Construction cost +25%, Base tariff, Full sale in year 5

Parameters				Parameters		
Installed capacity		66	MW	Project cost Year -4	14.60%	
Average annual energy		357	GWh	Project cost Year -3	17.00%	
Sale	Year 1	80.00%		Project cost Year -2	37.90%	
Sale	Year 2	85.00%		Project cost Year -1	30.10%	
Sale	Year 3	90.00%		Project cost Year +1	0.40%	
Sale	Year 4	95.00%		Base tariff	14.00	US cts/kWh
Sale	Year 5	100.00%		Per cent Base Tariff	100.00%	
Base Project cost		164.1	Million $	Applied Tariff	14.00	US cts/kWh
Per cent Base Project cost		125.00%		Results		
Applied Project cost		205.125	Million $	Discount rate	8.00%	
Annual O & M cost	1%	2.051	Million $	Production costs	5.91	US cts/kWh
				Net Present Value	250.547	Million $
				Internal rate return	17.82%	

Year	Energy	Revenue	Proj cost	O & M	Tot cost	Rev-Cost	Energy	Tot cost
-4	0.0	0.0	29.948	0.0	29.948	-29.948		40.744
-3	0.0	0.0	34.871	0.0	34.871	-34.871		43.928
-2	0.0	0.0	77.742	0.0	77.742	-77.742		90.679
-1	0.0	0.0	61.743	0.0	61.743	-61.743		66.682
1	285.6	39.984	0.821	1.641	2.462	37.523	285.6	244.494
2	303.5	42.483		1.744	1.744	40.739	303.5	1.744
3	321.3	44.982		1.846	1.846	43.136	321.3	1.846
4	339.2	47.481		1.949	1.949	45.532	339.2	1.949
5	357.0	49.980		2.051	2.051	47.929	357.0	2.051
6	357.0	49.980		2.051	2.051	47.929	357.0	2.051
7	357.0	49.980		2.051	2.051	47.929	357.0	2.051
8	357.0	49.980		2.051	2.051	47.929	357.0	2.051
9	357.0	49.980		2.051	2.051	47.929	357.0	2.051
10	357.0	49.980		2.051	2.051	47.929	357.0	2.051
11	357.0	49.980		2.051	2.051	47.929	357.0	2.051
12	357.0	49.980		2.051	2.051	47.929	357.0	2.051
40	357.0	49.980		2.051	2.051	47.929	357.0	2.051
41	357.0	49.980		2.051	2.051	47.929	357.0	2.051
42	357.0	49.980		2.051	2.051	47.929	357.0	2.051
43	357.0	49.980		2.051	2.051	47.929	357.0	2.051
44	357.0	49.980		2.051	2.051	47.929	357.0	2.051
45	357.0	49.980		2.051	2.051	47.929	357.0	2.051
46	357.0	49.980		2.051	2.051	47.929	357.0	2.051
47	357.0	49.980		2.051	2.051	47.929	357.0	2.051
48	357.0	49.980		2.051	2.051	47.929	357.0	2.051
49	357.0	49.980		2.051	2.051	47.929	357.0	2.051
50	357.0	49.980		2.051	2.051	47.929	357.0	2.051
Sum	17'672	2'474.01	205.125	101.537	306.662	2'167.348	17'672	344.390
PV	3'097.3	433.625	165.282	17.797	183.078	250.547	4'213.9	249.076
								5.91

Annex 6.12
Mount Coffee Hydropower Plant
Economic Analysis
Discount rate 8%, Base construction cost, Tariff +25%, Full sale in year 5

Parameters				Parameters		
Installed capacity		66	MW	Project cost Year -4	14.60%	
Average annual energy		357	GWh	Project cost Year -3	17.00%	
Sale	Year 1	80.00%		Project cost Year -2	37.90%	
Sale	Year 2	85.00%		Project cost Year -1	30.10%	
Sale	Year 3	90.00%		Project cost Year +1	0.40%	
Sale	Year 4	95.00%		Base tariff	14.00	US cts/kWh
Sale	Year 5	100.00%		Per cent Base Tariff	121.43%	
Base Project cost		164.1	Million $	Applied Tariff	17.00	US cts/kWh
Per cent Base Project cost		100.00%		Results		
Applied Project cost		164.1	Million $	Discount rate	8.00%	
Annual O & M cost	1%	1.641	Million $	Production costs	4.73	US cts/kWh
				Net Present Value	380.067	Million $
				Internal rate return	24.90%	

Year	Energy	Revenue	Proj cost	O & M	Tot cost	Rev-Cost	Energy	Tot cost
-4	0.0	0.0	23.959	0.0	23.959	-23.959		32.595
-3	0.0	0.0	27.897	0.0	27.897	-27.897		35.142
-2	0.0	0.0	62.194	0.0	62.194	-62.194		72.543
-1	0.0	0.0	49.394	0.0	49.394	-49.394		53.346
1	285.6	48.55057	0.656	1.313	1.969	46.581	285.6	195.595
2	303.5	51.585		1.395	1.395	50.190	303.5	1.395
3	321.3	54.619		1.477	1.477	53.142	321.3	1.477
4	339.2	57.654		1.559	1.559	56.095	339.2	1.559
5	357.0	60.688		1.641	1.641	59.047	357.0	1.641
6	357.0	60.688		1.641	1.641	59.047	357.0	1.641
7	357.0	60.688		1.641	1.641	59.047	357.0	1.641
8	357.0	60.688		1.641	1.641	59.047	357.0	1.641
9	357.0	60.688		1.641	1.641	59.047	357.0	1.641
10	357.0	60.688		1.641	1.641	59.047	357.0	1.641
11	357.0	60.688		1.641	1.641	59.047	357.0	1.641
12	357.0	60.688		1.641	1.641	59.047	357.0	1.641
40	357.0	60.688		1.641	1.641	59.047	357.0	1.641
41	357.0	60.688		1.641	1.641	59.047	357.0	1.641
42	357.0	60.688		1.641	1.641	59.047	357.0	1.641
43	357.0	60.688		1.641	1.641	59.047	357.0	1.641
44	357.0	60.688		1.641	1.641	59.047	357.0	1.641
45	357.0	60.688		1.641	1.641	59.047	357.0	1.641
46	357.0	60.688		1.641	1.641	59.047	357.0	1.641
47	357.0	60.688		1.641	1.641	59.047	357.0	1.641
48	357.0	60.688		1.641	1.641	59.047	357.0	1.641
49	357.0	60.688		1.641	1.641	59.047	357.0	1.641
50	357.0	60.688		1.641	1.641	59.047	357.0	1.641
Sum	17'672	3'004.07	164.100	81.230	245.330	2'758.737	17'672	275.512
PV	3'097.3	526.529	132.225	14.237	146.463	380.067	4'213.9	199.261
								4.73

ANNEX 26: EMERGENCY ACTION PLAN

No entries in this Annex

ANNEX 27: DECOMMISSIONING PLAN

No entries in this Annex

ANNEX 28: CIA OF ST. PAUL RIVER DEVELOPMENT

No entries in this Annex

ANNEX 29: MAIN CONCLUSION AND RECOMMENDATIONS

No entries in this Annex

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